COALBED METHANE RECLAMATION ACTIVITIES IN THE POWDER RIVER BASIN, WYOMING: SOCIAL AND POLICY DIMENSIONS OF ENVIRONMENTAL LEGACY MANAGEMENT

by

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DEDICATION

This dissertation is dedicated to my family. Thank you to my Mom, Deb, Dad, and Sarah for your unwavering support. Even when I did not believe in myself, you believed in me. To my husband Brenton, thank you for supporting my ambitions. You have worked to make this journey possible for me and I cannot express how much I appreciate that. To my son Beckett, you are my greatest joy and provide me endless motivation to pursue my dreams and achieve. You can accomplish anything, and I will always be here to help you.

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LIST OF ACRONYMS

APD – Application for Permit to Drill

BLM – United States Bureau of Land Management

CBM – Coalbed Methane

GT – Grounded Theory

PRB – Powder River Basin

SER – Society of Ecological Restoration

SLO – Social License to Operate

SRHA – Stock Raising Homestead Act

SUDA – Surface Use and Damage Agreement

UOG – Unconventional Oil and Gas

WYOGGC – Wyoming Oil and Gas Conservation Commission

ABSTRACT

The United States is producing more oil and natural gas than ever before. Sites of production are contributing to the known land-use phenomenon of energy sprawl, though little is known about how these sites will be reclaimed and how legacy effects will be governed and managed. Reclamation returns degraded energy landscapes to some productive capacity in order to avoid permanent environmental harm. Thus far, the technical aspects of reclamation have been the topic of most research while the human dimensions are under-studied. This research draws attention to the social and political dimensions of environmental legacy management. A period of coalbed methane development in the Powder River Basin, Wyoming (1999-2009) provides an instructive case study to investigate the legacy effects of energy resource development. After a decade of coalbed methane production, about 5,700 orphaned wells remained without viable industry operators to fund and manage well-plugging and reclamation. This dissertation uses a qualitative case study approach including document analysis, policy analysis, and forty semi-structured interviews with local surface owners, attorneys, state and federal regulators, local government officials, and industry personnel. Contextual research revealed that management of post-production oil and gas is a highly complex governance challenge made more complicated by the split estate property regime that characterizes the American West. Empirical research found that environmental legacy issues are exacerbated by ‘private participation’. Applying a framework tied to the concept of social license to operate, investigation of surface owner-industry relations revealed that individuals played a critical role in decision-making processes. Surface owner’s private participation resulted in decisions to forgo reclamation and integrate CBM-related infrastructure into ranching operations, therefore contributing to the scale and extent of environmental legacies. This dissertation also found that an adaptive, or ‘learn as you go’, policy approach in Wyoming enabled cost-shifting mechanisms to gain foothold, creating serious long-term environmental costs. Three specific cost-shifting mechanisms for CBM were identified: regulatory misalignment, overadaptation to the oil and gas industry, and industry bankruptcy. Together this dissertation highlights the importance of studying the social and political dimensions of post-production oil and gas activities for more effective environmental legacy management.

CHAPTER ONE

INTRODUCTION

A recent study documented that a century of energy development has resulted in aggregate loss of plant biomass equivalent to 5 million animal unit months and 120.2 million acres across the Great Plains of North America (Allred et al. 2015). The intensive energy development of the past two decades (U.S. Energy Information Administration 2020) presents a pressing human-environment issue regarding the legacies of energy production sites. The rapid pace and scale of the expansion of development has widespread implications for host communities and landscapes. Since the year 2000, an average estimated 50,000 oil and gas wells have been drilled in North America each year (Allred et al. 2015). The proliferation of wells brings attention to the topic of reclamation and restoration of oil and gas production sites. Ecological restoration is beneficial for nature and society as restoration can increase the supply and quality of ecosystem services, improve hydrology, reduce soil erosion, encourage the presence of native species, and aid in carbon sequestration (Aronson et al. 2010). While extensive research considers technical aspects of reclamation, the connection between landscape restoration and how communities fare in the years following rapid oil and gas extraction has received almost no scholarly consideration (Smith et al. 2001; Brown et al. 2005). This project seeks to understand how policy and social factors influence reclamation outcomes.

First, the terminology must be clearly defined. According to the Society for Ecological Restoration (SER) (2004), restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Reclamation practices return the degraded landscape to some productive capacity with improved ecosystem functionality (Bradshaw 1987). Productive capacity includes functional processes like nutrient cycling or water filtration but can also be interpreted in a more applied sense regarding agricultural operations, for example. Restoration acts to shift degraded or derelict lands to a state that emulates pre-disturbance conditions in regards to functional processes and ecosystem structure (SER 2004). Structure may include the diversity of species that are present, the number of trophic levels, or even the physical structure of the vegetation (Bradshaw 1987; Galatowitsch 2012). Higgs (2003) notes that restoration is defined by two concepts: historical fidelity and ecological integrity. Restoration addresses both explicitly while reclamation may partially improve both.

Using an environmental governance approach, the research examines the reclamation activities being carried out after a period of coalbed methane (CBM) development in the Powder River Basin (PRB) of Wyoming. An environmental governance approach is inclusive of forms of governance beyond policy and legislation to include the role of civil society organizations and individual actors (Lemos and Agrawal 2006). A multi-scalar approach that considers how multiple actors and processes influence reclamation outcomes is necessary. Reporting in the press and popular media has shown that a range of reclamation activities are occurring, from the total completion of reclamation projects to well sites that have seen no reclamation whatsoever (Moen 2006). Although a range of outcomes has become apparent, the explanation as to *why* certain outcomes are realized is thus far non-existent. Furthermore, contributing to the geographic subfield of energy geography, the proposed research will add to existing literature on unconventional oil and gas development (Gilmartin 2009; Haggerty and McBride 2016; Kroepsch et al. 2019; Lave and Lutz 2014) and restoration geographies (Eden 2002; Havlick and Doyle 2009; Smith 2012).

Overarching Research Question

The research question that guides this project surfaced from a desire to understand the state of energy communities and their landscape in the years after production has slowed dramatically or stopped entirely. Specifically, I am interested in understanding the following questions:

> What are the range of reclamation activities occurring across the Powder River Basin after CBM production stopped 5+ years ago; and how do policy and local social and physical contexts influence differences in reclamation outcomes?

To my knowledge, since there has been no research on the occurrence, type, and scale of post-drilling reclamation by geographers, this question will fill a critical gap in the literature.

The research question will be accomplished through the following six detailed objectives of the project:

1. Describe the historical context of energy development and the pace and scale of extraction for the study site;

2. Define and explain the regulatory framework (federal, state and local policies) around reclamation and restoration;

3. Characterize individual and community capacity of the case study area;

4. Examine how the unique physical geography of the case study area may impact reclamation activities;

5. Explore the perceptions of stakeholders including surface owners, attorneys, and regulators regarding the environment and landscape changes that have occurred since the decline of CBM development and in the years following; and

6. Observe and understand the context of current reclamation projects (if any) and lands that require reclamation.

Conceptual Framework

The conceptual framework that informs this dissertation is a combination of three different bodies of scholarship: (1) energy and resource geography; (2) environmental governance; and (3) reclamation science. Together, academic concepts from these literatures contribute to the research design and methodological approaches undertaken during the research process.

Geographic Approach

Reclamation and ecological restoration have received little scholarly consideration among geographers (Eden 2002; Havlick and Doyle 2009; Smith 2012). However, geographers are arguably some of the most appropriate researchers to tackle questions of ecological restoration due to their integrative skillset and ability to address the physical, social, political, and ecological contexts of restoration projects. Smith (2012) states, "Through spotlighting changing socio-cultural values and expectations, and ecological, economic, political and legal contexts, geography opens up new opportunities (and challenges) for restoring nature" (357). Moreover, Havlick and Doyle (2009) call for a restructuring of the common paradigm in ecological restoration to restoring geographies as opposed to restoring nature. The authors argue that restoring geographies best accounts for integrative social and environmental systems. Restoration deserves more attention from geographers and these works provide a sound foundation upon which subsequent research can build.

This research is situated in the geographic sub-discipline of energy geography. As stated by Calvert (2015), energy geography is, "the study of energy development, transportation, markets, or use patterns and their determinants" (3). The field of energy geography is not as well defined as other subfields of geography. Still, energy geography is increasingly relevant in a world where climate change, energy conflicts, and environmental degradation are serious issues. Despite the absence of strict disciplinary parameters, it is clear that geographers have historically engaged with the topic of energy development and its evolution, benefits, and consequences (Hoffman 1957; Lins 1979; Elmes & Harris 1996). Contemporary work in energy geography has concentrated on the longstanding hegemony of fossil fuels (Le Billon & Cervantes 2009; Huber 2011; Eldarov et al. 2015; Woodworth 2015) and more recently on sustainable energy development (Solomon et al. 2003; Cidell 2009; Güneralp & Seto 2012) and energy transition theories (Mälgand et al. 2014; Mans 2014).

Upon synthesizing past contributions and suggested topics of future research that arise in the energy geography literature, gaps can be identified. Serious policy analysis has been absent from the work of energy geographers (Solomon et al. 2003; Jiusto 2009; Huber 2015). The literature has called for longitudinal studies to provide empirical evidence on the longstanding impacts of localized extraction, as most studies occur at peak-drilling or immediately following the bust (Freudenberg 1992). Though this research is not a true longitudinal analysis, it is a *post facto* assessment that collects data 10 years post-production. Additionally, Jacquet (2014) identified a need for a clearer understanding of the complete development process by stating, a "better knowledge of the longer-term picture will aid communities in planning beyond the immediate booms and busts and to help mitigate the problems and accentuate the benefits of resource development" (8328).

This research will help to fill the above gaps identified in the scholarship. This study will provide insight into the lasting impacts of energy development 10+ years after drilling has declined with special attention to reclamation outcomes. The findings will shed light on the efficacy of reclamation policy, the level of reclamation that has been carried out, the influence of community resources and individual capacity on successful reclamation, and perceptions of energy landscapes. A comprehensive search for research on reclamation in the context of energy development in prominent geography journals (*Annals of the American Association of Geographers*, *Professional Geographer*, *Progress in Human Geography*, *Economic Geography* etc.) yielded no results. A similar search for scholarship on landscape perception in the context of energy development in those same journals yielded identical results. These failed searches indicate a need for the proposed research.

Environmental Governance

According to Bridge and Perreault (2009), for geographers, environmental governance is a broad analytical framework used to address the institutional arrangements, spatial scales, organization structures, and social actors involved in decision-making around natural resources and the environment. Environmental governance is characterized by the participation of nontraditional actors like businesses, Non-Governmental Organizations (NGOs), communities, and corporations in the decision-making process. The power and authority in environmental governance arrangements are often decentralized and devolved to subnational scales. Hybrid forms of governance between the state, firms, and civil society organizations typically characterize environmental governance. These hybrids include private-public partnerships between the state and firms, community-based natural resource management and co-management between the state and local resource users and communities, for example (Lemos and Agrawal 2006).

Traditional environmental management is state-centered, where centralized decision-making power and authority lies exclusively with the state. Stoker (1998) reminds us that the outcome of government and governance are the same, rather it is the decision-making process that differs. In traditional environmental management, there is less opportunity for local input and involvement, making the process more exclusionary and not well-informed by local environmental knowledge or place-specific context.

Benefits of environmental governance include its participatory nature, where more actors, including at the community-level, are able to engage. In this way, environmental governance promotes locally tailored, place-specific management actions and practices. Robust environmental governance networks are both institution-building and trust-building, a critically important benefit to consider in an era of growing distrust of government and institutions (Plummer and Armitage 2007). Moreover, it stands to reason that in the absence of centralized authority, environmental governance actors have the ability to weigh non-traditional and more creative solutions than would government alone. Together, these characteristics help make the case that environmental governance arrangements may produce better environmental solutions than what would be mandated in a strictly top-down approach.

On the other hand, there are some drawbacks to environmental governance. Establishing strong partnerships and networks does not happen immediately, so environmental governance can be considered time-consuming and initially unproductive (Plummer and Armitage 2007). Environmental governance networks are power dependent, according to Stoker (1998), where no one entity has the authority or capacity to make decisions alone. In times of crisis, the inability to respond quickly and unilaterally can be problematic. Next, the participation of many stakeholders' means there are numerous perspectives to contend with which can complicate decision-making. Lastly, the historic legacy of centralized government decision-making is difficult to deconstruct, and this legacy has the potential to make environmental governance arrangements appear messy, disorganized, and ineffective to those outside the network (Folke et al. 2005).

Power dynamics in environmental governance networks can pose a challenge. Armitage and Plummer (2007) note that in some instances, power-sharing can fail to materialize. Power asymmetries between actors can breed contempt and likely create inefficiency. Moreover, environmental governance arrangements often incorporate a diversity of federal, state, and municipal actors together with businesses, NGOs, civil society groups. Such complex arrangements can create confusion regarding accountability. Stoker (1998) calls this the 'accountability deficit' – where it is difficult to determine who should be held responsible for particular actions. Stoker (1998) states that this can lead to blame avoidance and scapegoating among stakeholders. Reed and Bruyneel (2010), citing Norman and Bakker (2009), state that the rescaling of authority from the state to subnational scales does not necessarily empower local stakeholders. In Norman and Bakker's (2009) analysis they found that while there were more local actors involved in decision-making, institutional capacity did not increase. Despite these challenges, the benefits of environmental governance provide enough merit for their continued implementation, especially in light of widespread environmental deregulation by the state in favor of neoliberal policies.

Reclamation Science

An estimated 15 million Americans lived within one mile of a natural gas well in 2013 (Gold and McGinty 2013). Extraction impacts the host landscape as well as the community. Documented changes resulting from extraction impact the local ecology (Entrekin et al. 2011; Nasen et al. 2011), economy (Brown 2014; Jacobsen and Parker 2016; Kinnaman 2011), social landscape (Brown et al. 2005; Jacquet and Stedman 2013;

Measham et al. 2016; Weber and Hitaj 2015), and land-use (Bekkedahl 2011; Drohan et al. 2012). To address these impacts, reclamation and restoration of the impacted area must be considered. However, the body of literature addressing restoration of oil and gas production sites is alarmingly small. The existing research is comprised of technical studies (i.e., Nasen et al. 2011; Rottler et al. 2017 and others), which generally fail to address human dimensions and social factors. Therefore, this study is an original research contribution as it examines how policy and individual and community capacity influence reclamation outcomes.

Case Study Site

The Powder River Basin is located in northeast/central Wyoming and extends northward into southeast Montana (Figure 1.1). This research exclusively considers reclamation activities in Wyoming. Within Wyoming, the Powder River Basin encompasses all of Campbell County and parts of Sheridan, Johnson, Converse, Crook, Weston, and Niobrara counties. The Yellowstone River lies to the north, the Laramie and Casper Mountains make up the Basin's southern boundary, and the Big Horn Mountains are to the west (Stearns et al. 2005). Covering roughly 20,000 square miles of semi-arid grasslands used primarily for livestock production, the Powder River Basin experienced rapid and intensive coalbed methane development from 1998-2008.

CBM production amounts began to soar in the year 2000. In the years prior, when CBM was in the development phase, the shale revolution had not yet begun. Natural gas made available by hydraulic fracturing was not developed, and CBM was seen as a critical energy resource to meet natural gas demand amidst shrinking supply. For context, CBM once accounted for 9% of U.S. natural gas production, and 25% of U.S. CBM was produced in the Powder River Basin (Thakur et al. 2014). In fact, the Powder River Basin was the third most productive CBM play in the U.S. after the San Juan Basin of New Mexico and the Raton Basin of Colorado/New Mexico (National Research Council 2010). However, after the economic downturn and subsequent decline in the natural gas market, some 5,700 orphaned CBM wells remain on farms and ranches in Wyoming (WYOGCC 2017), along with considerable uncertainty about who will take responsibility for well and land reclamation.

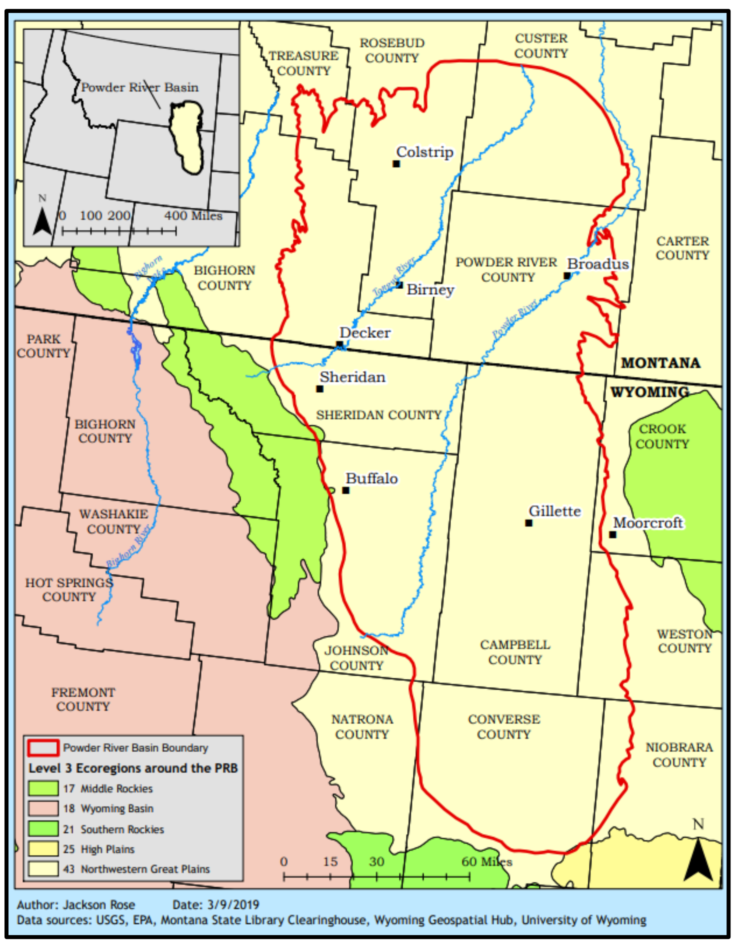

Figure 1.1. Map of the Powder River Basin, Wyoming

Coalbed Methane Development in the Powder River Basin

The communities, lands, and peoples of Wyoming's Powder River Basin are not strangers to natural resource development. A longstanding resource dependent region in the U.S. West, the first oil well was drilled in the Basin in 1889 and the Powder River Basin has faced coal, natural gas and oil booms ever since (Storrow 2014). That is why most citizens and policymakers in the PRB were not surprised to learn of the presence of coalbed methane in the area in the late 1990s. However, nothing could adequately prepare the region for what CBM would bring and the lasting impacts that would remain thereafter.

Ten years after the initial boom, the collapse of the dry gas market resulted in resource bust, with steep declines in production. Market changes forced many producers to suspend or minimize production and the reclamation phase of CBM in the PRB began. The reclamation phase is critical to guarantee that the legacy of Powder River Basin CBM production is not permanently destructive to the regional ecosystem and natural environment.

PRB county residents knew that an energy boom was approaching when the county courthouses began teeming with land men who were buying up any remaining mineral leases in the basin that potentially contained CBM reserves. Soon after, the development phase began and approximately 2,500 CBM wells were drilled in the Basin annually through 2008 (Zhorov 2014). During the early phases of development, landowners were approached by industry operators that had purchased the mineral rights for the subsurface material underlying their land. Despite most residents' general familiarity with energy development, CBM had never been extracted in this region on a large scale. Therefore, the intricacies of CBM development and the details of how the gas is extracted from the surface were largely foreign to landowners and local policymakers.

It is critical to grasp the full scope of economic, environmental, political and social impacts to the Powder River Basin from CBM by reflecting on the development and issues concerning reclamation. Lessons learned during and after the Powder River Basin CBM boom can be disseminated to states and local communities facing future energy development. This is particularly beneficial as the states and local communities that host energy development can become overwhelmed by changes, activity, and impacts, especially initially.

Dissertation Overview

This dissertation is organized using the manuscript formatting option. Therefore, four distinct manuscripts comprise the body of the document. Chapter Two articulates the federal and state policies that govern post-production oil and gas using Powder River Basin CBM as a case study and determines that implementation of effective reclamation is a highly complex governance challenge. The manuscript that is Chapter Three examines the historic legacy of resource development in Wyoming and how the split estate property regime in the state contributed to the extent of the reclamation issue. Chapter Four is a published journal article that applies the concept of social license to operate to bring attention to how individual landowners exerted influence over CBM development and reclamation by way of private participation in decision-making processes. Chapter Five addresses how the adaptive, or ‘learn as you go’, approach to policy and governance in Wyoming enabled environmental cost-shifting and resulted in long-term environmental legacy issues. A conclusion synthesizes the findings from the four separate manuscripts, specifies how the work has answered the guiding research question, and provides suggested directions for future research. A complete reference list follows the conclusion and an appendix detailing the methodological approach of grounded theory completes the dissertation.

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CHAPTER TWO

GOVERNING UNCONVENTIONAL LEGACIES: LESSONS FROM THE COALBED METHANE BOOM IN WYOMING

Contribution of Authors and Co-Authors

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Abstract

Surface reclamation is a critical feature in the legacies of unconventional energy development. U.S. legal frameworks are in place to govern reclamation but vary widely by state. While it is too early in the development cycle to assess the status of shale gas legacies, there are instructive case studies that draw attention to the challenges of governing reclamation. This paper explores land reclamation outcomes of the coalbed methane gas boom in the Powder River Basin of Wyoming and the ensuing issue of widespread well abandonment. We argue that the challenges associated with coalbed methane reclamation in the Powder River Basin track closely with what can be expected in the context of shale gas governance. Drawing on an extensive review of scientific literature on reclamation, policy analysis, and stakeholder interviews, we argue and specifically identify three key factors that have interfered with the effective definition, regulation and implementation of coalbed methane reclamation: (1) the absence of clear guidance from the scientific literature about what constitutes successful reclamation; (2) the complexity of both the jurisdictional environment and the oil and gas sector in the coalbed methane space; and (3) a lack of political will in the state of Wyoming to engage in pre-emptive environmental regulation. This paper aims to explore how these factors coalesce to make implementation of effective reclamation a highly complex governance challenge.

Introduction

This chapter brings attention to the complexities of governing post-production oil and gas activities or, in industry terms, the "legacy issues" associated with unconventional oil and gas development in the U.S. context. Legacy issues comprise the safe and thorough decommissioning of wells and pipelines and effective mitigation of environmental and social disruption including reclamation of land and water resources disturbed during production. Although most shale development has not yet entered a post-production phase, coalbed methane development provides an instructive case study in legacy issues. Although coalbed methane does not meet standard geologic criteria for unconventional resources, the pace and scale of development and the extensive infrastructure necessary for development are consistent. This chapter presents a case study of land reclamation following a coalbed methane gas boom in the Powder River Basin of Wyoming. Between 1998 and 2008, at least 16,000 wells were developed in the Powder River Basin (WYOGCC, 2016) – an arid, sparsely populated region characterized by extensive grasslands, livestock production and coal mining. Because coalbed methane development has already gone through the boom-bust cycle and is eight years into the legacy period, this case study offers a series of relevant considerations for shale development landscapes in the United States and Europe.

Specifically, this chapter explains factors that have interfered with the effective definition, regulation and implementation of the reclamation of land and coalbed methane infrastructure in the post-development period in the Powder River Basin. We argue that defining and implementing effective reclamation presents a highly complex governance challenge due to three major factors: the absence of clear guidance from the scientific literature about what constitutes successful reclamation; the complexity of both the jurisdictional environment and the oil and gas sector in the coalbed methane space; and finally, a lack of political will in the state of Wyoming to engage in pre-emptive environmental regulation. The chapter draws on an extensive review of scientific studies that address the definition and measurement of success in reclamation and policy analysis of developing regulatory and governance issues in Wyoming. The chapter is organized as follows: we provide an overview of coalbed methane development in the Powder River Basin and its current legacy challenges, next address briefly the issues of reclamation science, jurisdictional and structural complexity and the Wyoming policy environment in turn. The chapter concludes with a discussion relating governance issues identified in the coalbed methane example to the broader scholarly considerations regarding shale governance.

Background: Coalbed Methane Development in the Powder River Basin

The State of Wyoming ranks among the United States' most important energy producers. Second only to Texas in total energy production, the state has a long history of discovering, drilling and shipping energy resources from its position on the border of the Rocky Mountains and the Central Great Plains to energy hubs and markets. Remote and sparsely populated, Wyoming is one of the last states in the U.S. that remains significantly dependent on natural resource development at least relative to the overall U.S. economy, which has shifted heavily to tertiary and higher industries. An outcome and an indicator of Wyoming's dependence on natural resources is the tight coupling of the state's revenue stream to commodity prices. For example, in 2016, in response to the coal industry downturn, the Wyoming legislature cut funds provided to school districts by $36 million and reduced the budget of the University of Wyoming by $34 million along with making other reductions ("Budget Cuts", 2016).

This boom-bust context is important when considering the dilemmas and complexities surrounding legacy issues in the Powder River Basin. Straddling some 20,000 square miles of semi-arid grasslands used primarily for livestock production in southeast Montana and northeast Wyoming, the Powder River Basin refers both to a hydrological drainage region and a geologic structural formation. The area's huge coal reserves—some 40% of U.S. coal production occurs on massive strip mines in the region—constitute the source of shallow coalbed methane reserves. Following several decades of exploration, the pace of experimentation with coalbed methane development accelerated in the 1990s and the potential to extract methane by dewatering source formations through extensive pumping was discovered. By the late 1990s, the boom was on (Ayers, 2002). Operations quickly intensified and up to 3,655 wells were drilled in the Basin in 2001 alone (Ayers, 2002).

As in some shale regions of the United States, the Powder River Basin features a mosaic of different surface, subsurface and water ownership regimes and a correspondingly diverse group of stakeholders when it comes to regulation and oversight of coalbed methane development. In Wyoming, approximately 11.6 million acres of private land feature a split estate, in which the federal government owns the subsurface minerals ("Split Estate," 2012). Specifically, the Bureau of Land Management (BLM) manages and provides oversight of the federally owned minerals which requires coordination among BLM officials, the surface landowner and industry.

Ten years after the initial boom in the Powder River Basin the collapse of the dry gas market in 2008 resulted in a lasting bust, with steep declines in production. In response, many companies that had been active in the region suspended or reduced production, shifting coalbed methane into a post-production phase. However, the failure or restructuring of many companies involved in coalbed methane development that accompanied the natural gas bust has left the state of Wyoming and other stakeholders "holding the bag" when it comes to long-term reclamation of disturbed land and the safe and prudent abandonment of wells and other infrastructure.[1] Four thousand orphaned wells remain on farms and ranches in Wyoming in 2016 ("Orphan Well Program", 2016). Surface reclamation of these wells is especially problematic given the region's semi-arid grassland land cover. Nasen et al. (2011) found that in the grasslands of Saskatchewan, natural gas lease sites established in the 1950s show, "no significant improvements in terms of ground cover, species diversity and range health" (p. 203). The authors attribute this to poor impact mitigation strategies and reclamation practices in the study area and state, "the findings of this study indicate that lease sites left abandoned and/or suspended are not returning to a vegetation composition reflective of a healthy, native prairie" (p. 203). This is troubling in light of the extensive scale of surface disturbance by oil and gas activity in the period since 2000 (Allred et al., 2015) and emphasizes the need for a

[1] Orphaned refers to wells without a responsible operator. Orphaned wells emerge when the companies that drill and or operate the wells go out of business at the regional or national scale and are therefore unable to continue overseeing the well. Abandoned is a broader term that includes any wells that have ceased to produce and are no longer actively managed.

deliberate plan for surface reclamation as unassisted recovery is unlikely. In Wyoming, neither the state nor federal regulators has inventoried the status of land reclamation efforts, and it stands to reason that where wells are orphaned, so too are reclamation efforts.

Surface Reclamation after Natural Gas Development as a Multi-Dimensional Governance Challenge

In the following discussion, we outline the key factors contributing to the failure of surface reclamation of natural gas production sites in Wyoming: the ambiguity of reclamation science; jurisdictional complexity and Wyoming's political context. Our exploration of the consensus—or lack thereof—about what constitutes effective surface reclamation took the form of an in-depth review of the literature in ecological and environmental science journals.

Reclamation Success in the Scientific Literature

Post-production reclamation of the Powder River Basin's coalbed methane legacies is an enormous undertaking due to the scale of the development and the harsh physical environment characterizing the region. Coalbed methane production in this remote, arid region involved the construction not only of thousands of wells, but also of thousands of miles of roads, power lines, pipelines and hundreds of water impoundments. Along the way, thousands of acres of surface vegetation and soil were disturbed. It stands to reason that successful reclamation would remove or permanently ensure the safety and integrity of the pipelines, wells, roadways and other industrial infrastructure on the landscape and at the same time, would attempt to repair the effects of development on soils and surface vegetation. Regulation would in theory focus on documented success in achieving these goals.

However, measuring and documenting reclamation success turns out to be less than straightforward in scientific practice. Indeed, the very concept of defining reclamation “success” has been criticized by reclamation scientists as problematic (Suding, 2011; Zedler, 2007). Suding (2011) argues that the term success has come under fire due to the general ambiguity surrounding the criteria used to measure success, inadequate project monitoring, and limited data availability. Common methods and standards to assess success have not been established. Without explicit criteria to measure success, the language, project outcomes and implications for policy remain unclear.

Measuring success in studies of restoration science largely consists of assessing technical measures (Ruiz-Jaen & Aide, 2005a; Wortley et al., 2013). Wortley et al. (2013) conducted a comprehensive review of 301 articles on land-based restoration published from 2008-2012 across 71 journals to determine how restoration success is being measured. The authors found that ecological attributes (diversity and abundance, vegetation structure, and ecological functioning) were most often used (94%) as opposed to economic and social attributes like community engagement or job creation (3.5%). The Society for Ecological Restoration (SER), an international scientific society, suggests six metrics of restoration success (Table 2.1), where the metric is an ecological attribute that can be measured directly or indirectly. SER asserts that “success” involves continued progress toward target goals as demonstrated by some combination of the six attributes. Although the metrics of successful reclamation used by the SER are comprehensive, they are not easily adaptable to policy and accompanying regulations which often require measurements followed by a determination of project success. Moreover, ecosystem restoration is a time-intensive process. It is not within the scope of most restoration projects to extend their timeframe to allow for full ecosystem recovery, especially considering that unforeseen weather events and pest outbreaks, for example, can delay rehabilitation (Holl & Howarth, 2000). Therefore, measures of success that are promoted by the scientific community may not easily translate to policy.

1	Absence of threats
2	Physical conditions
3	Species composition
4	Structural diversity
5	Ecosystem functionality
6	External exchanges/connectivity

Table 2.1. SER's Six Attributes of a Successfully Restored Ecosystem (*Source*: SER, 2016).

Moreover, while restoration science has made progress in making its findings relevant to practitioners, the field struggles to provide clear guidance to policy processes. While there has been a growing body of knowledge that links the work of restoration theory to the practice of reclamation practitioners in the field, the same cannot be said for decision-makers. When Aronson et al. (2010) reviewed literature published from 2000-2008 in *Restoration Ecology* and twelve scientific journals, 1,582 peer-reviewed articles, it was found that 80% of papers did not address policy impacts or implications of the restoration effort. Without clear language directed at a policy audience, knowledge originating in the scientific community will not translate to decision-makers.

To increase the likelihood of project success and make restoration science more legible for policymakers, Suding (2011) recommends implementation of evidence-based assessments in restoration science to evaluate the effectiveness of particular restoration techniques. In addition, other studies suggest using reference sites, or sites of comparison, to add rigor to evaluations of restoration success (Choi, 2004; Ruiz-Jaen & Aide, 2005a; Ruiz-Jaen & Aide, 2005b; Wortley et al., 2013). According to the SER (2004), "the reference represents a point of advanced development that lies somewhere along the intended trajectory of the restoration" (5). In addition, historic baselines as a reclamation end goal have been critiqued since ecosystems can shift rapidly based on local conditions and changing climate, making historic targets unrealistic and reclamation success unlikely (Choi, 2004; Hobbs, 2007; Suding, 2011; Zedler et al., 2012). Instead, Choi (2004) champions the acceptance of a futuristic, as opposed to historic, paradigm in restoration (Figure 2.1), where the futuristic approach rejects evaluation based on historic conditions.

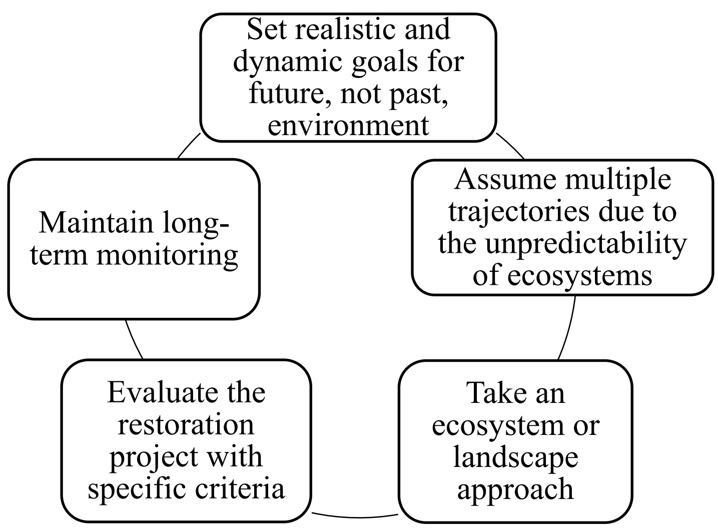

Figure 2.1. Choi's (2004) Futuristic Restoration

Similarly, Zedler et al. (2012) argue for the implementation of long-term adaptive restoration acknowledging that restoring lands to their pre-disturbed state may not be attainable. In this framework, restoration practitioners can begin their efforts as long-term experiments, "aiming for historical targets and gradually ruling out those that can no longer be achieved…as assessments indicate the objectives that are unachievable, more realistic targets would be adopted and new experiments might begin" (38). By doing so, time and money can be saved by allowing restoration practitioners to adjust efforts, based on precise objectives, to more suitable areas. This framework is especially relevant to unconventional oil and gas restoration since this body of knowledge is just emerging and adaptive restoration facilitates a 'learn as you go' mentality.

To mitigate common barriers to restoration project success, Geist and Galatowitsch (1999) champion a reciprocal, participatory model predicated on understanding how humans and nature can mutually benefit from restoration. The authors suggest that their "model shows human contributions aimed at addressing the needs of a given restoration area. As the restoration process progresses, the area itself may provide contributions to the needs of humans. As human needs are met, more contributions to the restoration area are possible" (974). Geist and Galatowitsch (1999) believe the best way of accomplishing this is through engagement and participation among local community members in the planning, implementation and monitoring of ecological restoration.

Restoration science provides ample guidelines for increasing the likelihood of restoration project success, but challenges emerge regarding the ways this science is shared. According to the literature, a positive reclamation outcome will likely be reached when a futuristic approach guides projects, clear project objectives are outlined at the outset, reference sites are used and technical as well as socioeconomic measures are considered. However, these conclusions have largely failed to translate into policy due to the absence of policy language in scientific studies and other related factors. This problem is well illustrated by the complexities involved in the governance of coalbed methane reclamation in the Powder River Basin of Wyoming.

Jurisdictional and Structural Complexity

Two primary sources of complexity exist in the regulatory space around surface reclamation of unconventional oil and gas development: the complicated jurisdictional and ownership regimes of land and minerals and the structure of the upstream oil and gas industry. Both sources complicate the reclamation of wells and infrastructure by necessitating the involvement of a complex ensemble of stakeholders (Figure 2.2), with industry stakeholders changing frequently as employees cycle through the landscape and with corporate restructuring and ownership change.

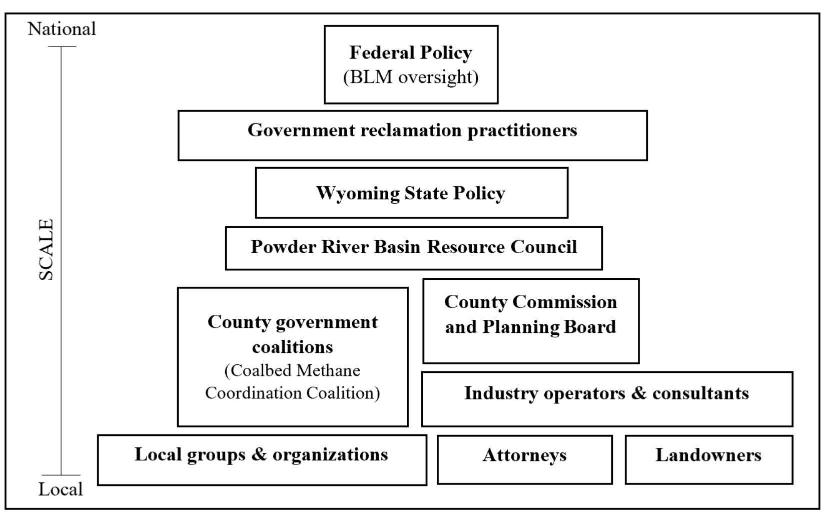

Figure 2.2. Actors Contributing to Reclamation Outcomes in the Powder River Basin, WY

As an example of this complexity, in Wyoming the regulatory environment for reclamation differs based on who owns the land (or minerals) that requires reclamation. Reclamation of public, federally owned land (or minerals) is carried out by the Bureau of Land Management (BLM). Conversely, the states are responsible for reclamation on privately owned land within their boundaries. The criteria for what constitutes reclamation success varies between the federal government and states and also from state-to-state. According to the BLM *Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development*, or the Gold Book:

> Reclamation generally can be judged successful when a self-sustaining, vigorous, diverse, native (or otherwise approved) plant community is established on the site, with a density sufficient to control erosion and non-native plant invasion and to re-establish wildlife habitat or forage production…The site must be free of State- or county-listed noxious weeds, oil field debris, contaminated soil, and equipment (43-44).

For lands administered by the state, standards for evaluating reclamation success are vague in comparison to the federal guidelines. According to Wyoming Statute 30-5-401, "Reclamation means the restoring of the surface directly affected by oil and gas operations, as closely as reasonably practicable, to the condition that existed prior to oil and gas operations, or as otherwise agreed to in writing by the oil and gas operator and the surface owner." Clearly federal standards are most robust requiring revegetation, erosion control, and removal of all noxious weeds, contaminated soils, and remaining oil and gas equipment. Wyoming state requirements are not as stringent and less up to date with current literature. Wyoming standards require that the land be restored to the condition that existed prior to oil and gas development. However, it has been acknowledged that restoring to historic targets is often not feasible (Choi, 2004; Hobbs, 2007; Suding, 2011).

Exacerbating this administrative heterogeneity is discrepancies among the ten BLM regional field offices in Wyoming. Curran (2014) compared the reclamation criteria of the Wyoming BLM field offices and found that each office operates using different criteria to assess reclamation success. The most comprehensive criteria include measures of percent vegetative cover, erosion control, weeds, grass, forbs, shrubs and plant vigor while the least comprehensive only consider percent vegetative cover and erosion control. This variation creates confusion for industry players with operators in multiple BLM jurisdictions. In addition, as written, assessing the degree to which vegetation stabilizes soils is subjective and misaligned with recommendations from the literature that promote the use of evidence-based assessments when judging reclamation success (Suding, 2011).

Mirroring the jurisdictional challenges that are a byproduct of the BLM's structure in Wyoming, policy approaches to implementing reclamation vary across and even within administrative scales. The backbone of federal and state reclamation policy is environmental assurance bonding. Bonding theoretically ensures implementation of reclamation through the following process: Prior to drilling, in the permitting phase, operators must pay a bond to be released after development is completed and a checklist of reclamation activities have taken place. Blanket bonding, a practice that allows operators drilling multiple wells within one state to pay a single bond to cover all wells within the state, amounts are far lower than if each well was bonded individually but, theoretically, adequate to cover the risk of a small number of abandonments. Bonds rely on reputation effects and provide incentive for companies to complete final reclamation as opposed to walking away leaving an orphaned well and the reclamation to the state (Gerard, 2000). Table 2.2 displays the bonding structure imposed by the federal government while Table 2.3 shows the environmental bond requirements for the State of Wyoming. Consider that for multiple wells drilled on private land by one industry company in Wyoming, a bond of $100,000 would be required while the same scenario on public land would only require a bond of $25,000.

Bond Type	Bond Amount
Individual lease bond	$10,000
Statewide (blanket) bond	$25,000
Nationwide (blanket) bond	$150,000

Table 2.2. Federal Bond Requirements for Onshore Oil & Gas Production Sites (*Source*: U.S. GAO)

Bond Type	Bond Amount
Individual well	$10 per foot of depth
Multiple wells (blanket bond)	$100,000

Table 2.3. State of Wyoming Environmental Bonding System, effective February 1, 2016. Wyoming's previous bonding system discussed in Section 2.3. (*Source*: Storrow, 2015)

Shortcomings of the environmental bonding system are well documented in the literature (Andersen et al., 2009; Holl & Howarth, 2000; Igarashi et al., 2014; Mitchell & Casman, 2011). Bond amounts are commonly critiqued as being far too low (Andersen et al., 2009; Holl & Howarth, 2000; Igarashi et al., 2014; Mitchell & Casman, 2011). Andersen et al. (2009) found that for orphaned natural gas wells in Wyoming between

1997-2007, there was a difference of $22,253 in the bond amount paid per well and the actual cost of reclamation. Furthermore, companies can decide to forfeit the bond if the cost of reclamation is higher than the bond posted, which it often is, and instead walk away (Holl & Howarth, 2000; Igarashi et al., 2014). Conversely, if the bond is too high, industry capital can be tied up limiting future investment (Gerard, 2000).

Wyoming offers a case study in the problem of setting bond amounts too low in an uncertain market environment. In the Powder River Basin alone, there are at least 3,000 orphaned coalbed methane wells that require reclamation by the State of Wyoming (Bleizeffer, 2015). Encouragingly, the Wyoming Oil and Gas Conservation Commission (WYOGCC) has plugged and reclaimed 1,018 orphaned wells since 2014 using funds collected from industry operators through taxation and bonding in a systematic well plugging and clean-up program spearheaded by Wyoming Governor Matt Mead in 2013 (WYOGCC, 2016a). From 2004-2013, the state had only cleaned up 183 orphaned wells (Storrow, 2013). However, despite state efforts, the number of orphaned wells continues to outpace the amount reclaimed. The circumstances leading to the orphaned well crisis reinforce the governance challenges presented by the characteristics of the shale development industry in the United States.

Approximately 130 industry companies operated in the Powder River Basin at the peak of coalbed methane development. Industry operators came from all over the country including Colorado, Texas, Illinois, Utah, Oklahoma, Michigan, Montana, Alabama, New Mexico and, of course, Wyoming. When coalbed methane development was expanding, large, established companies like Marathon Oil, Fidelity Exploration and Production Co.

and Peabody Natural Gas dominated the production landscape. As profitability waned in a poor price environment, the larger industry companies began selling their mineral holdings to smaller operators. The smaller operators lacked adequate capital to conduct reclamation, and worse, to avoid bankruptcy. The result has been a high number of bankrupt companies that left behind thousands of orphaned natural gas wells across the Basin. With landowners first out of the loop on the change of title of mineral rights and later unable to reach companies involved in bankruptcy proceedings, the chain of communication between surface owner and entities responsible for surface reclamation has been completely broken.

Wyoming Policy Environment

A lack of political will in the state of Wyoming to engage in pre-emptive environmental regulation has contributed to the governance challenge concerning unconventional oil and gas reclamation. In 2007, mineral development in Wyoming produced $14 billion in revenue through the collection of severance taxes from industry, more than any other means of state revenue generation (Cook, 2014). As a result, the Wyoming regulatory environment has been long subject to industry capture: for example, in the 1980s the oil and gas sector successfully obtained an exemption to the state's relatively progressive Industrial Siting Act (Haggerty and McBride 2016). The state of Wyoming created regulations ahead of federal regulators including those that concern pre-fracking disclosure requirements, chemical identification requirements and trade secret exemptions, at the direction of former democratic Governor Dave Freudenthal. However, this was only done to, "preempt federal regulators on this [fracking] to maintain state control over this policy area" (Cook, 2014, 107). The intentions here were to pre-emptively ensure state control of Wyoming's growing fracking industry.

Despite the legislature's pattern of reluctance to engage in regulation, some issues have turned into crises that require response. Such was the nature of the orphaned well issue. After the discovery that the state was on the hook for some 4,000 orphaned wells to the cost of at least $125 million, the Wyoming Oil and Gas Conservation Commission (WYOGCC) voted unanimously to update the state's bonding structure effective February 1, 2016 ("Rule Changes", 2015). The former rules required a bond of $10,000 for individual wells less than 2,000 feet, and $20,000 for wells greater than 2,000 feet in depth. The updated rules responded to economic analysis of real reclamation costs to arrive at a new a bond rate of $10 per foot for all individual wells which can be adjusted after three years to account for actual plugging costs and inflation. Blanket bonds were increased from $75,000 to $100,000 (Storrow, 2015). This improvement, though a sign of progress, was enacted long after it can have any impact on coalbed methane reclamation activities. Furthermore, some policy analysts doubt that the increased blanket bond amounts will suffice specifically when considering the scale of extensive horizontal drilling (Storrow, 2015).

Discussion

The legacy challenges present in the Wyoming coalbed methane landscapes—thousands of orphaned wells, permanently degraded surface vegetation and largely abandoned water management infrastructure—are clearly a scenario to be avoided at future development sites. The political environment in Wyoming created distinct barriers to effective regulation of the coalbed methane infrastructure. All the same, the coalbed methane legacy crisis in Wyoming highlights some of the inherent features of unconventional oil and gas development that create enormous difficulties from a policy standpoint. These characteristics merit attention as international policy making forums undertake strategic environmental assessments to inform the development of novel policy.

The greatest challenge from a legacy management standpoint in coalbed methane is a familiar one for shale development in the United States: the sheer intensity of infrastructure and the number of players involved in its installation, maintenance and ultimate decommissioning. Even the most robust regulatory framework would be hard pressed to accommodate the basic administrative task of managing the huge number of actors and the great number of facilities in this upstream development space. The turnover and cycling in ownership and associated reclamation obligations after the bust greatly exacerbated the challenges of overseeing and enforcing existing regulations to the point of a major policy failure.

The case of abandoned coalbed methane infrastructure and failed reclamation also points to the need for capacity in the form of funding and technologies to accomplish clean up—and contingency plans for accomplishing that clean up in the event of major changes in the economic and market environment. It's clear that bond amounts must be adequate to cover the actual cost of reclamation activities. Without this policy-driven protection, the host state and taxpayers can be left to fund clean-up effort.

A potential solution to the problem of effective oversight of a sprawling infrastructure and enforcement across a diverse field of players and stakeholders is coordination and capacity building. Here industry has the potential to be a strong ally, as companies typically hold superior technical and institutional capacities for monitoring and inventorying assets than do state or federal agencies. However, in the U.S., the proprietary nature of corporate assets often halts any effort to use the knowledge base of industry for the benefit of effective regulation. Whatever the role of private industry, the necessity to build capacity on the part of regulatory agencies cannot be overstated—their technological, administrative and enforcement capacities have to grow before they are outpaced by rapid development and have to remain in place after development slows. Here again, smart technology has the potential to provide important capacity through monitoring networks using tools such as remote sensing.

Coordination to provide effective legacy management proves complicated due to jurisdictional fragmentation, a known problem for shale management in the United States and abroad (Cook, 2014; Kulander, 2013; Rabe, 2014; Warner & Shapiro, 2013; Zirogiannis et al., 2016). The vast differences in shale gas regulation from state-to-state (Rabe, 2014; Warner & Shapiro, 2013; Zirogiannis et al., 2016) as well as tension and competition between state and local governments for autonomy and authority (Davis, 2014) all work as obstacles to coordinated legacy management.

The related lack of consistency and outdated nature of some of the reclamation standards also speak to the fundamental challenge of simply defining reclamation and establishing the metrics necessary to monitor its progress. However, recent literature offers policy strategies to accommodate the inherent complexities of reclamation (Igarashi et al., 2014; Mitchell & Casman 2011). For reclamation on federal lands, the U.S. BLM recently shifted to an approach governed by maximum allowable disturbed acreage meaning, “a firm has to do a sufficient amount of reclamation on currently disturbed lands to qualify for developing wells in other areas” (Igarashi et al., 2014, p. 7). In effect this is a form of adaptive restoration, a framework championed by Zedler (2012) that necessitates strong project management and regular monitoring. By mandating reclamation throughout the course of the project, restoration techniques can be assessed and modified as needed. Igarashi et al. (2014) illustrate through economic modeling that completing interim reclamation throughout the lifespan of the well decreases terminal reclamation costs after production ceases. Moreover, Chenoweth et al. (2010) compare the costs associated with unsuccessful reclamation of oil and gas production sites to instances when reclamation is completed successfully in its first attempt and found that, “reclamation failures can result in a 50% cost increase over initiating proper reclamation techniques from project implementation” (Chenoweth et al., 2010, 13). Still, all of these strategies hinge on investment in robust monitoring and implementation capacities, ideally in public-private partnerships that leverage existing technologies and knowledge.

Conclusion

In the Powder River Basin of Wyoming, coalbed methane development was rapid and intense, all the while operating without the necessary policy-driven protections for landowners, the community and the environment. The result is a landscape littered with orphaned wells that state funds must pay to reclaim. Countless landowners face the challenge of ranching and carrying out daily activities on un-reclaimed land without any certainty of when restoration will take place. Landowners have had to turn to other authorities for information and assistance, including the local resource council and county government coalition. Whilst filling an important niche, the state should adopt a more proactive approach by drafting deliberate and comprehensive reclamation policy and providing the means for adequate enforcement. This is challenging in a state like Wyoming where revenues and the oil and gas industry are tightly coupled. The findings of this case study are closely related to what can be expected regarding the legacy of shale gas production. To avoid delayed restoration and destructive legacy issues, revision of state and federal reclamation policy is needed to prevent the proliferation of orphaned wells in shale basins and the resulting financial burden on host communities and taxpayers.

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CHAPTER THREE

SPLIT ESTATE AND WYOMING'S ORPHANED WELL CRISIS: THE CASE OF COALBED METHANE RECLAMATION IN THE POWDER RIVER BASIN, WYOMING

<u>Contribution of Authors and Co-Authors</u>

Manuscript in Chapter 3

Author: Kathryn Bills Walsh

Contributions: Conceived the study, performed the research and analyses, interpreted results, and wrote the manuscript.

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Abstract

This case presents the stakeholder conflicts that emerge during the development and subsequent reclamation of abandoned natural gas wells in Wyoming where split estate, or the separation of surface land and mineral rights from one another, occurs. From 1998-2008 the Powder River Basin of northeastern Wyoming experienced an energy boom as a result of technological innovation that enabled the extraction of coalbed methane (CBM). The boom resulted in over 16,000 wells being drilled in this 20,000 square-mile region in a single decade. As of May 2017, 4,149 natural gas wells now sit orphaned in Wyoming as a result of industry bankruptcy and abandonment. The current orphaned wells crisis was partially enabled by the patchwork of surface and mineral ownership in Wyoming that is a result of a legal condition referred to as split estate. As the coalbed methane boom unfolded in this landscape and then began to wane, challenges emerged most notably surrounding stalled reclamation activities. This case illuminates these challenges highlighting two instances when split estate contributed to issues between landowners and industry operators which escalated to litigation.

Introduction

The U.S. West has long been host to a variety of extractive industries. The mainstay of many local Western economies, the extractive industry relies on access to subsurface minerals for production. Across the West, minerals are owned by a variety of entities including the Federal Government, the host State Government, and private individuals. Coupled with the patchwork of public- and privately-owned surface land, the mosaic of surface land and underlying mineral ownership is increasingly complex. Therefore, it is germane to ask, how have we arrived at such a complicated land and mineral ownership regime in the U.S. West and what are the present-day implication of such a regime in the context of energy development?

To answer this research question, a case study of the Powder River Basin, Wyoming will be presented. The Powder River Basin is a worthy case study site for three key reasons: (1) the pattern of surface and mineral ownership is extraordinarily complex (Figure 3.1); (2) as a region in the U.S. West, the area was impacted by a variety of legislative measures that were consequential to the current mosaic of surface and mineral ownership; and (3) the completion of reclamation activities following a recent coalbed methane (CBM) boom have been complicated by split estate ownership. It is worth investigating how we have arrived at the current ownership pattern because it has present-day implications for landowners in the region.

Case Examination

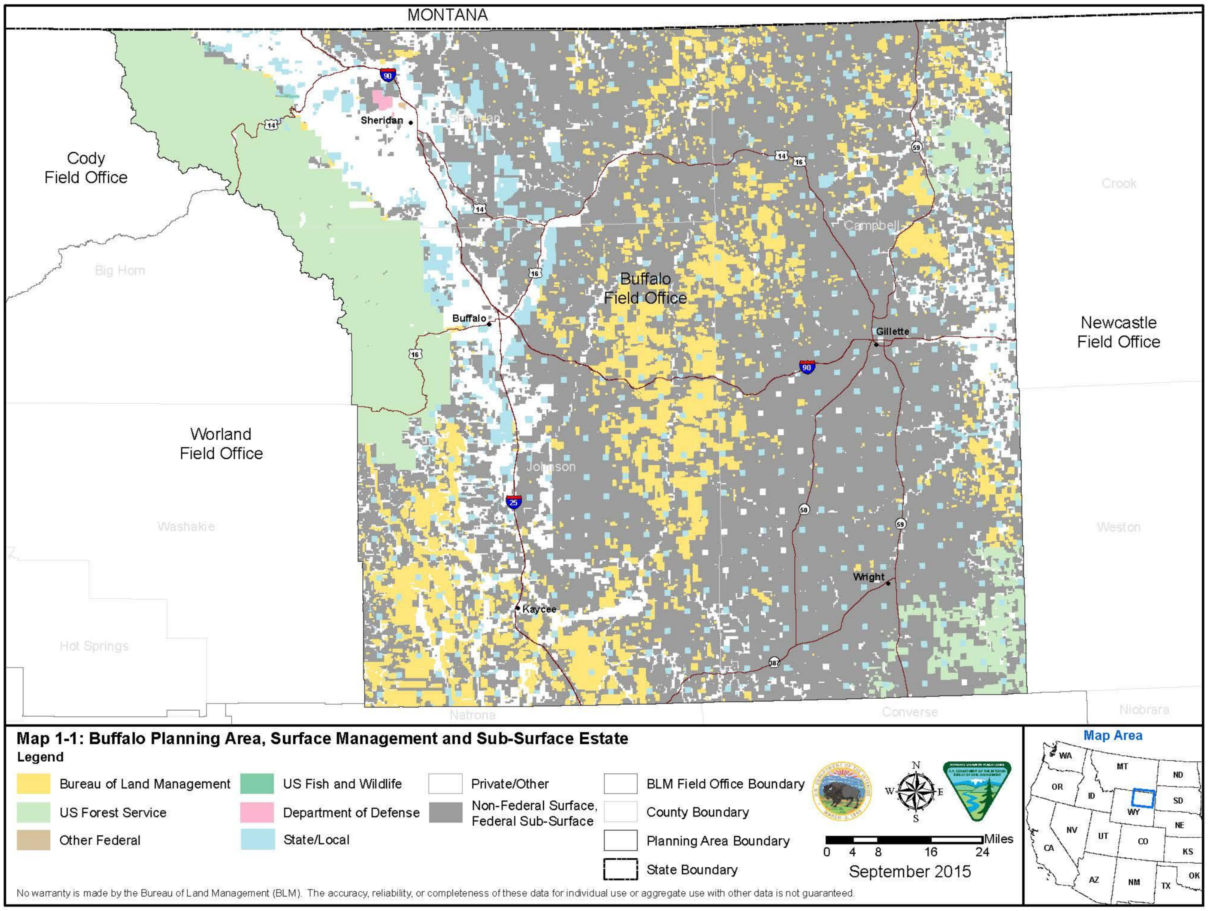

Figure 3.1. Land and mineral ownership pattern in three Powder River Basin counties. *Note*: Split estate lands in grey (Source: Bureau of Land Management, Buffalo Field Office ARMP, 2015)

General Definitions of Core Concepts: The Origins of Split Estate

The Homestead Act of 1862 was one of the most revolutionary modes of public land distribution in American history. Signed into law by President Abraham Lincoln, the Homestead Act of 1862 allowed American citizens, that were head of household and at least 21 years old, to apply for a 160-acre homestead at their local land office. The conditions of the Act required the citizen to reside on the land, build a home, make improvements to the land, and actively farm for five years before being granted possession of the land [1]. The scale and spatial extent of the Homestead Act was vast. Ten percent of U.S. land area was given away under the Homestead Act [1], and in Wyoming, 29% of total land area was distributed as homesteads [2]. Specifically, in the Powder River Basin, over 5,966 land patents were granted as a result of the 1862 Homestead Act [3]. Of particular importance is the fact that this Act, upon meeting the conditions after five years, granted ownership of the surface land *and* the underlying minerals to the homesteader. The result was a proliferation of privately-owned minerals and lands as opposed to those owned publically by the Federal Government or the State.

The Stock Raising Homestead Act (SRHA) of 1916 was signed into law by President Woodrow Wilson in 1916, and granted homesteads of 640-acres for livestock production. The homesteads contained non-irrigable land unsuitable for cultivation. Therefore, in order to be granted possession of the land after five years, the homesteader was required to carry out rangeland improvements amounting to $1.25 an acre [4] as opposed to agricultural cultivation [5]. In the semi-arid Powder River Basin, the environment was conducive to stock raising and at least 4,787 homesteads were granted under this Act [3]. The SRHA's predecessor, the 1862 Homestead Act, distributed surface land and minerals together (as did the 1909 Enlarged Homestead Act, although the parcels were larger in area). The defining feature of the SRHA was that the subsurface minerals were no longer granted to the homesteader and were instead reserved for the Federal Government. The language of the law specifically states, "Excepting and reserving, however, to the United States all the coal and other minerals in the lands so entered and patented, together with the right to prospect for, mine, and remove the same pursuant to the provisions and limitations of the Act of December 29, 1916 (39 Stat., 862)" [3]. In other words, the SRHA stated that the minerals must be reserved for the Federal Government. This resulted in a legal condition referred to as split estate. Split estate occurs when the surface land and subsurface minerals are owned separately by two different parties [6]. In the case of the SRHA, the surface was owned privately but the minerals were property of the Federal Government.

Traditionally, surface landowners have often been dissatisfied with the, "perceived imbalance of power that mineral owners have over surface owners/users" [7, p.417]. In part this stems from the fact that surface owners are required by law to grant land access to prospectors and federal agents for the purpose of mining and mineral recovery [8]. A provision of the SRHA states:

> Any person qualified to locate and enter the coal or other mineral deposits, or having the right to mine and remove the same under the laws of the United States, shall have the right at all times to enter upon the lands entered or patented, as provided. By this subchapter, for the purpose of prospecting for coal or other mineral therein, provided he shall not injure, damage, or destroy the permanent improvements of the entryman or patentee, and shall be liable to and shall compensate the entryman or patentee for all damages to crops on such land by reason of such prospecting.

Despite these provisions that require compensation to the surface owner if degradation were to occur, conflicts between surface landowners and mineral owners happen and occasionally escalate to litigation. The case study of CBM development in the Powder River Basin helps to illustrate these concepts.

Case Background: Coalbed Methane Development in the Powder River Basin, Wyoming

The Powder River Basin (PRB) is located in northeast/central Wyoming and extends northward into southeast Montana. Within Wyoming, the PRB encompasses all of Campbell County and parts of Sheridan, Johnson, Converse, Crook, Weston, and Niobrara counties. The Yellowstone River lies to the north, the Laramie and Casper Mountains make up the Basin's southern boundary, and the Big Horn Mountains are to the west [9]. Covering roughly 20,000 square miles of semi-arid grasslands used primarily for livestock production, the region experienced rapid and intensive CBM development from 1998-2008. Approximately 2,500 CBM wells were drilled in the Basin annually through 2008 [10]. After the economic downturn and subsequent decline in the natural gas market, some 4,149 orphaned gas wells remain on farms and ranches in Wyoming [11], along with considerable uncertainty about who will take responsibility for well and land reclamation. According to the Wyoming Oil and Gas Conservation Commission, orphaned refers to, "wells for which the agency is unable to require the responsible party (owner or operator) to plug and abandon them and rehabilitate the surface because the responsible party no longer operates in the state, is bankrupt, or out-of-business" [12]. A State well plugging program does exist, but the rate at which wells become orphaned outpaces the rate at which the state can plug wells. Plugging the well, "prevents potential discharge of water, oil or gas from the well bore and ensures these fluids stay within their proper formations" [12]. Moreover, the state only plugs and abandons the well and does no additional surface reclamation.

The post-production, reclamation phase is critical to guarantee that the legacy of CBM production is not destructive to the regional ecosystem and natural environment. Some environmental concerns related to CBM activities are directly related to the process of CBM extraction. According to Nghiem et al. (2011), "The extraction of CBM involves the reduction of pore pressure by pumping the water from the deep confined aquifer above and within the coal seams to the surface, allowing the methane gas to desorb from the coal" [13, p.317]. In other words, water needs to be removed from the coal seam to reduce the pressure underground. Once the pressure is reduced, the methane gas is free to escape (see diagram in slides). The depressurization process mobilizes underground water, called produced water, to the surface, which is often salt-rich. Produced water may be reinjected, treated, used in livestock operations, stored in reservoirs, used for irrigation or dust control, or removed from the site. The contents and quality of the produced water dictate how it is managed.

In the U.S. West, water from CBM development is most often discharged into surface reservoirs or reinjected underground [13]. Surface discharge of produced water has prompted some research regarding potential ecological impacts [14, 15, 9]. First, during peak extraction, each CBM well produces approximately 40.32 million gallons of water pumped to the surface per day [16]. Unsurprisingly, Schneider (2001) found that CBM development was responsible for lowering water levels in aquifers, contamination of surface waters, disruption of surface hydrology, and soil erosion [17]. Horpestad (2001) revealed that discharge waters have increased the amount of total dissolved solids in nearby soils which can reduce plant's capacity for nutrient uptake [14]. Lastly, Stearns et al. (2005) found that soils exposed to CBM discharge waters have increased sodium content [9]. This allows salt tolerant species to flourish, “making it easier for them to invade and outcompete native vegetation” [9, p.35]. These ecological impacts are especially concerning considering the reliance on agricultural activities in the Basin.

The reclamation issue is further complicated by surface and subsurface ownership regulations in the area resulting from split estate. The rural nature of the PRB requires the initiation of infrastructure projects during CBM development. To access remote well locations, the construction of roads and utilities, including power lines, subsurface water infrastructure, and compressor stations, are required (Figure 3.2). During these construction activities, topsoil is removed, vegetation is lost, water and electrical infrastructure is buried 4-6 feet underground, roads are constructed, local hydrology is changed, and reservoirs are built (Figure 3.3). Theoretically, reclamation is intended to correct these disturbances post-production. Ecological restoration is beneficial for nature and society as projects increase the supply and quality of ecosystem services, improve hydrology, reduce soil erosion, encourage the presence of native species, and aid in carbon sequestration [17].

Figure 3.2. Un-reclaimed compressor station, Sheridan County, WY (Source: author)

Figure 3.3. CBM produced water reservoir, Sheridan County, WY (Source: author)

<u>Mandatory Access to Subsurface Minerals</u>

The contemporary measure used to help landowners dictate how the surface can be used for access, and to hold mineral developers accountable for any land degradation resulting from their activities, is a legal contract called a Surface Use and Damage Agreement (SUDA). Specifications regarding how the development and subsequent reclamation will be carried out is detailed in the SUDA including points of access, infrastructure placement and restoration of the surface after extraction ends, among others. Traditionally, surface owners were only compensated when there was documented damage to the surface land by the mineral developer. The nature of contemporary energy development, which requires construction of various infrastructure, poses new challenges for surface landowners with mineral development on their property. To help address these emerging issues, the State of Wyoming passed the Split Estates Act on July 1, 2005. The Act requires the mineral owner compensate the surface owner for access and, "loss of production and income, loss of land value and loss of value of improvements caused by oil and gas operations" [8, p.2]. Despite the passage of the Act, there is question as to whether the State laws apply to federally owned minerals. Wyoming legislators insist that, in fact, they do. Although this legislation may have helped to avoid some disputes between landowners and industry operators, other conflicts did arise that led to litigation (Paxton Resources L.L.C. v. Brannaman 2004; Pennaco Energy, Inc. v. Sorenson 2016).

Examples of Litigation

As mentioned previously, the mosaic of surface and mineral ownership has impact on the citizens of the Powder River Basin. Residents live among and not separate from this ownership pattern. These land and mineral divisions inform the activities of the citizens and, on the ground, cannot be ignored. Moreover, some surface owners have been negatively affected by split estate. The legal case of Pennaco Energy, Inc. v. Sorenson illustrates the problems that can arise from split estate and the legal obstacles that must be overcome in search for resolution.

Brett Sorenson, the plaintiff, sued Pennaco Energy, Inc. in late 2015 for unpaid surface damage and use payments and for damages resulting from the failure to repair water wells and reclaim land. Sorenson is a ranch-owner in Arvada, Wyoming, located in the southeast corner of Sheridan County. In the 1990s, Pennaco Energy obtained mineral leases underlying Sorenson's ranch. Pennaco Energy was one of eight mineral holders, including the State of Wyoming, that had rights to subsurface minerals beneath Sorenson's ranchland. This fact alone illustrates the complexity inherent in such a complicated surface and mineral ownership regime. When Pennaco Energy obtained mineral leases underlying Sorenson's land, the two parties entered into a SUDA. Pennaco then drilled 10 CBM wells and constructed 5.67 miles of road and 4.19 miles of pipeline. Pennaco honored the surface use contract until 2010 when the company sold its interest in the leases beneath Sorenson's ranch and the rights in the SUDA to CEP-M which immediately assigned the interests to another company, High Plains Gas. After this transaction, Sorenson stopped receiving all payments and no reclamation was completed [18].

In the years following, Sorenson was motivated to litigate against Pennaco Energy for abandoning its liabilities. The District Court found Pennaco Energy guilty and awarded Sorenson $1,055,982.62 for: (1) unpaid annual surface payments; (2) costs related to reclamation; and (3) costs to replace a damaged artesian spring. Sorenson was awarded an additional $311,478.13 in attorney fees, as well. Pennaco Energy was found culpable because there was no exculpatory clause included in the SUDA. An exculpatory clause is described as follows:

> Absent an express clause that terminates its obligations, the original lessee-assignor will continue to be responsible to the lessor for covenants in the

> lease under the doctrine of privity of contract. Many oil and gases leases contain clauses eliminating contractual liability of this nature, but some do not. Where they do not, the courts are nearly universal in their finding that the original lessee-assignor retains obligation to the lessor with respect to at least some of the covenants under the lease [18, p.8].

It stands to reason that Sorenson was successful in large part due to the representation he was able to secure. Sorenson's attorneys from Yonkee & Toner, LLP in Sheridan, Wyoming chose to represent him using a contingent fee contract. Yonkee & Toner, LLP agreed to represent Sorenson but their compensation was contingent on the case being won. Agreements like this take place occasionally but not often, as attorneys must be willing to work within such an arrangement. This brings to light the question of landowner range of choice when they feel industry operators are not upholding their contractual obligations. Litigating is contingent on the landowner having the means to endure such a process, financially, emotionally and otherwise, or securing an attorney willing to work within a contingent fee contract. Other ranchers are likely in similar situations, faced with uncertain land reclamation and limited financial resources to secure an attorney to litigate against industry operators. For this reason, the Sorenson case is much more of the exception than the rule. There are a handful of other exceptions, in the form of legal cases, that make clear the impacts split estate can have on surface landowners.

One such exception is the case of Paxton Resources, L.L.C vs. Dan M. "Buck" Brannaman and Mary C. Brannaman. In November 1999, the Brannaman's and Paxton Resources entered into a SUDA as Paxton had the rights to the minerals underlying their ranch east of Sheridan, Wyoming. At that time the Brannaman's had no mineral holdings.

Four years after the SUDA was drafted, in 2003, the Brannaman's brought a lawsuit against Paxton for damages to their property and lost income. The case was heard in the 4th Judicial District Court of Wyoming. The Brannaman's alleged that Paxton did not adhere to the SUDA. Specifically, Paxton did not properly store CBM materials including pipe, tractors and 55-gallon drums and that roads and well sites were poorly located which contributed to increased erosion. Mary Brannaman testified that, "Coalbed methane crews turned their roads into mud bogs, left trash on the ground, drove across rangeland, mixed topsoil with salt-laden subsoil and let hillsides erode away" [19]. Ultimately, the Brannaman's were awarded $810,887 for Paxton's breach of contract and breach of the duty of good faith and fair dealing [20].

Conclusion

In conclusion, the complicated mosaic of surface and mineral ownership in the Powder River Basin, and throughout the U.S. West, is a product of historical actions that have significant present-day implications. The making of this ownership regime dates back to the first Homestead Act of 1862. Subsequent legislative measures, most notably the Stock Raising Homestead Act of 1916, also contributed to the region's complex ownership pattern. The result of these legislative measures is the complicated surface and mineral ownership pattern that exists in the region today. Derived from this pattern is the legal condition known as split estate, where the surface land and subsurface minerals are owned by separate parties. Split estate has led to conflicts between surface and mineral owners in the region, some escalating to litigation despite the passage of Wyoming's

2005 Split Estates Act which was designed to provide more protection for surface landowners. By profiling some of these legal cases, together with the historical narrative that explains how the surface and subsurface ownership pattern was created, the effect of land and mineral tenure on the region's residents can be better understood.

Case Study Questions

1. Split estate produces a number of different ownership scenarios including: (1) private surface/private minerals; (2) private surface/state-owned minerals; (3) private surface/ federally-owned minerals; and (4) federally-owned surface/federally-owned minerals. Imagine and list the potential challenges inherent in each scenario regarding surface-owner/mineral-owner negotiations (i.e. SUDAs) and reclamation activities.
2. Based on the description provided in the case and the photos on the accompanying slides, sketch a CBM well site. Be sure to include the well infrastructure and access roads, power, water, pipelines and a compressor station.
3. Why do you think that the federal government altered the rules around granting mineral estate ownership between the passage of the 1862 Homestead Act and the 1916 Stock-raising Homestead Act? Use historical context to bolster your explanation.
4. What may prevent a surface owner from litigating against a negligent operator?

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CHAPTER FOUR

SOCIAL LICENSE TO OPERATE DURING WYOMING'S COALBED METHANE BOOM: IMPLICATIONS OF PRIVATE PARTICIPATION

Contribution of Authors and Co-Authors

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Abstract

Unconventional oil and gas (UOG) projects have emerged as fundamental, yet often controversial, components of contemporary energy systems. In contrast to the prevailing academic focus on sites of conflict, this paper explores why and how the social license to operate succeeds in UOG settings, or how private landowners accept or accommodate development. This paper applies the concept of social license to operate to landowner-industry relations during an episode of coalbed methane (CBM) development in the Powder River Basin, Wyoming. Conclusions draw on forty semi-structured interviews with stakeholders, including industry personnel, oil and gas attorneys, and surface owners that hosted CBM development. The findings indicate that mutual respect, procedural fairness, and trust were necessary preconditions of social license. These three preconditions created an opening for surface owners to effectively engage in private participation and advocate for their instrumental priorities. However, the key priority of surface owners to retain energy infrastructure, instead of demanding reclamation, has contributed to the existing U.S. land-use phenomenon of energy sprawl. Therefore, reclamation policy should aim to secure positive personal outcomes for private surface owners while mitigating against the cumulative environmental impacts of energy production.

Introduction

There is widespread interest in social acceptance (or lack thereof) of unconventional oil and gas (UOG) projects as they emerge as a fundamental, yet often controversial, component of contemporary energy systems (Boudet et al. 2014; Davis and Fisk 2014; Howell et al. 2017). UOG technologies have proven controversial enough to inhibit industry from earning a social license to operate in some countries, states, and cities where there are bans on hydraulic fracturing (Fry et al. 2015; Vasi et al. 2015; Weile 2014). While research often focuses on sites of conflict, fewer studies consider why and how social license succeeds in UOG settings, or how private landowners accept or accommodate development.

The rise in U.S. UOG production has been rapid (U.S. Energy Information Administration 2019) and development involves both publicly- and privately-owned lands. The unique mineral property rights regime in the U.S. puts individual landowners at the center of UOG development, and by extension, at the center of scholarly questions about the nature of the social license to operate (SLO). The legal condition of split estate characterizes much of the U.S., notably the American West, where the surface and subsurface estates are often owned by two separate parties (Jacquet et al. 2018; Walsh 2017). Minerals can be owned by the federal government, state government, and private individuals. In some instances, several mineral estates may underlie private surface, increasing the number of stakeholders involved in resource development planning.

Such an arrangement requires negotiations between private surface owners and mineral developers. During negotiations, surface owners engage in “private participation” in the energy project planning phase (Jacquet 2015), which affects how development proceeds, and ultimately the land-use and long-term environmental outcomes of energy production. Private participation refers to the influence landowners exert over decision-making processes in the planning and development of energy projects. This research uses the concept of SLO to study the relationships and private negotiations between individual surface owners and mineral developers and examines how these interactions influence the environmental legacies of energy production. A recent episode of coalbed methane (CBM) development in the Powder River Basin, Wyoming provides a case study.

Citizens, industry, government, and researchers have adopted the concept of SLO to describe aspects of corporate social responsibility and public acceptance of mining activities (Moffat and Zhang 2014). Scholarship on the mining industries often uses SLO to describe relationships between a specific host community and a single mining project (Holley and Mitcham 2016; Riabova and Didyk 2014; Walsh et al. 2017). The social license frame has wider application in a growing body of literature applying the concept to oil and gas projects (Jijelava and Vanclay 2017; Lacey and Lamont 2013; Mercer-Mapstone et al. 2018; Shaffer et al. 2017; Wilson 2016). This study builds on such literature by rescaling SLO from the community to the property scale. The research identifies the elements involved in individual surface owner-mineral developer negotiations, how these informed the conditions of SLO for CBM development, and their implications for the environmental legacies of production.

Three specific questions guide the analysis: (1) What conditions, actions, and/or strategies contributed to the establishment of social license between surface owners and

CBM companies? (2) Was SLO perceived as mutually beneficial by surface owners, CBM operators and regulators? (3) What were the environmental implications of private negotiations for SLO and what are the implications for reclamation policy? Considering the period of CBM production ended about a decade ago, the *post facto* analysis featured in this paper allows for consideration of reclamation and legacy issues that are often absent from boom/bust research.

This report begins with a review of the social license literature, with special attention to studies that address UOG development and CBM in particular. Next, a description of the study area provides geographic orientation and background into the period of CBM development. An overview of the qualitative case study research design is followed by a subsequent presentation of the findings and a discussion section. The paper closes with a summary of the policy implications and suggestions for future research.

Negotiating Social License in Oil and Gas Projects

Acknowledging that the definition of SLO is somewhat imprecise (Brueckner and Eabrasu 2018; Thomson and Boutilier 2011), social license is said to exist when a "mining project is seen as having the broad, ongoing approval and acceptance of society to conduct its activities" (Prno and Slocombe 2012, 346). SLO has been described as an informal social contract between industry and community (Curran 2017; Lacey et al. 2016). Prno and Slocombe (2012) emphasize that before an SLO is granted "communities must believe the social, environmental, and economic benefits of a project outweigh its potential impacts" (348). Germane to this research, the environmental impacts of resource development activities feature prominently in decisions to grant SLO by host communities (Bice 2014; Gunningham et al. 2004).

For UOG projects, the concept of SLO has been applied to study public reactions to proposed developments by analyzing public complaints (Shaffer et al. 2017), examining local perceptions (Wilson 2016), and identifying the key components of social license (Jijelava and Vanclay 2017). The regulatory regime for social impact assessment in the U.S. is limited to federal settings, and regulatory social impact assessment for mineral mining projects has been referred to as, "a permitting hurdle rather than an integral part of operational planning and management" (Harvey and Bice 2014, 328). In light of these observations, the concept of SLO has increasingly been used to understand levels of social acceptance.

Studies about extractive industries have identified conditions for the establishment of SLO, including legitimacy, trust, procedural fairness, and credibility (Gehman et al. 2017; Luke et al. 2018; Thomson and Boutilier 2011). Legitimacy, defined as "the acceptance of the project by the host community especially in terms of its fairness" (Jijelava and Vanclay 2017, 1078) establishes the foundation for the generation of social license. Studies demonstrate that trust is also central to the social license process (Mercer-Mapstone et al. 2018; Zhang et al. 2018). In Thomson and Boutilier's (2011) conceptualization of the social license continuum, "gaining the full trust of a community leads to the highest level of SLO: co-ownership or psychological identification" (1079). Relatedly, social license is influenced by how stakeholders perceive the fairness of procedures (Lacey et al. 2016). Luke et al. (2018) state, "perceptions of injustice around resource allocation and decision-making have been consistently identified to lead to public dissatisfaction and potentially, social resistance, in cases where a social license is withdrawn" (655). Credibility is earned when a company follows through on community obligations, is believed to be technically competent, and invested in their own "social performance" (Jijelava and Vanclay 2017, 1078).

There is a growing body of scholarship examining SLO and the CBM industry in Australia, where the resource is referred to as coal seam gas (Curran 2017; Hindmarsh and Alidoust 2019; Lacey and Lamont 2014; Luke et al. 2018). Curran (2017) explores how opposition groups contested coal seam gas in the Northern Rivers region of New South Wales leading to the revocation of the company's legal license to operate. The development was halted due to the lack of social license and adequate community consultation. Curran (2017) states, "by casting the social license as 'real', the government had transformed it into a much more tangible contestation tool" (432). Ultimately, the politicization of social license as an instrument of democracy proved an effective means of halting and eventually terminating the proposed drilling (Curran 2017). In their comprehensive review of the coal seam gas industry's SLO in Australia, Luke et al. (2018) provide regional analysis of public reactions to proposed developments.

This SLO research has made important contributions to scholarly understanding of public perceptions, regional variations, and the spectrum of social acceptance for coal seam gas in Australia. However, our understanding of when and if SLO is achieved warrants additional study. More specifically, researchers have yet to study CBM through the lens of SLO in the U.S. context. The U.S. landscape for CBM development is unique due to the split estate property regime, prominent role of private landowners, and high number of industry firms operating to develop the resource. Therefore, this study contributes to the existing literature by applying the concept of SLO to private negotiations between surface owners and mineral developers in the CBM fields of Wyoming.

Private Participation and Landowner Experiences with UOG Development

Community engagement and consultation processes, like information-sharing campaigns and public forums, are required for the generation of social license (Curran 2017; Jijelava and Vanclay 2017; Zhang et al. 2018). Mercer-Mapstone et al. 2018 state that, “meaningful engagement between companies and communities has been proposed as a foundation for relationships that support a social license” (671). In this study, landowner-industry communications constitute the engagement and are viewed through the lens of private participation in the planning of energy projects (Jacquet 2015; Malin et al. 2018; Walsh and Haggerty 2019). For example, surface owners hosting CBM wells in Wyoming were able to privately participate in planning processes to make infrastructure siting decisions. Jacquet (2015) surveyed landowners in the Marcellus Shale of Pennsylvania about their participation in the planning of wind and natural gas developments. The study determined that “[private] participation appears to increase landowner perceptions of control and information access, and ultimately positive attitudes toward the developments” (231).

Given the inherent power asymmetry between landowners and the UOG industry, putting negotiations among the two entities at the center of a social license analysis draws attention to a persistent question in UOG research. Do the inherent power asymmetries and the disruptive nature of UOG development predict negative experiences on the part of landowners that host UOG projects? A range of landowner experiences living with UOG and negotiating with UOG industry firms has been documented in rural settings (Bugden and Stedman 2018; Haggerty et al. 2019; Raimi 2017). Some studies have reported instances of environmental injustice in UOG lease negotiations and development more broadly (Davidson 2018; Malin and DeMaster 2016; Malin et al. 2018; Schafft et al. 2018). For example, Malin and DeMaster (2016) study the experiences of dairy farmers in the Marcellus Shale region of Pennsylvania. Though farmers report that natural gas leasing was beneficial to their agricultural livelihoods, they face a "devil's bargain" as they become more reliant on volatile natural resource economies and often experience "procedural inequities and greater environmental risk" (278).

An analysis by Bugden and Stedman (2018) complicates this depiction of Pennsylvania landowners as marginalized. The authors note that landowners accrue financial benefits and do not face high risk of environmental harm, though this is contingent upon ownership of property and/or minerals and influenced by the industry firm that is conducting operations. Haggerty et al. (2019) present the "balancing act" framework to describe how farmers and ranchers in three U.S. regions manage the benefits and challenges of hosting UOG development. Though farmers and ranchers described financial and other benefits of energy development, participants also acknowledged a set of tradeoffs that are made to secure benefits (i.e. accommodating traffic and questionable industry conduct) (Haggerty et al. 2019).

A growing body of scholarship addresses acceptance and satisfaction with UOG development on the part of landowners and host regions (Jerolmack and Walker 2018; Kriesky et al. 2013; McEvoy et al. 2017; Walsh and Haggerty 2019). Jerolmack and Walker (2018) describe support for hydraulic fracturing in an Appalachian community as “quiet mobilization” whereas residents favored industry based on their partisan identities, community obligations, and belief in the rights of private property owners to sign leases. Despite power imbalances inherent in contract negotiations between surface owners and industry, research has shown that landowners are empowered by access to qualified legal counsel if they desire and are able to secure legal representation (Walsh and Haggerty 2019).

In light of the reviewed literature, questions remain about the existence and conditions of SLO in the context of U.S. CBM development, and how individual landowners experience private negotiations with CBM companies. Luke et al. (2018) state that, “relatively few academics have collected data to provide an understanding of support levels for unconventional gas in different regions, and at different social scales” (655). This research aims to contribute to this gap in the scholarship by considering the central role private surface owners played in how energy development unfolded in Wyoming’s CBM fields.

Case Study: The Powder River Basin, Wyoming

This paper describes how surface owners and mineral developers negotiated the conditions for SLO during a period of CBM development in the Powder River Basin of

Wyoming (Figure 4.1). A detailed description of the study site and the CBM development history (1998-2009) can be found in Walsh and Haggerty (2019). Noteworthy characteristics of the Powder River Basin relevant to this case study include the widespread prevalence of split estate mineral and surface ownership, the resource-dependent nature of Wyoming's economy (James and Aadland 2011), and the dominance of extensive livestock ranching as a surface land-use (Chapman et al. 2004; U.S. Census of Agriculture 2012). In CBM development in the Powder River Basin, individual ranchers constituted the primary non-industry, non-governmental stakeholder group.

In brief, 3.7 Trillion Cubic Feet (TcF) of CBM was produced in the Powder River Basin between 1998-2009 (WYOGCC, n.d.). At the peak of development in 2008, over 18,000 wells were operating within this 19,500 square mile basin across a matrix of private and public ranch land (USGS 2013; WYOGCC, n.d.). The remote nature of the Powder River Basin required the initiation of infrastructure projects to facilitate CBM operations. Access roads, power lines, underground gas and water pipelines, compressor stations, and surface water reservoirs were constructed along with well sites.

In the case of Powder River Basin CBM, the split estate property regime and related legislation, specifically the state of Wyoming's 2005 Split Estates Act, requires legal contracts between surface owners and mineral developers. The contracts are called surface use and damage agreements. These agreements dictate how the surface can be used to develop the resource, surface owner compensation and reclamation requirements. Though required by law to provide access to mineral rights holders, Powder River Basin surface owners act as gatekeepers to CBM resources. Industry operators are only permitted entry after good faith contract negotiations are complete. Wyoming oil and gas statute does not define what constitutes “good faith negotiations” but does put the burden on the operator to prove negotiations were conducted in “good faith” if there is a dispute. During the negotiation process, surface owners exert influence over contract terms and development plans (Walsh and Haggerty 2019). Surface owner’s private participation, or the communication and negotiation between individual landowners and industry companies during this resource development phase, constitute the engagement that is a necessary precursor to social license. Negotiations merit consideration as they inform how development proceeds and have potential long-term environmental implications.

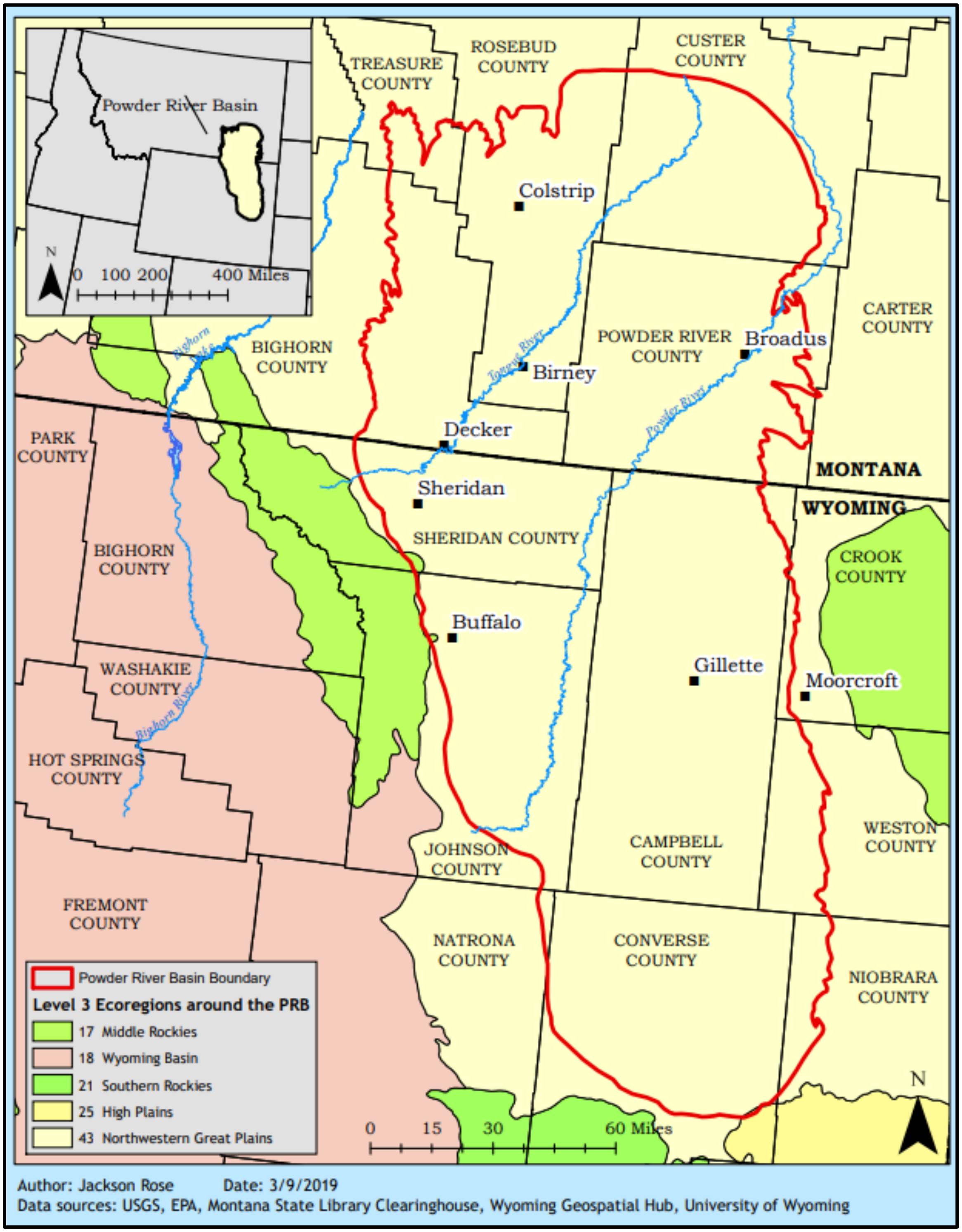

Figure 4.1. Map of the Powder River Basin, Wyoming

Agriculture-Energy Overlay in the Powder River Basin, Wyoming

Many landowners in the Powder River Basin accommodated CBM development despite its disruptive nature (Haggerty et al. 2019; Walsh and Haggerty 2019). Land parcel sizes average 4,000 acres and enable range livestock production at extensive scales (U.S. Census of Agriculture 2012). CBM development in this region does not require hydraulic fracturing. Instead, the extractive process features shallow natural gas wells drilled to less than 2,500 feet (Thakur et al. 2014). CBM well sites are relatively small in their geographic footprint due to the material properties of the resource. On the large livestock ranches in the region, CBM well sites do not substantially interfere with operations.

Earlier studies have claimed that the agriculture-energy overlay in the basin is particularly synergistic because of large ranch sizes, smaller well sites, and limited crop production (Haggerty et al. 2019; Walsh and Haggerty 2019). It stands to reason that because of the state's longstanding experience with resource extraction there is general acceptance of working landscapes among Wyoming residents (Western 2002). This heritage helps explain the lack of major public opposition at the outset of CBM development despite the fact that CBM extraction was new to the Basin. Development challenges were reported (Bleizeffer 2002; Bohrer 2003), but never escalated to demands for industry or regulators to curtail CBM activities.

Reclamation after Coalbed Methane Production

One critical dimension of the SLO for CBM development involves major legacy issues in the Powder River Basin. The region experienced widespread abandonment when natural gas prices failed. In total, just over 5,700 CBM wells have been declared "orphaned" due to company bankruptcy (Killough 2018; WYOGCC 2019). Orphaned wells are defined as "wells for which the agency [WY Oil and Gas Conservation Commission] is unable to require the responsible party (Owner or Operator) to plug and abandon them and rehabilitate the surface because the responsible party no longer operates in the state, is bankrupt, or is out-of-business" (WYOGCC 2017).

Wyoming's Oil and Gas Commission is responsible for plugging and reclaiming orphaned wells associated with private and state minerals, while the U.S. Bureau of Land Management (BLM) is responsible for orphaned wells on federal land or drilled into federally-owned minerals. Both agencies mitigate hazard by conducting proper plugging and abandonment activities at the well site. Even for wells with a responsible operator, reclamation of infrastructure associated with CBM development is contingent upon the preferences of the surface owner. Allowed by Wyoming state and federal law, a surface owner can choose to forgo reclamation and instead integrate the energy infrastructure into their ranching operation for long-term use.

However, the basic biogeography of the region adds to the urgency of legacy issues. Reclamation practices are meant to return the degraded landscape to some productive capacity with improved ecosystem functionality (Bradshaw 1987). The Powder River Basin is a semi-arid grassland, receiving 12-18 inches of annual precipitation (Chapman et al. 2004). Thin soil horizons coupled with a climate characterized by frequent wind increase potential for erosion and make this a difficult landscape to reclaim after oil and gas production activities (Norton and Strom 2013). For example, Nasen et al. (2011) conducted a study in grasslands of southwestern Saskatchewan to determine the rate of recovery for thirty-one sites impacted by petroleum and/or natural gas development. Results indicated that impacts persist for at least fifty years after abandonment, with the authors stating that "lease sites left abandoned and/or suspended are not returning to a vegetation composition reflective of a healthy, native prairie" (Nasen et al. 2011, 203). Related literature echoes these results (Avirmed et al. 2015; Rottler et al. 2017; Simmers and Galatowitsch 2010; Viall et al. 2014), and together these studies suggest that unassisted recovery without implementation of reclamation techniques is unlikely in semi-arid grassland environments affected by oil and gas production.

The surface disturbance required to extract CBM expanded the scale of the reclamation challenge, while contributing to an existing phenomenon of land-use change in the U.S.: energy sprawl (Trainor et al. 2016). A recent study documented that a century of energy development has resulted in aggregate loss of biomass equivalent to five million animal unit months and 120.2 million acres across the Great Plains of North America (Allred et al. 2015). To mitigate energy sprawl and correct surface disturbance, conducting timely and effective reclamation after oil and gas production is vital. Considering that the preferences of surface owners often dictate the amount of reclamation that is completed, landowner-industry negotiations, especially those related to landowner strategies to forgo or encourage reclamation, deserve scholarly attention. Together this context emphasizes the critical role of landowner choices in the implementation of reclamation practices, and by extension, implications of the features of the SLO at the property scale for the long-term outcomes of development.

Methods

This research employed a qualitative case study approach to gain comprehensive insight into the study of a particular geographic phenomenon. Crowe et al. (2011) state, “A case study is a research approach that is used to generate an in-depth, multi-faceted understanding of a complex issue in its real-life context” (1). This research examines the utility of the concept of SLO to describe relationships between surface owners and CBM companies in Wyoming’s Powder River Basin. The rationale for use of a qualitative case study approach is two-fold.

First, the absence of similar cases in the literature provides few points of comparison. The lack of relevant scholarship challenges the idea that an informed hypothesis could be generated and tested over the course of this project. Instead, the purpose was to discover the elements involved in individual surface owner-mineral developer negotiations. Secondly, this research aims to uncover the conditions, actions, and strategies of surface owners as they relate to industry activities on their surface. This information could best be obtained via semi-structured interviews, as a flexible approach was required to account for different circumstances on the ranches of individual surface owners. Powder River Basin ranches vary in their operations as well as in the number of industry companies that were on-site to develop minerals and in other aspects (e.g., size, water availability, etc.). A qualitative approach accounts for such variability and the necessity to ask slightly different questions of each surface owner and stakeholder group more broadly.

Therefore, the bulk of the data was collected by semi-structured interviews with a diverse sample of stakeholders involved in all aspects of surface owner-industry negotiations. The sampling frame was defined by the geography of the Powder River Basin, WY. Specifically, the sample includes surface owners that hosted CBM development on their property; oil and gas attorneys based in Sheridan, Buffalo, and Gillette, WY; industry personnel that have been involved in the extraction of CBM in the region; local government employees; an employee from a regional NGO; a reclamation contractor based in the Powder River Basin; and State and Federal Officials representing the Wyoming Oil and Gas Conservation Commission, WY Department of Environmental Quality, WY State Engineer's Office, and the BLM. Together, the sample addresses the variety of stakeholders involved in negotiation processes between surface owners and mineral developers (Table 4.1). CBM production declined nearly a decade prior to this study; interviewees were providing a *post facto* assessment.

Sampling was purposive and conducted using the snowball sampling method. Media articles (Moen 2006; Morton 2007) and exploratory research indicated that there had been a proliferation of individual surface owners and mineral developers negotiating in the Powder River Basin over the course of a CBM boom. To understand the elements at play as they relate to this case, stakeholders that were involved in negotiation processes constitute the sample. Therefore, participants were selected purposively to ensure that they had relevant expertise. To build the sample, snowball sampling methods were undertaken. Oil and gas attorneys, industry personnel, and government officials are embedded in professional networks. Likewise, surface owners are often connected with neighbors, other residents, and/or community/regional organizations. The sample expanded through access to social networks. Questions asked of participants fell into diverse but related categories depending on the stakeholder group (Table 4.2).

Timing of Data Collection	**Interview Participants**	**Total Interviews Conducted**
Spring/Summer 2016	Government employees (n=6) Surface owners (n=2) Agency staff (n=1) NGO employee (n=1) Reclamation contractor (n=1) Industry personnel (n=1)	12 interviews
Summer 2017	Surface owners (n=11) Agency staff (n=7) Attorneys (n=6)	20 interviews with 24 participants
Winter 2018/2019	Industry personnel (n=4)	4 interviews
TOTAL	Surface owners (n=13) Agency staff (n=8) Attorneys (n=6) Government employees (n=6) Industry personnel (n=5) NGO employee (n=1) Reclamation contractor (n=1)	**36 interviews with 40 participants**

Table 4.1. Interview Sample and Timing of Data Collection

However, the authors faced recruitment challenges especially when targeting industry professionals. In addition to snowball sampling, attempts at industry personnel recruitment included web searching for active or defunct companies and any related contact information, web searching through CBM permits on the WYOGCC website to locate company names with follow up searches on the WY Secretary of State website to locate company contact information, and conversations with professional geologists not associated with CBM in an attempt to tap their professional networks. Most of these recruitment attempts failed, although web searching followed by cold-calling/emailing proved the most successful.

Stakeholder Group	**Categories of Interview Questions**
Surface Owners (SO)	Ranch operation and level of development; industry relations; reclamation perceptions, status, and satisfaction level(s); resources, support & information gathering
Agency Staff (AS)	Volume and characteristics of industry operators; policy environment for CBM; landowner-industry relations
Attorneys (AT)	Policy environment for CBM; legal cases regarding CBM; impressions of the volume and characteristics of industry operators; landowner-industry relations
Government Employees (GV)	Policy environment for CBM; government to government coordination; revenue generation; challenges & opportunities
Industry Personnel (IP)	Firm structure and development planning; policy environment for CBM; landowner-industry relations

Table 4.2. Interview Question Categories for Prominent Stakeholder Groups (Note: all participants were asked similar background questions about their job tasks and responsibilities and perceptions of the CBM boom)

This study reports on thirty-six semi-structured interviews with forty participants. In-person interviews (n=24) took place at participant residences, offices, and at local breweries, restaurants, and cafes. The remaining interviews were conducted by phone (n=12). Interviews ranged in length from 19 minutes to an eight-hour interview and ranch tour. The average interview was 64 minutes in duration. Each interview was audio recorded with the participant’s consent. Audio recordings were professionally transcribed and coded using Nvivo 12 Pro software. In this paper, interviewees are distinguished by a basic identifier consisting of the sector they represent followed by a number (see Table 1 for abbreviations).

In accordance with grounded theory (Glaser and Straus 1967), data analysis was conducted using an iterative process. Coding took place followed by additional fieldwork as evidenced by the timing of interviews (Table 1). At the conclusion of fieldwork, three rounds of coding commenced. The first round of coding scanned for themes and theoretical frames emerging from the data. This prompted the creation of a coding scheme or code book that guided data analysis during the second round of coding. A third and final round of coding was conducted to verify the theory being generated by the data and ensure consistency and analytical rigor.

Conditions for Social License

The social license concept proved to be a useful frame to analyze surface owner-CBM company negotiations. CBM stakeholders interviewed for this research described three key conditions for the cultivation of SLO: (1) building trust and mutual respect; (2) recognition of potential opportunities brought about by the period of resource development; and (3) engagement with mineral developers. Each condition involved the implementation of particular strategies on the part of stakeholders that helped to keep the SLO intact. However, participants also explained that the social license was threatened at various times, confirming previous literature that describes the SLO as dependent on ongoing maintenance (Bice 2014; Brown and Fraser 2006).

<u>Building Trust and Mutual Respect</u>

Our findings from the CBM fields of Wyoming are consistent with the canon of SLO scholarship that finds trust to be an essential component of generating social license (Jijelava and Vanclay 2017; Mercer-Mapstone et al. 2018; Zhang et al. 2018). Specifically, the mindset and individual character of negotiators played a vital role in establishing trust. All surface owners shared the importance of maintaining a non-adversarial mindset and open lines of communication when entering into conversations with companies, as stated by a surface owner:

> *We made sure we had communication with every one of the [companies], we knew who they were, they knew who we were, we were not dishonest, not out to get more than we had coming. So they trusted us and we trusted them and [that] worked fine.* (SO1)

A field engineer from a CBM company expressed similar sentiment, "I treated everybody else's land how I wanted mine treated. And their feelings. And that is the best thing you can do" (IP1). The sample of surface owners described themselves as being open-minded and available to industry, while at the same time being firm and demanding respect. SLO was strengthened when industry built trust by acknowledging and meeting the expectations of surface owners, as indicated in this statement:

> *I demanded that they do things right, I didn't let them get away with anything but I respected them as I would want to be respected myself and we had such a great relationship…I actually would let them do things with no charge in exchange for a favor here or there…it worked well.* (SO2)

This quotation demonstrates that trust was strengthened over time when industry conducted their operations properly and with regard for the surface owner. Seeing the industry work to uphold agreements enabled surface owners to respect CBM company efforts.

Industry and landowning stakeholders interviewed for this study often mentioned the benefits of a non-adversarial approach. For example, one surface owner described his willingness to accommodate CBM production on his ranch this way:

> *What I told them was, look you're not going to have a problem with me in getting your wells drilled as long as I get to help select the locations to keep them out of my way and so that I can... place them in a place that…may be ultimately beneficial to the ranch…They said fine…and actually I had a pretty good relationship with them.* (SO3)

This statement brings attention to another key theme in the SLO of CBM in Wyoming; landowners that cooperated with industry did so not only because of their ideologies and values about energy development, but because of the benefits to their agricultural operations.

Divergent Interests, Aligned Outcomes

As previous studies have shown, the landowners interviewed for this study similarly experienced tradeoffs involved with the period of CBM development—tradeoffs that can also be considered in terms of the benefits perceived by stakeholders in the SLO. Surface owners were willing to be accommodating (rather than adversarial) to maintain SLO, and perhaps endure less-than-desirable industry conduct (high traffic volumes, dust, littering, landscape change), because they recognized opportunities to capitalize on the period of resource development in the long-term. One landowner said, "To me the power, the roads, and the water is the big help to the landowner or rancher. And we put up with all the other mess and hassle" (SO4).

Interestingly, a key rationale for the maintenance of SLO was long-term acquisition of CBM related infrastructure rather than monetary compensation. One interviewee explained that "[t]here was probably $5M of infrastructure on the ranch and I wanted to be able to use it" (SO3). Surface owners often implemented strategies to secure long-term integration of CBM infrastructure into their ranching operation during the early phases of resource development, as noted by a representative of the federal government:

> *There's…coordination with the private surface owner to acknowledge their wishes. Maybe they want to keep roads, maybe they want to keep that well…as a stock water well and they want to keep some of that infrastructure in place…and that might've been their plan from the inception of the development.* (GV1)

This regulator observed that surface owners had preferences about the infrastructure they wanted to acquire and often took action early on in the development to ensure their preferences would be met.

Surface owners and industry were both invested in maintaining a strong social relationship but for different reasons. The majority of surface owners in the sample were more willing to grant SLO to secure infrastructural improvements on their ranch while industry SLO efforts related to cost-savings.

> *In most of those cases the ranchers are saying leave the roads, leave the power lines, which saves everybody money…In almost all cases the landowners are having [industry] abandon gas and water pipelines in place and they are taking over those pipelines to use as water lines.* (AT1)

This attorney directly mentions that by forgoing reclamation, industry saves money as do surface owners who are able to acquire the infrastructure at no (financial) cost.

Ultimately, surface owners were more willing to grant SLO knowing the CBM infrastructure would be put to long-term beneficial use, and they were accommodating of industry to ensure their infrastructural preferences would be met. Industry was equally invested in maintaining strong social relations so they could eventually pass on the infrastructure to the surface owner, saving time and money that would be spent on reclamation. This set of circumstances provided fertile ground for the work required to keep SLO intact.

Indeed, the circle of this “win-win” dynamic of trading CBM development for long-term ranch infrastructure was not limited to landowners and surface owners. In interviews, surface owners, regulators, and industry all confirmed the potential for benefit related to the private acquisition of CBM related infrastructure. Infrastructure enhancement benefitted surface owners, while industry saved money and time by forgoing reclamation of all the infrastructure that had been constructed. Regulators were satisfied because such arrangements were permitted by law and reduced the need for administrative oversight and inspection.

Surface Owner-Industry Relations

The practical benefits and opportunities brought about by CBM development prompted surface owners to engage with CBM operators using a collaborative approach. Implementation of surface owner planning preferences into development plans required productive engagement and strong, consistent communication with industry. One surface owner said, “I didn't want them to reclaim the roads. Where I'd ask the roads be put were going to be [of] long term benefit to the ranch” (SO3). Stakeholders shared that surface owner input was valued and translated into modified plans of development. The fact that early negotiations were regarded as procedurally fair provided strong foundation for the initial generation and continued preservation of SLO as indicated in the statements, "I actually had quite a lot to say about where to put roads" (SO5) and, "I had a lot of say about where [compressor stations] went and what [industry] was going to do" (SO6). These quotations indicate that industry asked for surface owners' input and, more often than not in the case of these interviewees, took their preferences into consideration.

On the other side of the negotiating table, industry personnel made a deliberate effort to satisfy landowner desires in order to preserve existing social relationships and maintain relationships into the future, as indicated by this statement:

> *There was a few times where it would come down to a decision and corporate would be telling us we had to do something a certain way and we would almost just flat out not do it. Or just come up with some excuse why we couldn't or something, just to satisfy a landowner because we're the ones that have to live with them.* (IP2)

This quotation demonstrates that on-the-ground CBM company personnel would make an effort to meet surface owner expectations in order to keep social relationships strong considering the multi-year lifecycle of CBM development. Mineral developers were also inclined to listen to the input of surface owners based on their local environmental knowledge:

> *These [are] multi-generational ranches. These families know what happens with the weather…and they say hey you don't want to build there. That snow drift can be terrible or whatever. When you had that rapport with the landowners and you listen to them that meant a ton. But as soon as you totally disregard those 5 generations of experience, that is the biggest slap in the face that a [CBM] company could give to a landowner.* (IP3)

As indicated by the quotation, industry acknowledged that to maintain positive social relationships and avoid any development delays related to poor siting decisions, it was important to listen to surface owner input. An attorney commented on the importance of negotiating robust legal contracts to best ensure surface owner input was taken into account:

> *The best thing is upfront if you get a good surface use agreement with the operator, then you can help dictate where those roads would be and power lines and…it would more likely become a…beneficial use for you as a rancher down the line… the first step is to make sure the landowner is able to negotiate…so that road isn't going through your best pasture... you may want to use it in the future.* (AT2)

Sometimes, effective communication was a product of luck and depended on the individual character of industry personnel, as shared by one surface owner:

> *The one company…had a landman that we contacted and he was excellent. He was a consultant first and then he went to work for them later on and boy that guy was good. And we had really good luck with him.* (SO4)

The Social License in Jeopardy

Social relationships between surface owners and industry were influenced by several factors including those related to personality, preferences, and personnel. The dataset revealed that, at times, the social license between surface owner and the industry operator(s) was in jeopardy. Times of greatest vulnerability coincided with instances when industry disregarded the terms of the surface use and damage agreement. Surface owner responses show them as creative and crafty in bringing these issues to industry's attention. Consider one case of a ranch where the CBM operator (or contractor) had neglected required maintenance on the CBM access roads on the ranch, leading to unusable roads with unsafe driving conditions. To make a point about the problem this presented to him, the surface owner stranded a group of industry visitors on one of the poorly maintained roads forcing industry personnel to walk back to his house from a remote area on the ranch. This strategy seemed to pay off:

> *It's in the contract in inches how deep [the ruts in the roads] can be and [industry wouldn't] take my word for it. I'm not unreasonable but since you are, I can be. And that next Monday they were out and they fixed ruts all over. And actually did a pretty good job to where a lot of them are still good today.* (SO5)

In interviews, all surface owners referred to a kind of "common sense approach" to respecting the land and resources of the ranch. If industry behaved in ways that demonstrated blatant disrespect for that common sense notion of stewardship, it could put SLO in jeopardy. Ranchers used the negotiating power they acquired through industry impropriety in this stewardship framework to practical ends. A ranch owner shared one such experience when industry damaged a CBM access road by using it directly after a bad snowstorm. The surface owner converted his disgust at this industry impropriety into an agreement for the CBM operator to pay for a new fence:

> *They tore up a road pretty bad…when all was said and done, I said that was pretty unnecessary. I wanted a new fence...to fence off a pasture. [The CBM operator] said, "why?" I said for the damage….He didn't answer and I'm not much of an actor but you've got to act mad. And I was acting mad and I walked away from him to get my point across. About a week later a fence contractor came up and said where do you want that fence built?* (SO1)

As the preceding quotations indicate, through acts of defiance, surface owners were able to pressure industry to correct or compensate mistakes. Industry personnel recognized the importance of doing so to maintain social license and continue their activities without delay.

> *As soon as you get on the bad side of a landowner things go downhill really quick. We would bend over backwards to try to accommodate [surface*

> *owners] in every which way. And it got to a point…where they would just keep asking for more and more and it got hard to convince corporate to spend the extra money or the extra time to change things around. But I would always do everything I could to try and make that happen just because it would make our life so much easier in the field.* (IP2)

Surface owners would not allow CBM companies to get away with contract noncompliance or undue surface degradation. Although company representatives would mount limited resistance to surface owners' preferences for correction or compensation, ultimately industry would rectify issues to maintain SLO.

However, the complicated nature of CBM company ownership and operational dynamics could challenge the preservation of social license. Industry operators varied in size, capital resources, history/longevity, and familiarity with the local geography. They often hired subcontractors to perform on-ranch work. Ineffective communication amongst the diverse collection of industry personnel operating on a single ranch could threaten the social license. One surface owner said, "There was a lot of different contractors. And some of the contractors were…better than others" (SO5). The fast-paced nature of CBM development meant a high volume of stakeholders, both industry operators and their contractors, were often at work on a single ranch. An industry personnel stated, "There wasn't enough people to do the work so companies would hire contractors and all you could hope for is the contractor that you were hiring was somebody who could be an extension of your values" (IP3).

A state water inspector acknowledged that the benefits received by most surface owners were often contingent on the behavior of the operating industry company:

> *I saw a great benefit to many landowners…they had access to wells, pipelines, stockwater, irrigation opportunities…And certainly there were a*

> *lot of issues and it depended on the operator. We had some that went out of their way to work with the landowners and some that could care less.* (GV2)

An attorney expressed a similar point indicating that acquisition of instrumental benefits was challenging at times and at least somewhat contingent on the industry firm conducting operations:

> *[Surface owners] got water, they got power, they got roads, they got money but there was a lot of conflict, a lot of anguish and just depended on character of your methane operators. The ones from Michigan were the worst and some were just complete scams.* (AT2)

A federal regulator made a similar observation about the diverse nature of industry operators:

> *At the beginning we had some good strong companies with high integrity but you always had the crumbs coming in, small operators that were...coming in to make a quick dollar, and that's the ones that bit BLM [and] landowners in the butt.* (GV2)

Discussion

Our findings reveal the conditions, actions, and strategies important to generation of social license between split estate surface owners and mineral developers in the CBM fields of Wyoming, furthering scholarly understanding of how and why private landowners accept or accommodate development. Consistent with the canon of SLO literature, mutual respect, procedural fairness, and trust were necessary preconditions of SLO (Curran 2017; Tyler 2000). Surface owners perceived that industry conduct was procedurally fair as their input into CBM development plans were often implemented. The ability of surface owners to influence and benefit from infrastructure development underpins all dynamics of SLO generation. Industry personnel valued input in order to avoid delays associated with disagreements or poor siting decisions. This form of private participation was needed to achieve SLO in the case of Powder River Basin CBM.

Policies like Wyoming's 2005 Split Estates Act support good faith negotiations between surface owners and mineral developers despite surface owners' weakened legal position relative to the owner of the mineral estate. This legislation mandates that surface owners and industry communicate to negotiate compensation, surface use, and required reclamation. Communication supports relationship-building between surface owners and industry firms. This regulatory framework, coupled with the absence of any overarching federal legislation governing UOG projects, creates an opening for surface owners to influence development plans, levels of reclamation on their property, and enables private participation.

However, interactions between surface owners and mineral developers were not free from conflict. Descriptions of episodes when the social license was vulnerable were commonplace, but explanation of how conflicts were resolved and issues rectified often followed, suggesting that ultimately the SLO remained intact. In this way, our study provides findings consistent with those made in previous research about the benefits and challenges of hosting energy resource production (Bugden and Stedman 2018; Haggerty et al. 2019; Raimi 2017).

Specifically, the integrity of SLO is firm-dependent, with some operators investing more time and personal resources to maintain SLO than others. This finding aligns with observations made by Bugden and Stedman (2018) and Haggerty et al. (2019)

that differences among industry firms conducting operations contribute to differences in local outcomes of UOG development. This is an important finding considering the dynamic landscape of industry operators conducting UOG extraction on split estates in the U.S. In this case study, operators ranged from large, well-capitalized multinational corporations to small companies that operated on a state or regional basis. The energy industry, including UOG producers, are often regarded as a homogenous “black box” (Ehsani 2018, 22). This study reveals that at a fine scale, considering a single energy resource in a highly localized context, there is clear and broad variation in the type of companies operating. Understanding the differences in how different kinds of UOG companies perceive and manage reputational risk related to SLO requires additional study.

From previous SLO research, open questions remain about whether SLO is perceived as mutually beneficial by different stakeholder groups (Curran 2017). This study reveals that securing and retaining SLO was mutually beneficial to involved stakeholders, including private surface owners, industry operators, and regulators. Each group had a distinct set of instrumental priorities that could best be achieved when social relationships were strong. For surface owners, acquisition of CBM related infrastructure for long-term use was a top priority. In order to obtain infrastructure, non-adversarial engagement was required to ensure industry followed through on surface owner input into siting and development plans. Industry operators saw value in allowing CBM infrastructure to be acquired by the private surface owner after development, and built rapport with surface owners to make this a reality to save time and money that would have been spent on reclamation. Regulators were satisfied because such arrangements between surface owners and mineral developers regarding infrastructure acquisition were permitted by law. Operators were also incentivized to work at maintaining SLO, since CBM development has a multi-year lifecycle (Walsh and Haggerty 2019). A strong SLO allowed for activities to proceed smoothly with limited surface owner interference.

Our analysis reveals that surface owners received real, tangible benefits from CBM that made them more inclined to maintain SLO and led them to accommodate development. However, presence of SLO does not translate to positive environmental outcomes. This study demonstrates clear environmental implications of the individual negotiations between surface owners and CBM companies, or private participation. Landowners made deliberate choices about use of their surface, especially related to infrastructure, with vision for how their ranching operation could be upgraded for the future. However, the fact that private surface owners often negotiated to acquire CBM related infrastructure for long-term use on their ranches often resulted in forgoing reclamation entirely. Here, surface owner choices contributed to the known U.S. land-use phenomenon of energy sprawl (Allred et al. 2015; Trainor et al. 2016) and increased the cumulative surface acreage disturbed by energy development. Private participation complicates efforts to mitigate the cumulative environmental impacts of energy development.

5,700 CBM wells have been declared orphaned throughout the basin (Killough 2018; WYOGCC 2019), expanding the reclamation challenge. When addressing orphaned wells, the State of Wyoming's well plugging program, administered by the

Wyoming Oil and Gas Conservation Commission, attends only to the well site. The agency is not responsible for reclaiming any associated infrastructure, no matter the preferences of the surface owner. Acknowledging that unassisted ecosystem recovery in the Powder River Basin is unlikely (Avirmed et al. 2015; Nasen et al. 2011; Rottler et al. 2017; Simmers and Galatowitsch 2010; Viall et al. 2014), it is clear that the potential for long-term surface disturbance and degradation is high. Policymakers should carefully consider this trend when shaping legislation.

Conclusion and Policy Implications

This paper set out to explore how the concept of SLO can be used to study the relationships and negotiations between surface owners and CBM operators and how these interactions influence environmental outcomes. The analysis suggests that SLO provides a useful framework to examine how private surface owners and mineral developers interact during periods of resource development. Findings indicate that SLO is established and maintained so surface owners and industry operators can secure distinct instrumental benefits. Key to the preservation of social license is private participation, where individual landowners make decisions to acquire CBM related infrastructure to upgrade their ranching operations. However, forgoing reclamation in favor of infrastructure acquisition contributes to the known U.S. land-use phenomenon of energy sprawl. Reclamation policy should aim to secure positive personal outcomes for private surface owners that host resource development while mitigating against the cumulative environmental impacts of energy production. Ultimately, private surface owners can be powerful in directing energy project planning with consequences for environmental legacies.

Further research should include a comprehensive critical review of surface owner protection acts across U.S. states where split estate is common in the context of UOG. Such a review would answer and open questions about the opportunities for and limits of private participation, mandates that facilitate engagement, and the broader positionality of private surface owners hosting UOG across the country. Research should also examine UOG policy beyond surface owner protection acts to assess whether there are areas where industry, surface owner, and regulatory interests overlap and could help to mitigate against stalled reclamation and energy sprawl. Considering that opportunity for private participation and development outcomes are firm-dependent, future research should also consider how the different characteristics and practices of UOG operators contribute to social acceptance. Additional studies addressing approaches and outcomes of private surface owner–industry negotiations across geographies and resource types are important avenues for future research.

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CHAPTER FIVE

THE 'LEARN AS YOU GO' APPROACH: A CAUTIONARY TALE OF ENVIRONMENTAL LEGACY MANAGEMENT IN WYOMING'S COALBED METHANE FIELDS

Contribution of Authors and Co-Authors

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Introduction

While it has put the U.S. at the top of world production rankings, the recent surge in onshore oil and gas development has introduced a complex set of environmental management challenges. Among them, environmental impacts associated with the decommissioning and end-of-life phase of oil and gas development, so-called legacy issues, present an emerging and understudied area of concern (National Academies of Sciences, Engineering, and Medicine 2018). An estimated 982,371 active oil and gas wells in the United States (U.S. Energy Information Administration 2019) will require reclamation at the end of their productive lives: abandoned[2], unplugged wells pose risks to groundwater quality and are a source of fugitive methane emissions (Townsend-Small et al. 2016) while un-reclaimed surface disturbance contributes to habitat loss and the risk of invasive species (Allred et al. 2015).

While the petroleum engineering community expresses optimism about the technical feasibility of fully reclaiming oil and gas well sites, the historical record suggests a more complicated story. Given that the U.S. Environmental Protection Agency (2018) estimates that only one-third of abandoned wells have been plugged, leaving an inventory of 2.3 to 3 million[3], it seems that past regulatory structures have been insufficient to ensure full remediation of oil and gas legacy issues. Because the most recent episode of onshore drilling activity in the United States had a vast surface footprint

[2] Abandoned is a broad term that includes any wells that have ceased to produce and are no longer actively managed.

[3] This wide range is largely the result of inadequate data and records on the location and status of older wells drilled prior to the 1950s, though it is not atypical for oil and gas wells to be abandoned or orphaned today.

and occurred in a regulatory environment that can be characterized as reactive and uneven, it is critical to explore the legacy issues of UOG from diverse perspectives. A geographical perspective emphasizes a multi-scalar, integrative analytical approach to describing legacy issues, with attention to the particulars that emerge as local material and economic circumstances meet national and global policies and market forces (Haggerty et al. 2018).

This study examines the relationship between the dynamics of environmental cost-shifting in UOG development and the evolution of legacy issues. Environmental cost-shifting describes "the legal, economic and geographical means by which many of the environmental 'costs' of producing resources have been re-allocated across space and time" (Bridge 2009, 1231). Environmental cost-shifting provides resource geographers a framework to study the longer-term environmental outcomes of energy resource development by identifying and describing the mechanisms that facilitate the reallocation of costs. Using a case study of coalbed methane (CBM) production in the Powder River Basin, Wyoming (1999-2010) now in the legacy phase, this paper analyzes the character and mechanisms of shifting environmental costs over the lifecycle of a CBM development boom. Findings and conclusions will be instructive for the management and regulation of environmental liabilities in active oil and gas plays in the U.S. and internationally.

This paper begins with a literature review of scholarship regarding the known environmental costs of UOG development and the regulatory approaches that have been used to govern the management of such environmental costs. A description of the case study site for geographical orientation is followed by an overview of the qualitative research methodology. Findings are presented and then interpreted in a discussion section. The conclusion summarizes the research and suggests directions for future study.

The Environmental Legacies of UOG Production

Assessing the environmental costs or impacts of UOG production has been the topic of a growing body of research (Lave & Lutz 2014; Jacquet 2014; Mayer 2016). Despite the fact that many UOG plays have yet to reach the end-of-life phase, some studies do exclusively focus on environmental legacy effects (Allred et al. 2015; Brandt et al. 2014; Davies et al. 2014; Kang et al. 2016; O'Sullivan and Paltsev 2012; Trainor et al. 2016). The scholarship on environmental legacies largely focuses on the risk of fugitive methane emissions, the scale and severity of surface disturbance, and reclamation of abandoned wells and infrastructure.

Natural gas is understood to have a larger greenhouse gas footprint than coal or oil (Howarth 2014) though there is still uncertainty as to the amount of greenhouse gases, specifically methane, being emitted from UOG wells. Research suggests that early studies likely underestimated the amount of methane being leaked from the North American natural gas system (Brandt et al. 2014). Fugitive methane emissions are a serious concern for global climate change (Howarth 2014), though reports have not indicated that CBM wells in the Powder River Basin are at a particularly high risk of leaking methane during the legacy phase (Bryner 2002).

Approximately 24,000 CBM wells were drilled in the Powder River Basin resulting in substantial surface disturbance (Bleizeffer 2015). Trainor et al. 2016 identify 'energy sprawl' as the most significant driver of land-use change in the United States. The authors analyze the landscape impact, or total land area required for production, for each energy resource. Their analysis found that among natural gas energy sources (shale gas, tight gas, CBM, conventional), CBM has the highest landscape-level impact (Trainor et al. 2016). In the case of Wyoming CBM, acres of semi-arid grasslands were converted to accommodate production. Due to the local geography, these rangelands are difficult to restore because of ecological constraints related to soil type and amount, precipitation, and erosion by wind (Norton and Strom 2013). The improbability of unassisted ecosystem recovery in the region is especially concerning because the legacy of CBM production in Wyoming includes at least 5,700 wells being declared orphaned[4] amidst a network of CBM-related infrastructure including access roads, power lines, water reservoirs, and compressor stations (WYOGCC 2017).

CBM production in the Powder River Basin is unique from other forms of UOG development. CBM is extracted from shallow wells drilled to less than 2,500 feet. There is no hydraulic fracturing or horizontal drilling involved in CBM production. Instead, depressurization of the coal seam is required in order to facilitate the escape of gas (Nghiem et al. 2011). The depressurization process mobilizes subsurface water which is often salt-rich. Produced water is reinjected, treated, used in livestock operations, stored

[4] Orphaned wells are, "wells for which the WYOGCC is unable to require the responsible party (owner or operator) to plug and abandon them and rehabilitate the surface because the responsible party no longer operates in the state, is bankrupt, or is out-of-business" (WYOGCC 2017).

in reservoirs, used for irrigation or dust control, or removed from the site. The contents and quality of the produced water dictate how it is handled during extraction. In the U.S. West, water from CBM development is most often discharged into surface reservoirs or reinjected underground (Nghiem et al. 2011). During peak extraction, a Powder River Basin CBM well produces approximately 40.32 million gallons of water pumped to the surface per day (Rice et al. 2000). Though not identical to other forms of UOG recovery, strategies to manage high volumes of produced water are required in the context of both shale gas and CBM.

Other characteristics of CBM development track closely with different forms of UOG production. CBM developed at a rapid pace and scale, similar to what is seen in other UOG resource plays. The urgency of industry activities is consistent across UOG geographies and types (Garvie and Shaw 2016; Lozano-Maya 2016), though some governments react to the fast-paced nature of the UOG industry by imposing bans (Chailleux and Moyson 2016; Ritchie 2014; Wegener 2013). This was not the case in Wyoming, where an adaptive or 'learn as you go' approach characterized the regulatory environment. The spectrum of UOG policy approaches are described in the next section.

Regulatory Approaches that Govern the Environmental Costs of UOG

Governance of UOG in the United States is understood to be particularly fragmented and disjointed (Kulander 2013; Rabe 2014; Warner and Shapiro 2013; Zirogiannis et al. 2016). Governance of the UOG industry lies predominantly in the hands of each state, and only with the federal government if drilling takes place on federal land. In the U.S., each state is responsible for regulating the industry, providing oversight, taxation, disclosure of information to the public, and creating and enforcing reclamation requirements. The responsibility of states to govern the natural gas industry within their bounds has yielded vast differences in regulation from state-to-state (Rabe 2014; Warner and Shapiro 2013; Zirogiannis et al. 2016). Warner and Shapiro (2013) state, "the federal government has largely and deliberately cut itself out of the regulatory picture in ways that are seemingly more conducive to the big business interests in the states and the states themselves" (475). This notion is affirmed by the 2005 Energy Policy Act which assigned state's jurisdiction over the oil and gas industry (Warner and Shapiro 2013). Rabe (2014) found state governance of UOG is largely dictated by political partisanship within the state, "a growing divide between strong-Republican and strong-Democratic states appears to be producing substantial variation in state policy development on the issue of shale governance" (8372). In fact, upon analysis of UOG policies, Rabe's (2014) primary conclusion is heterogeneity among states. State-dominated governance regimes often follow a horizontal or vertical pattern of diffusion, but UOG policy does not. Rabe attributes this to the relative newness of intensive natural gas drilling and/or the influence of partisan control.

More recently, four models of government and policy approaches to UOG development have been theorized (Witt et al. 2018). The authors first outline the adaptive approach as "allowing industry to proceed, then adapting and responding as required" (422). The cautious, or 'go-stop' approach sees development stall while regulations are tightened, and public perception is measured. Third, the innovative or 'do it the first time' approach requires information to be gathered, baseline studies to be carried out, and regulations reformed before industry activities begin. Last is the conclusive, or ‘ban it’ approach where, in response to public consensus, industry activities are completely or partially banned. In the U.S., since each state is responsible for UOG governance, there is no universal policy approach. Instead, individual states can be categorized based on Witt et al.’s (2018) four models of UOG governance.

According to Witt et al.’s (2018) framework, Wyoming can be characterized as having an adaptive policy approach. Fast-paced CBM development in Wyoming contributed to the regulatory environment being reactive rather than preemptive (Walsh and Haggerty 2018) though open questions remain as to how the adaptive policy approach contributed to substantial environmental legacy issues. Therefore, this case study explores mechanisms of environmental cost-shifting in the CBM fields of Wyoming. Specifically, the research addresses how the ‘learn as you go’ approach to regulating the CBM industry contributed to serious long-term environmental legacy issues.

Limited Legacy Research by Human Geographers

Despite a large and growing body of work by geographers on resource commodity chains, (Le Billon 2001), global value chains (Havice and Campling 2017) and global production networks (Bridge 2008), there is tendency for these analyses to be production-minded and negligent of ‘back-end’ (Coe 2012) or ‘backstream” (Bridge and Le Billon 2013) impacts and activities. One exception is the concept of environmental cost-shifting (Bridge 2009) which is one factor that has contributed to falling resource prices over time. Bridge (2009) explains that costs associated with the management of byproduct wastes and pollutants from resource production are deliberately under-estimated in resource prices. The result has been resource price decline, as the costs of environmental liabilities are often shifted to the state and/or related public institutions.

Environmental cost-shifting is facilitated through a variety of interrelated mechanisms that enable the environment and social costs of resource production to be ignored. Although the Powder River Basin experienced social change during the CBM boom, the scope of this work only considers environmental costs. Mechanisms act to shift the environmental costs of production to other spatial and time scales. For example, mechanisms include the "spatialization of environmental burdens" (Bridge 2009, 1232) where those who benefit most from resource production live away from sites of pollution and those who benefit least bear the brunt of environmental burdens. Characteristics of cost-shifting can be related to geographical as well as legal and economic dimensions. The presence and interconnectedness of cost-shifting mechanisms are a product of the regulatory environment in which they exist. This research seeks to identify the cost-shifting mechanisms that were at play during the CBM boom in Wyoming and the implications for environmental legacy management.

In line with this study's focus on CBM's environmental legacies, past research by geographers does feature inquiry related to environmental restoration (Eden 2002; Havlick and Doyle 2009; Smith 2013). Eden (2002) investigates how restoration has multiple meanings expressed through 'restoration rhetoric'. Havlick and Doyle (2009) describe that, overtime, restoration practitioners and scholars have expanded their focus to include human elements as well as technical science. The authors argue that geographers should become more involved in studies of 'restoration geographies' because of their ability to consider, analyze, and assess human-environment interactions. More recently, Smith (2013) describes the human geography perspective on restoration which, "is refocused back on the ways in which society engages with and experiences (restored) nature, and rationalizes ideas thereof" (354). Though these studies do not focus exclusively on restoration after energy resource production, they do open questions about the human dimensions of restoration that can best be answered from a geographic perspective.

Case Study Site: The Powder River Basin, Wyoming

This case study explores mechanisms of environmental cost-shifting in the CBM fields of Wyoming – a state that can be classified as an example of adaptive policy and governance. Specifically, the research addresses how the 'learn as you go' approach to regulating the CBM industry contributed to serious long-term environmental legacy issues. Powder River Basin CBM provides an example of some common UOG dynamics. The boom occurred at an extensive scale, development happened rapidly, and the landscape of industry operators was diverse and dynamic. Therefore, the case is instructive for the environmental management of post-production UOG in the U.S. and internationally.

The state of Wyoming typifies a resource-dependent economy, with 50% of the state's general fund revenues being derived from natural resources in 2014 (U.S. Department of the Interior n.d.). A leader in U.S. coal and natural gas production, extractive industries feature prominently in the state's history and heritage. In the U.S., 40% of coal is extracted from the Powder River Basin (U.S. Geological Survey 2013). The region consists of semi-arid grassland prairie with annual average precipitation between 12-18 inches (Chapman et al. 2004). Agricultural operations tend to focus on range livestock production at extensive scales. The state of Wyoming, like much of the U.S. West, is characterized by a split estate property regime. Split estate exists where the surface land and underlying minerals are owned separately by two different parties. A mosaic of private-, state- and federally-owned land and minerals created a patchwork property regime within which CBM development unfolded in the region (Walsh and Haggerty 2019). A more detailed description of the study site and the CBM production boom can be found in Walsh and Haggerty (2019).

The Legacies of Coalbed Methane Development

Only a small number of UOG resource plays are in the legacy phase. Powder River Basin CBM is one such resource play considering that production declined sharply beginning in 2010. 2019 CBM production rates were only 17 percent of what they were at peak in 2009 (WYOGCC 2020). Therefore, this case study is instructive for other locales that host UOG in their planning for decommissioning and environmental legacy management.

The CBM boom saw over 24,000 wells drilled within this 19,500 square mile basin across a matrix of private and public ranch land (Bleizeffer 2015; USGS 2013). The remote nature of the Powder River Basin required the initiation of infrastructure projects to facilitate CBM operations. Access roads, power lines, underground gas and water pipelines, compressor stations, and surface water reservoirs were constructed along with well sites. A number of context-specific characteristics set the Powder River Basin CBM resource play apart from other natural gas producing regions. Unlike the shale gas wells of the Marcellus in Pennsylvania or the Bakken in North Dakota, CBM wells in the Powder River Basin are shallow, with some being drilled to a depth of less than 1,000 feet. The physical properties of the resource, or CBM's materiality, act to open the resource play to a range of industry operators, from well-capitalized companies to small scale operations, since upfront costs to drill shallow natural gas wells are low.

As is true of most energy booms, CBM development unfolded at a rapid pace and on a scale few had predicted. After production declined, approximately 5,700 orphaned CBM wells remained (WYOGCC 2017) along with considerable uncertainty about who would take responsibility for well and land reclamation. A number of studies were conducted related to the orphaned well phenomenon to project clean-up costs and asses water law pertaining to discharge permitting and groundwater protection (Andersen et al. 2009; Andersen and Coupal 2009; Bryner 2004; Buccino and Jones 2004). Studies revealed that for orphaned gas wells in Wyoming between 1997-2007, there was a difference of $22,253 in the bond amount paid per well and the actual cost of reclamation (Andersen et al. 2009). Related media articles appeared frequently in local newspapers focusing on inadequate bonding (Richards 2017a), the cost of orphaned well management (Richards 2016) and litigation against negligent CBM operating firms (Storrow 2016). The environmental liabilities of Powder River Basin CBM are still being managed, discussed, and reported on though there are open questions about how the adaptive policy approach contributed to environmental cost-shifting and how stakeholders perceive lasting environmental change.

Methods: Qualitative Approach

The research design features an overarching qualitative case study approach. According to Rust et al. (2017), "qualitative research tends to study specific cases for maximum exploration using an inductive approach with a smaller, often nonrandom, subset of a population" (1305). This study adheres to this definition of qualitative research especially in its use of single case study and purposive sampling techniques.

Part of this qualitative methodology includes document analysis. Document analysis is relied on in order to analyze institutional reports, press releases, letters and memoranda, and various public records. Document analysis, "requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge" (Bowen 2009, 27). Document analysis is particularly well-suited to case study research (Bowen 2009) and mixed-methods research to foster triangulation (Bowen 2009; Patton 1990). Policy analysis is also a component of this research. Approaches to policy research vary, as no distinct set of methodologies exist. However, common themes that emerge in policy research have been noted (Blackmore and Lauder 2005). The desire to decipher between the intentions of policymakers and what is truly taking place is a pervasive theme that applies to this study.

Description of Sample and Interview Protocol

Data were collected by thirty-six semi-structured interviews with a diverse sample of forty stakeholders involved in all aspects of coalbed methane production activities (Table 5.1). The sampling frame was defined by the geography of the Powder River Basin, WY. Specifically, the sample includes thirteen surface owners that hosted CBM development on their property; six oil and gas attorneys based in Sheridan, Buffalo, and Gillette, WY; five industry personnel that have been involved in the extraction of CBM in the region; six local government employees; an employee from a regional NGO; a reclamation contractor based in the Powder River Basin; and eight State and Federal Officials representing the Wyoming Oil and Gas Conservation Commission, WY Department of Environmental Quality, WY State Engineer's Office, and the BLM. Together, the sample addresses the variety of stakeholders involved in coalbed methane development. Coalbed methane production declined nearly a decade prior to this study; interviewees were providing a *post facto* assessment.

Stakeholder group	**Number of Interview Participants**
Surface Owners (SO)	n=13
Agency Staff (AS)	n=8
Attorneys (AT)	n=6
Government Employees (GV)	n=6
Industry Personnel (IP)	n=5
NGO Employee	n=1
Reclamation Contractor	n=1
TOTAL	**n=40 interviews**

Table 5.1. Interview Sample

Purposive sampling was used to ensure participants had relevant experience with CBM development. The sample was therefore non-random and recruited using referrals from a local community partner, snowball sampling, and cold-calling and e-mailing. On average, interviews lasted one hour and took place at participant homes, local cafes, breweries and offices. Each interview was audio recorded with the permission of the participant. Each audio recording was professionally transcribed and coded according to the principles of grounded theory (Glaser and Strauss 1967).

Features of Wyoming's Adaptive Policy Approach for Environmental Cost-Shifting

Using data collected in interviews and document analysis, this *post facto* assessment describes the dynamics of Wyoming's adaptive policy environment and its evolution over time. The consequences of this governance approach for cost-shifting are related to three primary features of the policy environment: (1) industry operators faced a low barrier to participation in the CBM play; (2) the regulatory environment failed to anticipate widespread turnover amongst the CBM industry cohort; and (3) a few consequential bankruptcies resulted from the pattern of industry turnover and contributed to the proliferation of orphaned CBM wells. Findings reveal that regulatory change did take place overtime, though adaptation did not occur soon enough to prevent widespread environmental legacy issues.

Low Barrier to Industry Participation

For industry companies, there was a low financial barrier to entry into the Powder River Basin's CBM fields due to the relaxed regulatory environment as well as the material properties of the CBM resource. Bond amounts required by state and federal governments were low and accompanied by inexpensive permit costs. Materially, coalbed methane wells are shallow, drilled to less than 2,500 feet, and therefore affordable to drill in comparison to hydraulically fractured shale gas wells, for example. One regulator said, "Everybody who had a backhoe and cheap drill rig was out here buying a lease and trying to produce gas because most of these wells are fairly shallow" (AS1). A local government official said:

> *"there was a whole lot of these smaller outfits that... you just needed a water drilling rig for methane. You didn't need a big rig like they use for oil...You could buy a rig and get your leases and start drilling"* (GV1)

Because wells were inexpensive to drill, the opportunity to produce Powder River Basin CBM was available to a high number of industry firms of different types.

Financial assurance bonds required by the state and federal governments prior to drilling were universally described as being much too low (Table 5.2). During the height of CBM production in the Powder River Basin, for state-managed wells, an individual well bond in the amount of $10 per foot of well depth was required, or a $100,000 blanket bond that covered all wells drilled by single company across the state. For federal wells, an individual well bond cost $10,000 and a state-wide blanket bond cost $25,000.

Stakeholder Group	Qualitative Data Regarding Low Bond Amounts
Agency Staff	“not sufficient” (AS1) “too low” (AS2) “the bond amounts required didn’t scare industry enough to force their hand to actually reclaim” (AS3)
Attorneys	“bonding requirements were pretty low” (AT1) “state could have had a substantially better bonding situation” (AT2) “it’s not a reclamation bond and doesn’t create any incentives for reclamation nor does it provide money for the government should a company forfeit and go under” (AT3)
Government Employees	“the bond wasn’t enough to cover when you had to go back in and reclaim and some of these companies would just bail and they’d go bankrupt” (GV1) “not enough bond collected at the beginning” (GV2)
Surface Owners	“the bond was so little” (SO1) “the state was asleep at the wheel in getting their bonding” (SO2) “the bonding was too cheap” (SO3)

Table 5.2. Qualitative Data Describing State and Federal Bonding Requirements

Many participants commented that bond amounts were kept low in order for the state to remain “business-friendly” (GV4). A state agency official explained, “there’s some point where if you have a higher bond amount then [oil and gas industry] are just not going to come to your state” (AS6). An attorney described that, “You've got to walk a fine line with that stuff, you don't want to discourage, especially in this state when we're so reliant on that revenue. We want new wells to get drilled because that revenue keeps us afloat” (AT2). Together, qualitative data revealed that bonds were generally described as being too low as to not discourage oil and gas industry activity within the state.

Review of documents reporting on the costs associated with the State of Wyoming well plugging program found that there is a difference of $3,380.63 between the amount of bond paid per well compared to actual clean-up costs (Table 5.3).

However, there is a substantial range with some wells costing as little as $2,708.96 to reclaim and others up to $29,627.37. Considering that at least 5,700 CBM wells were declared orphaned in the Powder River Basin, a shortfall of approximately $19.2 million exists between the bond funds collected and the actual cost of reclaiming orphaned well sites. Although the monetary cost seems manageable or even low relative to what the state earned from CBM production and industry producers, the environmental costs are high. The landscape-level impact of producing CBM is highest of any natural gas energy source, and the geography of the Powder River Basin is unforgiving. Environmental degradation is unlikely to correct itself over time, and intervention is required to facilitate reclamation of production sites and associated infrastructure.

WYOGCC Orphaned Well Program (2014 – September 2019)

Total cost of reclaiming orphaned wells	$12,722,994.00
# of wells reclaimed by WYOGCC	2,361
Cost of reclamation (per well)	$5,388.82
Average bond collected (per well)	$2,008.19
Difference between bond collected & actual reclamation cost (per well)	**$3,380.63**

Table 5.3. Cost of Wyoming's Well-Plugging Program for CBM Wells

Moreover, though permits were required in advance of drilling, permit costs were low. According to the qualitative data, the state Application for Permit to Drill (APD) administered by the Wyoming Oil and Gas Conservation Commission were originally

$50 per well and have since increased to $500 per well. For federal wells, in the early 2000s the APD administered by the BLM cost $4,500/well. Permit costs then increased to $6,500 and now it costs $10,000 per well to obtain an APD.

Together, the upfront costs to produce CBM in the Powder River Basin were low, and therefore not prohibitive allowing a spectrum of industry companies, from well-capitalized international firms to small-scale operators, to participate in the production of the CBM resource. Small-scale operators pose a greater risk to environmental legacy management since they have less capital and resources to fulfill their reclamation obligations.

Unanticipated and Widespread Industry Turnover

In total, 254 CBM companies applied for 76,305 APDs in the Powder River Basin. The data revealed that there was great turnover of CBM assets amongst industry operators and that company turnover followed a typical pattern. According to one attorney:

> *"the big company [comes] in and [drills] all the wells...taking all the good production and as soon as production starts to fall off they'll sign or sell their lease...to a mid-size company and the mid-size company produces that asset until it falls below their standard of production. They sell it to a small guy and small guy does it as long as he can, until he goes bust basically. Soon as he goes bust you have a small guy you can't collect anything from"* (AT2)

The regulatory environment failed to anticipate the high degree of ownership turnover that would come to characterize the CBM operator cohort. Stakeholders described that it was typical for CBM wells to change ownership several times (Figure

5.1). No regulations or rules prevented industry lease sales, re-assignments, mergers, or acquisitions. The WYOGCC did not track industry operators that had a history of bankruptcy and bond forfeiture, allowing them to re-emerge in the CBM fields under new company names (Richards 2017b). In addition, the pattern of industry turnover is significant because bigger companies often fulfill reclamation obligations or sell their leases and do not forfeit bonds because of reputational effects. One agency staff member explained, “those bigger companies were a little more concerned about their reputation” (AS4). The result was small-scale operators holding the greatest number of CBM assets as production waned.

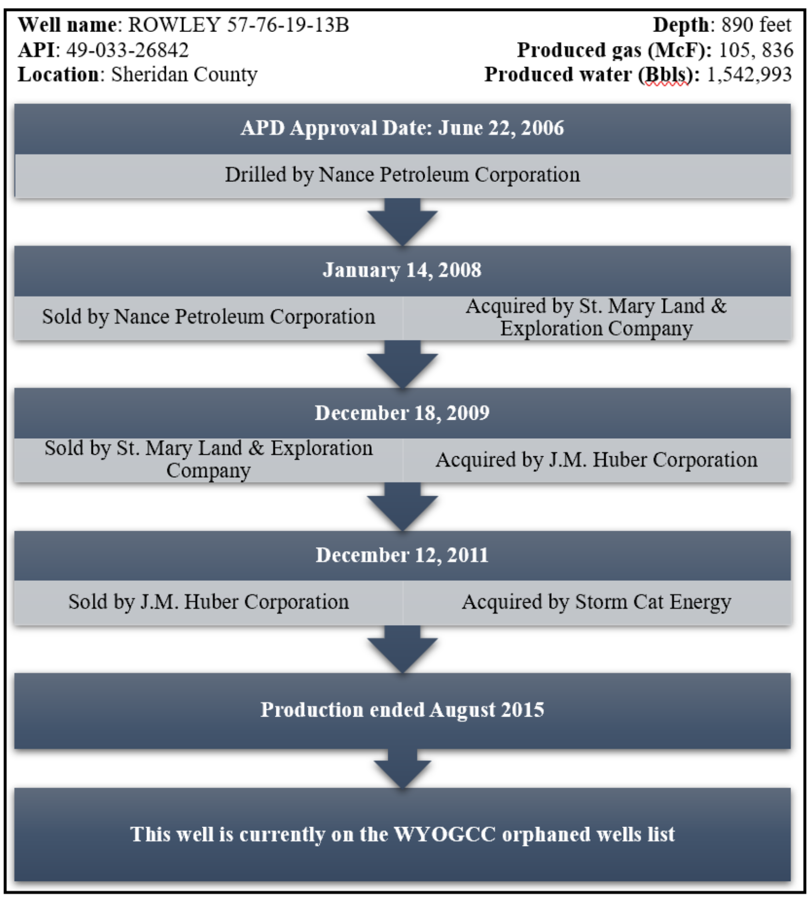

Figure 5.1. Ownership History of One CBM Well

<u>Consequential Industry Bankruptcies</u>

At the conclusion of the CBM play, a few small and under-capitalized companies remained. As described by one attorney:

> *"The Anadarkos of the world sold out to smaller companies many of which didn't have a lot of financial wherewithal to begin with and a lot of them are in bankruptcy, have been in bankruptcy or some haven't even had enough money to file for bankruptcy, they just leave and don't even go through bankruptcy. They just disappear and are gone. So there's been a real issue with orphaned wells and reclamation"* (AT3)

As resource prices declined, a few smaller operators continued to acquire a high number of CBM assets. These small-scale operators were unable to fulfill reclamation requirements as outlined in SUDAs and as required by state and federal law. This resulted in bond forfeiture and orphaned well status for those CBM development sites. These late-stage operators often did not have adequate resources to cover all of the reclamation liabilities they inherited which led them to bankruptcy. For example, two small companies had abundant CBM mineral holdings when natural gas prices fell in 2008 and the CBM play began to bust: High Plains Gas and Storm Cat Energy. These two companies were actively securing CBM assets after initial price declines.

High Plains Gas produced CBM from March 2007-May 2012. During that timeframe, the Henry Hub natural gas spot price fell from $7.11 to $2.43. In 2014, the state of Wyoming took responsibility for reclaiming 2,300 wells that once belonged to the company. High Plains Gas closed its doors owing about $50 million in unpaid taxes, royalties, and debts. The company did not have the funds to formerly declare bankruptcy.

Storm Cat Energy began producing CBM in March 2004, when the natural gas spot price was $6.58. Production ended in June 2015 with a spot price of $2.78 (United

States Energy Information Administration 2020). Storm Cat Energy then declared bankruptcy, and at least 1,008 of their CBM wells have been declared orphaned. Together these two operators are responsible for over half of all orphaned CBM wells. Wyoming's 'learn as you go' approach failed to anticipate or prevent these bankruptcies which greatly increased the scale and severity of legacy management issues.

Adaptation Over the Course of the CBM Play

However, regulatory change did occur as CBM production advanced, indicating that the state policy environment was, in fact, adaptive. For example, modifications were made to improve bonding structure. The WYOGCC increased bond amounts required by industry operators, but the new bond amounts were not effective until February 2016, well after CBM production had slowed. Another component of bonding changes included the requirement that bonds be submitted for idle wells. One attorney explained: "the state was a little behind and the bonds were inadequate but over time they caught up and are demanding additional bonding for idle wells" (AT4). According to chapter three of the WYOGCC rules, "wells which are not producing, injecting, or disposing in an economic manner are deemed to be idle" (3-7). The realization that idle wells were at increased risk of abandonment and orphan status prompted this rule change. The new rule mandates that idle wells to be bonded an additional $10 per foot of well depth.

As described earlier, a few small CBM operators contributed most to the proliferation of orphaned wells. Companies like High Plains Gas and Storm Cat Energy were producing thousands of wells as prices dropped, and failed to manage their environmental liabilities due to inadequate capital. Despite the absence of state or agency rules to regulate such industry dynamics, legal counsel recognized that smaller operators were acquiring more CBM assets and acknowledged the risk associated with their limited capital and likely inability to fulfil reclamation obligations. Attorneys began to write contract terms that required surface owners approve lease transfers so they could investigate the new company. If surface owners were not satisfied with the new company's finances or reputation, they could refuse to allow the transfer. Attorneys adapted their practices to protect their clients from the risks associated with undercapitalized, small-scale operators. However, these kinds of updated contract terms were not included in many early SUDAs and therefore had limited impact.

Government Intervention to Manage Orphaned Wells

Industry bankruptcy required state/federal involvement to reclaim orphaned wells. In December 2013, Wyoming's Governor Matt Mead created a state well plugging and cleanup program to begin reclaiming wells on the orphaned wells list. Prior, from 2004-2013, the state had only cleaned up 183 orphaned wells (Storrow 2013). Governor Mead's program set out to reclaim 1,200 wells over the course of four years using funds collected via the production tax paid by industry operators. Funds allocated to this program totaled approximately $7.7 million. According to a WYOGCC update, "In 2019, a total of 533 wells were removed from the orphan well list. Since 2014, 2,802 total wells have been removed" (WYOGCC 2019). Progress is underway, although only about half of an estimated 5,700 orphaned CBM wells have been reclaimed. This program attends only to the well site and does not reclaim any related CBM infrastructure no matter what terms may have been agreed upon by the surface owner and former industry operator in the SUDA.

Federal governance of oil and gas wells differs from states. Importantly, the BLM has Record of Title authority which states do not. Record of Title authority allows the BLM to hold responsible any industry operator/mineral owner who has an interest in the lease (a record title holder) no matter if they actively produced the well. Therefore, the BLM can pursue record title holders until they find a viable, solvent company who is then responsible for the reclamation. A BLM agency staff member explained:

> *"[BLM] go after operator record, or title holder…we currently have nearly 3,000 wells that we have notices and intent to plug and abandon. A fair number of those are being submitted by the record title holder so there's a lot of effort and...planning…we're going to be plugging a lot of wells in the near future"* (AS5)

However, as eluded to by this staff member, this process has high administrative costs and is time-consuming, but fewer orphaned wells are reclaimed using federal funds. In fact, the BLM agents interviewed for this research reported that they only had 106 orphaned federal CBM wells, but other qualitative data disputes this figure and suggests the number is likely higher. Nationwide, a 2018 Government Accountability Office report indicates that the BLM does not properly track data on potential liabilities and the costs of reclaiming orphaned wells (U.S. GAO 2018). Together, the data reveals that CBM production in the Powder River Basin created long-term environmental legacy issues.

Discussion

As stated by one attorney, "the methane play was initially cost effective because the industry was externalizing its costs" (AT4). Together, the data reveal that Wyoming's adaptive policy approach created openings for cost-shifting mechanisms to gain foothold, leading to serious long-term environmental legacy issues. Data indicates the existence of three specific cost-shifting mechanisms for CBM in Wyoming: (1) regulatory misalignment; (2) overadaptation to the oil and gas industry; and (3) industry bankruptcy.

Regulatory misalignment is mismatch between the existence and substance of regulations and the legacy issues that need mitigating. In the case of UOG policy in Wyoming, the 'learn as you go' approach created a regulatory environment that was not well-suited to manage upcoming industry activity and the environmental costs of production. Regulations were absent or insufficient and there was significant lag time between when issues emerged and adaptations were implemented. All the while, as reported in earlier research, CBM production was occurring in a region marked by jurisdictional complexity (Walsh and Haggerty 2018). Confusion about authority acted to further entrench the adaptive policy approach since questions about jurisdiction stalled the regulation of activities that were fundamental to the process of CBM extraction and had high environmental consequences. As mentioned by participants in our sample, management of the water removed from CBM wells was challenging, and regulations outlining proper management procedures did not exist when CBM production began and rapidly increased. The result was destructive environmental change due to flooding of bottomlands by discharge waters which are known to increase salinity of soils and increase the potential threat of invasive vegetative species (Stearns et al. 2005).

Another mechanism of cost-shifting exhibited in the case study of Powder River Basin CBM is overadaptation. Overadaptation to the oil and gas industry is risky considering the volatility of commodity prices tied to global markets. In Wyoming, because of the state's reliance on natural resource production for revenue generation (U.S. DOI n.d.), there is overadaptation to the oil and gas industry to the detriment of longer-term consideration of environmental impacts. Bond amounts and APD permit costs were inexpensive and did not provide a significant barrier to industry participation in the resource play. The state was slow to adapt to the growing challenge of environmental legacy management by increasing bond and permit amounts to adequately fund reclamation. Participants shared that these upfront costs were kept low so as not to discourage industry activity within the state.

A third cost-shifting mechanism that contributed to serious environmental legacy issues in the Powder River Basin was industry bankruptcy. A few consequential industry bankruptcies contributed most to the proliferation of orphaned wells. Boomhower (2014) explains that, "one important implication of bankruptcy protection is that firms in hazardous industries will take excessive environmental and public health risks" (1). This was the case for small-scale, late-stage operators like Storm Cat Energy and High Plains Gas. Measures to review industry ownership change to limit small-scale operators from being responsible for reclaiming a disproportionate number of CBM assets were not in place. Liability was limited by bankruptcy protection, resulting in reclamation obligations being shifted to the state or federal government.

A 2019 report from the Government Accountability office estimates that the federal government may be responsible for between $46 and $333 million for oil and gas well reclamation due to industry bankruptcies (U.S. GAO 2019). The state of Wyoming has had to pay approximately $12.8 million to reclaim 2,361 wells, only half of the total orphaned CBM wells that exist. There is growing national concern about the number of abandoned oil and gas wells across the country, accountability for causing environmental harm, and who is responsible for managing and paying for clean-up (Bloom 2019; Coletta 2020; Olalde and Menezes 2020). Rapid energy development in the U.S. after the shale revolution has just begun to elevate questions about legacy management in individual states and across the nation (Walsh and Haggerty 2018).

The environmental liabilities of CBM that were originally the responsibility of private industry firms were transferred to state and federal governments as a result of a few consequential industry bankruptcies. However, government management, like Wyoming's state well plugging program, attends only to the well site which is inadequate considering CBM production's high landscape-level impact (Trainor et al. 2016). Associated CBM infrastructure, like access roads, power lines or compressor stations, are not reclaimed as part of the state's program, even if original contracts between the surface owner and former industry company required such activities. Therefore, an additional consequence of cost-shifting in Wyoming is that full reclamation to pre-disturbance conditions is not achieved. This is exacerbated by a related implication of environmental cost-shifting in this context: the reclamation of semi-arid grasslands is incredibly challenging as the climate and geography of the region limit reclamation success (Nasen et al. 2011; Norton and Strom 2013; Viall et al. 2011).

As noted, not all CBM operators declared bankruptcy abandoning their reclamation obligations. Instead, reclamation outcomes were firm-dependent. Other studies have noted that differences in local outcomes of UOG development are a result of differences between industry firms conducting operations (Bugden and Stedman 2018; Haggerty et al. 2019). Future studies should be careful not to describe industry behaviors as monolithic since there is variability from one operator to the next.

Conclusion

This case study explores mechanisms of environmental cost-shifting in the CBM fields of Wyoming. The research addresses how the 'learn as you go' approach to regulating CBM industry activities contributed to serious long-term environmental legacy issues. This case study of Powder River Basin CBM identified three specific cost-shifting mechanisms: (1) regulatory misalignment; (2) overadaptation; and (3) industry bankruptcy. This analysis has contributed to the literature on the 'backstream' phases of oil and gas production, specifically well and land reclamation. In doing so, we have expanded upon the emerging scholarship on restoration geographies by examining a real-time example of environmental cost-shifting: a case that draws on theory but is applied in nature.

The orphaned well phenomenon in the Powder River Basin, Wyoming provides a rich case to examine and analyze the challenges associated with governing post-production oil and gas activities. As larger shale plays begin to enter the legacy phase of development, research concerning timely and effective reclamation will be at a premium. Data collection by way of a qualitative case study research design found that the management of CBM's environmental liabilities have been subject to cost-shifting. Our analysis suggests that research into UOG legacy effects relative to governance and policy approach is an important avenue for future research.

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CHAPTER SIX

CONCLUSION

At the time this study was conceptualized, there was no known research published related to the human dimensions of post-production oil and gas activities and outcomes. The technical aspects of reclamation were well-studied in journals like *Ecological Restoration* and the *Journal of Environmental Management*, but examination of how social factors influence the scale and extent of legacy effects was not yet a topic of study. However, there was growing acknowledgement that increased energy resource production after the shale revolution was converting acreage at an alarming rate – a domestic land-use phenomenon referred to as energy sprawl (Allred et al. 2015; Trainor et al. 2016). Even so, scholarly research had yet to consider oil and gas legacy effects from a geographical or social science perspective.

Therefore, a case study of the legacy effects of a period of CBM development in the Powder River Basin, Wyoming was conducted for this dissertation. Preliminary research revealed that the Basin was host to thousands of orphaned CBM wells no longer tied to responsible industry operators. The post-production challenges facing the region were well publicized and actively being managed. Researching the social dimensions of CBM's legacy effects emerged as an opportunity to conduct applied case study research whilst contributing to known gaps in the literature. For example, serious policy analysis had been absent from the work of energy geographers (Solomon et al. 2003; Jiusto 2009; Huber 2015), and this dissertation provides a novel contribution to geographic scholarship through its analysis of federal and state oil and gas reclamation policy. Rural sociologists had drawn attention to the lack of studies offering a longitudinal perspective on resource development (Freudenberg 1992) or examination of the complete development process and "better knowledge of the longer-term picture" (Jacquet 2014, 8328). Though this dissertation is not a true longitudinal analysis, it is a *post facto* assessment that draws on data collected approximately fifteen years after production declined. Findings shed light on the longer-term legacy of CBM development for the people and environment of the Powder River Basin. Though the study intended to capture *post facto* perspectives from the outset of the project, the overall research design evolved in response to emerging areas of interest in the academic literature, popular media, and from government agencies.

Research Evolution

As this research was in progress, scholarly, media, and government attention to post-production oil and gas activities burgeoned. The National Academies convened a panel on unconventional hydrocarbons with a two-day meeting dedicated exclusively to legacy issues (National Academies of Sciences, Engineering, and Medicine 2018). The Government Accountability Office published multiple reports examining the management of the environmental liabilities of oil and gas production (GAO 2018; GAO 2019). Countless press articles were published reporting uncertainty surrounding the scale of domestic oil and gas well abandonment issues and their likely cost (Bloom 2019; Richards 2017). Meanwhile, the scholarly literature began to feature studies considering

SLO in the context of UOG (Brueckner and Eabrasu 2018; Luke et al. 2018; Shaffer et al. 2017; Zhang et al. 2018), examining how rural landowners define and experience the costs and benefits of energy development (Bugden and Stedman 2018; Haggerty et al. 2019), and investigating the longer-term environmental risks of oil and gas production (Davidson 2018; Patterson et al. 2017).

Originally, this dissertation sought to better understand the range of reclamation activities occurring across the Powder River Basin after CBM production declined. To a certain extent this objective has been achieved. Chapter Two provides context to better understand the regulation of post-production oil and gas, while each remaining article captures the nuance of a particular reclamation status or scenario. Chapter Three draws attention to landowner dissatisfaction with reclamation and eventual litigation while Chapter Four examines how landowners accommodate development and forgo reclamation. Finally, Chapter Five investigates the liabilities of CBM and analyzes cost-shifting mechanisms for environmental legacy management. However, to be in conversation with the scholarship on SLO and growing concern over the environmental risks of UOG development, the project evolved from what was originally proposed. The final dissertation shifted to focus on landowner experience and involvement with CBM decision-making processes, rather than focusing only on reclamation activities. In accordance with grounded theory, this shift was also the result of the data being collected in the field and the theories that were emerging from that data.

For example, the interview data collected during initial fieldwork described and emphasized the importance of landowner-industry relations, especially in the context of landowner involvement in energy project planning. I heard stories of industry companies and their representatives being welcomed onto properties, and other stories where disagreement and contention led to the erosion of the landowner-industry relationship. Through analyzing the qualitative data, landowner-industry relations on Wyoming ranches emerged as being akin to a type of SLO. The concept of 'private participation' surfaced as an especially vital component of CBM's SLO which had real bearing on the reclamation activities (or lack thereof) occurring on ranches. Research projects are dynamic, and completing this dissertation was no different. Its evolution produced a number of significant findings that can be directly applied to policy improvement and also propel the academic scholarship forward.

Synthetic Findings

This dissertation examined how political and social factors influenced how CBM production and reclamation activities unfolded and continue to unfold in the Powder River Basin, Wyoming. Using a qualitative case study approach, the expertise and experiences of stakeholders made up the bulk of data supplemented by document and policy analysis. Research design and data analysis strategies informed by grounded theory led to the emergence of several novel findings related to the guiding research question and associated research objectives.

First, management of post-production oil and gas activities constitutes a highly complex governance challenge. Three key factors interfere with the effective definition, regulation, and implementation of CBM reclamation: (1) the absence of clear guidance from the scientific literature about what constitutes successful reclamation; (2) the complexity of both the jurisdictional environment and the oil and gas sector for CBM; and (3) a lack of political will in the state of Wyoming to engage in pre-emptive environmental regulation. At the time these findings were made, only initial fieldwork had been conducted. Additional data collection revealed that the option to forgo reclamation deepens the challenge of governing post-production oil and gas. Considering this option is acceptable within Wyoming's current regulatory structure, avoiding long-term destructive legacy effects from CBM is unlikely. Preserving the option to forgo reclamation privileges individual property rights over cumulative environmental outcomes and create risks of permanent surface degradation and landscape change.

Other contextual research showed that the split estate property regime has implications for energy development and how CBM reclamation proceeded in the region. Subsurface minerals are owned by governments or private individuals, and there is no legal requirement that surface owners be notified of any mineral ownership change or lease agreements. However, the surface must be used to access underground mineral resources, elevating the importance of landowner-industry relations on the ground and as a topic of study.

Investigating landowner-industry relations revealed that individual actors, namely surface owners, play an important role in CBM project planning by way of 'private participation'. SLO provides a useful framework to analyze and interpret how landowners accept or accommodate development. Mutual respect, procedural fairness, and trust were necessary preconditions of SLO which created an opening for surface owners to engage in private participation and advocate for their instrumental priorities. The ability of surface owners to influence and benefit from infrastructure development underpins all dynamics of SLO generation. However, presence of SLO does not translate to positive environmental outcomes. This study demonstrates clear environmental implications of the individual negotiations between surface owners and CBM companies, or private participation. Landowners made deliberate choices about use of their surface, especially related to infrastructure, with vision for how their ranching operation could be upgraded for the future. However, the fact that private surface owners often negotiated to acquire CBM related infrastructure for long-term use on their ranches usually resulted in forgoing reclamation entirely. Here, surface owner choices contributed to the known U.S. land-use phenomenon of energy sprawl (Allred et al. 2015; Trainor et al. 2016) and increased the cumulative surface acreage disturbed by energy development.

Lastly, an ‘adaptive’ environmental policy approach enabled the environmental costs of CBM to be shifted across space and time. The ‘learn as you go’ approach to regulating CBM industry activities contributed to serious long-term environmental legacy issues. In Wyoming, 5,700 CBM wells were declared orphaned, and well-plugging became the responsibility of the state or BLM. This case study identified three specific cost-shifting mechanisms: (1) regulatory misalignment; (2) overadaptation; and (3) industry bankruptcy, that contributed to issues with environmental legacy management and stalled reclamation.

This dissertation revealed that acceptance and satisfaction with energy development and distrust and litigation against industry operators can exist simultaneously within one resource play. This research began to unpack why there is variability in experiences, but additional study is needed to expand our understanding of the spectrum of resource development outcomes. An important component of future studies should be attention to local policy approaches to learn how differences in governance influence legacy outcomes.

Findings advance our understanding of the national land-use phenomenon of energy sprawl by elevating the importance of social contexts together with the technical dimensions of energy development and reclamation. Research found that private participation complicates efforts to mitigate the cumulative environmental impacts of energy development. To the best of my knowledge, this study is the first to explore and describe the important role of individual actors, and that the desires of individual people have real bearing on how development proceeds and the level and type of reclamation that is completed. Though civil society organizations have been well-researched in the context of environmental governance, the role of charismatic individuals is deserving of additional scholarly attention.

Policy Recommendations

Each chapter of this dissertation has described aspects of the regulatory environment for oil and gas reclamation and shares implications for policy. This section translates conclusions into a set of policy recommendations which are discussed in conversation with examples from other geographies.

This case study research has produced the following policy recommendations to strengthen the regulatory environment for UOG reclamation: (1) implement standards for interim reclamation; (2) introduce a time limit on abandonment status to supplement idle well bonding; and (3) establish mechanisms to review asset transfers between operators.

First, interim reclamation, or "partial reclamation during production activities" (BLM n.d.) is known to reduce the overall cost of reclamation projects (Igarashi et al. 2014) and more quickly stabilize and revegetate the well site (Stahl 2010). Interim reclamation accounts for the fact that industry operators have more capital resources while production is occurring. For this reason, should adopt statutes requiring interim reclamation. Regulatory strategies to achieve this include maximum allowable disturbed acreage where there is a cap on the amount of acreage a single industry company can disturb. Therefore, some reclamation would be completed before the company could expand its operations.

In Colorado, for sites featuring hydraulic fracturing, interim reclamation must begin three-twelve months after fracking is complete. However, like Wyoming, there are no set time limits for finishing interim or final reclamation (Finley 2016). Suggestions that Wyoming's oil and gas policy include mandated interim reclamation are not uncommon. Andersen and Coupal (2009) suggested that the state adopt a policy framework that includes interim reclamation requirements. Stahl (2010) championed a policy program where operators get credit for successfully completing interim reclamation that would decrease the overall time a site remains disturbed while creating incentives for producers.

Second, as discussed in Chapter Five, based on the acknowledgment that idle wells pose additional environmental risk, the state of Wyoming requires idle wells to be bonded at an additional $10 per foot of well depth. To support and strengthen this change, a policy imposing time limits on abandonment status should be established. Temporary abandonment time limits impose a limit on the amount of time a well can remain abandoned before either producing again or being thoroughly decommissioned. Currently, the state of Wyoming imposes no time limits. The state of Colorado does have temporary abandonment time limit of six months, and by comparison, fewer inactive oil and gas wells that have yet to be decommissioned (5%) than Wyoming (9%) (Ho et al. 2016). Without a time limit, abandonment extensions have been shown to lengthen cleanup time limes in places like Texas and North Dakota (Alboiu and Walker 2019).

Lastly, Wyoming should institute mechanisms to review asset transfers between industry operators. Evidence from this research suggests that CBM assets were transferred from larger, well-capitalized firms to small-scale operators that did not have the financial resources to cover their environmental liabilities. The state should look to create an oversight program, likely within the Wyoming Oil and Gas Conservation Commission, in which regulators ensure the financial stability and compliance record of operators purchasing assets. State legislators could also amend the Split Estates Act of 2005 to require initial operators to be fully, or at least, partially liable for well decommissioning and site reclamation (Ho et al. 2016). The federal government has record of title authority, allowing the BLM to pursue past operators to fulfil reclamation obligations, and have far fewer orphaned wells to manage.

Limitations and Reflections

Despite making many important contributions to scholarship, this research is not free from limitations. First, CBM is not a traditional form of UOG that requires deep wells, horizontal drilling, or hydraulic fracturing. Therefore, there is limited generalizability to other resource plays like those in the Marcellus Shale of Pennsylvania or Permian Basin of Texas. The geography of the Powder River Basin, namely its remoteness and rolling hills of semi-arid grasslands, played an important role in how development unfolded and the opportunity for reclamation success. Consequently, the results of this dissertation cannot be generalized to other geographies that are more urban or less arid, for example.

This study can be characterized as a *post facto* assessment of CBM development and reclamation activities. Inherent to post facto research are difficulties related to participant memory. I found that participants were not always able to recall specific details related to the CBM development process or the timing of certain events or activities. In an effort to enhance recollection, participants were presented with relevant documents to 'jog' their memory, or we would embark on ranch tours where the landscape assisted participants in remembering details about CBM development and reclamation activities.

Recruitment of study participants was difficult due in part to the *post facto* nature of this study. Recruitment of industry personnel was especially challenging but critically important to the research and therefore worth extra time and effort. After reaching out to all potential participants suggested by a trusted community partner, only one industry interview had been conducted. Ultimately more creative strategies were implemented to build the industry sample. For example, I searched the WYOGCC list of APDs for active CBM company names. This produced a short list of companies which I used to search the Wyoming Secretary of State website, where all businesses located in Wyoming are listed along with a representative and their contact information. I used the published contact information to cold-call and cold-email potential participants. This process resulted in one interview. I was able to secure another industry interview after scouring CBM-related newspaper articles for quotations from industry representatives. I then searched on-line for the quoted individual's contact information, reached out to the individual, and eventually scheduled and completed one interview.

Despite my creative efforts, only five industry personnel were interviewed over the course of this project. As reported in the dissertation, most industry companies that were active during the height of CBM development are now defunct, and therefore not listed with contact information on the Secretary of State website. Bankrupt companies have no phone number or web presence, and therefore no convenient 'staff listings' or 'contacts' webpages to use to connect with potential study participants. There are no more CBM industry networking events, workshops, or conferences being held in the Basin that would have been sites to meet potential study participants. Many industry personnel that were employed in CBM have since re-located outside of the study region. At the height of CBM production, the landscape of industry operators was diverse and robust but has since completely evaporated making recruitment of industry personnel incredibly difficult if not near impossible.

Taken together, this dissertation helps us to assess how well we can use qualitative data to study a phenomenon that occurred over a decade ago. Over the course of 15-20 years, people move, priorities change, and memories fade. In *post facto* research, some challenges related to memory and recruitment are to be expected. I argue that these challenges are exacerbated in the context of oil and gas and the communities that host production. Since *post facto* research occurs during the years following resource bust, community activities related to energy governance and planning are infrequent if occurring at all. The workforce is inherently transient, and with little production industry personnel are often relocated or relocate themselves to a region with greater opportunity. Participants were sometimes reluctant to discuss activities of the past as they had moved on and preferred to look ahead rather than backward. In energy communities, there is a general tendency to be forward-facing – looking ahead to the next boom or engaging in a type of 'amnesia' about eventual bust during production peaks. Potential participants were focused on the activities of today and some declined interviews because, to them, CBM was no longer relevant.

However, the challenges experienced over the course of this project should not deter social scientists from performing *post facto*, qualitative research in energy communities. Instead, project planning and research design should be informed by the acknowledgement of these potential difficulties. For example, the time frame for participant recruitment should be extended. To build a research sample, snowball sampling techniques and reliance on trusted informants is recommended. For this dissertation, referrals from two trusted community partners were invaluable. Since potential participants may struggle to see the relevance of *post facto* research, individuals should be compensated if possible. Unfortunately, funds did not allow participants to be compensated in this study, but when possible, I sent research products to participants that had expressed interest.

Summary

This dissertation has answered and opened geographically significant research questions related to the environmental legacies of energy resource development. Specifically, this project has elevated the importance of inquiry into the influence of political and social factors on oil and gas legacy effects for academics, reclamation practitioners, and policymakers alike. As an original contribution to the early literature on post-production oil and gas activities, a number of important considerations for future studies are identified. Future research should not ignore the influential role of individual actors, variability among industry players, the role of the policy approach and regulatory environment in place, the local geography as it applies to the type and scale of extraction and the potential for eventual reclamation success, surface and subsurface ownership regimes, and the full development picture including the legacy phase.

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APPENDIX

GROUNDED THEORY METHODOLOGY

About Grounded Theory

Grounded Theory (GT) was developed in the mid-1960s by sociologists Barney Glaser and Anselm Strauss in response to increasingly positivist approaches to social research (Glaser & Strauss 1967). GT is a theory-generating methodology in which, "theory development [is] based on actual data gathered through qualitative research" (Corbin & Holt 2005, 49). Therefore, the theory being developed is *grounded* in the data. As a mode of analysis, GT favors research questions that are open, broad and not informed by an existing theoretical framework. In this way, GT best allows theory to emerge from the data rather than be imposed on the data (Corbin & Holt 2005). This contrasts with research that was the norm prior to the discovery of GT which focused on verifying existing grand theories. Therefore, most importantly, GT is a mode of analysis to further the generation of theory as opposed to the verification of existing theoretical frames.

To do so, data collection and analysis is conducted using an iterative process informed by research participants. Data analysis is done as fieldwork progresses to inform sampling and refine interview questions to best speak to the emerging theory. Moreover, GT attempts to, "be faithful to the understandings, interpretations, intentions and perspectives of the people studied on their own terms, as expressed through their actions as well as their words" (Clarke 2007, 428). In this way, the theory under development is well *grounded* in the data. In pursuit of this, GT employs particular tenets which elaborate on the intent and describe the utility of Grounded Theory.

Theoretical sampling

One of GT's central tenets is the use of theoretical sampling. When designing the research, predetermined sample groups and/or sample sizes are not used like in selective or representative sampling (Draucker et al. 2007). Instead, "theoretical sampling focuses on finding new data sources (persons or things – and not theories) that can best explicitly address specific theoretically interesting facets of emergent analysis" (Clarke 2007, 425). The sampling is driven by concepts of theoretical interest that surface as a product of analysis. Corbin and Holt (2005) describe that, "the researcher follows the trail of concepts looking for sites, persons or events that enable further comparisons of data, thereby extending knowledge about the properties, dimensions and relationships between concepts" (51). The iterative data collection and analysis that is the hallmark of GT is conducive to theoretical sampling. That way, after initial data collection the researcher can perform analysis and then, based on relevant theoretical concepts, tailor upcoming data collection to the most appropriate sample. To that end, GT champions the use of constant comparative analysis when processing data and to dictate future theoretical sampling.

Comparative Analysis

In fact, comparative analysis is the second tenet of GT. Corbin (2017) states that, "It is through constant comparisons during which data are compared for similarities and differences that concepts are identified, developed, and integrated" (302). Moreover, the comparative nature of GT analysis fosters reflexivity on the part of the researcher to, "ask questions of themselves and the data" (Corbin 2017, 302). This continual questioning drives the iterative research process that is GT. Corbin (2017) notes that possible questions include, "'what is going on here'…'how does this particular concept relate to other concepts' and 'what further data is needed to fully develop each major concept or category in term of its possible properties and dimensions'" (302)? These sample questions illustrate that through comparison and questioning, the research can be driven by developing theory. To that end, Schwandt (2001) states, "From this process [comparative analysis], the analyst identifies underlying uniformities in the indicators and produces a coded category or concept. Concepts are compared with more empirical indicators and with each other to sharpen the definition of the concept and define its properties" (1137). Here, Schwandt (2001) clearly links comparative analysis and the third tenet of GT, coding to categories.

Coding to Categories

In GT, data collection and analysis take place simultaneously. After an initial fieldwork phase, the researcher begins a period of analysis. Conceptual coding is the hallmark means of analysis in GT. Holton (2007) articulates this point in her description of the coding process:

> *The essential relationship between data and theory is a conceptual code. Coding gets the researcher off the empirical level by fracturing the data, then conceptualizing the underlying pattern of a set of empirical indicators within the data as theory that explains what is happening in the data* (266).

Coding the data into conceptual categories facilitates their eventual integration into a developing theory. But as Holton (2007) suggests, coding is a *process* and coding to categories is not the starting point. In the first period of analysis, the researcher performs open coding where the textual data is 'opened up' and broken down, segment by segment, and assigned particular labels to denote relevant phenomenon (Corbin and Holt 2005; Clarke 2007). Codes are not determined a priori and instead emerge from the data under analysis. The research continues with theoretical sampling and another round of data collection. Coding follows, facilitated by constant comparative analysis, and data reduction eventually occurs when the most robust codes are, "then densified into more enduring and analytically ambitious 'categories'" (Clarke 2007, 424). These categories represent groupings of relevant conceptual codes.

The process of grouping codes to relevant categories is sometimes called axial coding, but axial coding is rarely distinguishable from open coding as both occur in tandem (Clarke 2007). Upon categorizing, the analyst fleshes out the categories with the data collected on each concept, which become the category's properties and dimensions. Eventually, the categories are grouped under a core category, the most abstract concept pertaining to the emerging theory. Corbin and Holt (2005) describe that, "constructing the core category from identified concepts is termed selective coding – because one must choose from among many possibilities the construct that is most representative. The core category explains what is going on in this research in a larger sense" (51). The core category has a few particular features. Most notably, the core category is mentioned/referenced/described frequently in the data and meaningfully relates to other categories of significance (Holton 2007). After teasing out the core category by means of analysis, selective data collection and coding continue, but at a faster pace. Since the core category has been identified, the researcher can be deliberate in their sampling and coding and ignore data and materials that are not relevant to the emerging theory. The iterative research process continues until theoretical saturation has been reached.

Theoretical Saturation

Theoretical saturation occurs when, "no additional data are being found whereby the [researcher] can develop properties of the category…One reaches theoretical saturation by joint collection and analysis of data" (Glaser and Strauss 1967, 61). The researcher undertakes comparative analysis to drive the collection of data until no new concepts, or dimensions or properties of concepts, emerge. At this point, the category is said to be saturated, and data collection ends. The analyst can recognize when saturation has been reached when the data are repetitive (Corbin and Holt 2005). However, the analyst should pay particular attention as, "repetitive themes have very little to do with theoretical saturation and grounded theory when the repetitive data are not in service of a theoretical category" (Charmaz 2008). Categories must be in service of the developing theory and have clear parameters. In this way, when saturation has been reached, the researcher can be confident that the theory being built is well grounded in a theoretically sound sample of data. However, Dey (2007) provides cautionary advice that, "Elegance, precision, coherence, and clarity are traditional criteria for evaluating theory somewhat swamped by the metaphorical emphasis on saturation. Elaboration should not obscure the quest for refinement" (186).

Memo Writing

The final tenet of GT is the use of memos to catalog the ongoing analysis, emerging categories and developing theory on the part of the researcher. The importance of memoing cannot be overstated. Lempert (2007) asserts that, “It [memo writing] is *the* fundamental process of researcher/data engagement that results in a ‘grounded’ theory” (245). Memos are the researcher’s own notes and analytical ideas that are written continuously throughout the research process. They help to, “conceptualize the data in narrative form” (Lempert 2007, 245). Memos help the researcher to track concepts as they evolve and organize complex theoretical ideas and insights. Despite the critical importance of memoing, memos do not have to be recorded formally. In fact, most memos are written by hand in fieldwork journals or research notebooks. Memos can take multiple forms depending on the preferences and style of the researcher (Corbin and Holt 2005). Without memos, the researcher would be left with a pile of well categorized-data but no inclination as to how the relevant concepts amount to new theory. Holton (2007) summarizes this point, “Although typically based on description, memos raise that description to the theoretical level through the conceptual rendering of the material” (282).

Debates in Grounded Theory

As mentioned, GT was founded in 1967 by sociologists Glaser and Strauss as a systematic methodology for generating theory in social research. As with anything (or anyone) celebrating a 50th anniversary, the past has been marked by some discord.

General critiques have been leveraged against GT, but, most notably, the perspectives of the original founders diverged in the 1970s and branched into two separate approaches to GT research. The rift between Glaser and Strauss, and their different interpretations of GT, are discussed next.

The Rift Between Grounded Theory co- founders Glaser and Strauss

Evidence that Glaser and Strauss had begun to view GT differently emerged in the mid-1970s with Glaser's publication of *Theoretical Sensitivity* (1978). Telling, of course, was that this was a solo publication and also the work referred to GT differently than how it had been presented originally in *The Discovery of Grounded Theory* (1967). The publication of *Theoretical Sensitivity* marked the emergence of Glaserian GT although this brand of GT was not formally named until 1995 (Stern). Straussian GT arose about a decade later with Strauss' publication, *Qualitative Data Analysis* (1987).

Simply put, Glaserian GT is considered 'emergent' while Straussian GT is referred to as 'constructivsit' (Corbin and Holt 2005). As stated by Clarke (2005), "For Glaser, categories emerge upon comparison and properties emerge upon more comparison" (428). Basically, the theory is embedded in the data and it is the task of the researcher to discover what the theory is (Corbin and Holt 2005). The theory will emerge from the data. In contrast, Straussian GT recognizes that there are multiple ways to interpret data. In this way, Strauss acknowledged the positionality of the researcher. Moreover, in Straussian GT, theory is constructed out of the data, it does not simply emerge. Clarke (2007) distills the reasoning behind the rift between founders as, "In a nutshell, GT co-founder Barney Glaser accused Strauss of abandoning their original version of GT, and 'forcing data' through the procedures outlined in *Basics* rather than allowing 'emergence' and 'letting the data speak for themselves'" (428). It should also be noted that the bifurcation produced new methods associated with the two branches of GT, but most notably Straussian GT. With Schatzman (1991) Strauss helped pioneer the use of Dimensional Analysis as a supplemental method to GT. In this regard, Strauss' students continued to apply GT and, through its evolution, created additional supplemental methods including Situational Analysis (Clarke 2003). This brings up a good point, and one made particularly well by Morse (2009) and Corbin (2009). Corbin (2009) states, "…to write about his [Straussian] version implies that over time and with usage a methodology does not undergo change. It also implies that the people who write and talk about the method are not subject to change" (35). We should not be alarmed at the rift between co-founders. In fact, it is a good reminder that methodologies evolve, as do the people who create, utilize and write about them.

Critiques of Grounded Theory

Since GT is a qualitative research methodology, critiques that have been made against qualitative approaches more broadly have also been directed at GT. These general criticisms are well summarized by Clarke (2007): "the wide array of critiques of GT as a method have largely fallen within the general critiques of qualitative research as not positivist (enough), reliant on oral statements which can be lies, reliant upon researchers who are likely biased, etc." (426). Qualitative researchers have been responding to these and similar criticisms since the emergence of qualitative approaches. For this reason, detailed description of these criticisms and associated responses will not be provided. Instead, the focus will be on critiques of GT specifically.

No research methodology is free from judgement, which is a hallmark of rigorous science. Methods are continuously scrutinized in the spirit of refinement and increasing replicability. GT has been subject to four key critiques and countless others. Here, the focus will be on the four prominent critiques. First, some critics share the view that GT is too esoteric and difficult to learn independently without having some sort of 'apprenticeship' to assist with uptake (Clarke 2007). Next, individuals have claimed that the methodological boundaries between GT and phenomenology are blurry at best. Third, Mattingly and Garro (2000), among others, have alleged that GT is guilty of, "'fracturing' the data, for 'violating' the integrity of participants narratives, for 'pulling apart' stories" (Clarke 2007, 426). Lastly, (neo-) Marxist critiques date back to GT's discovery when critics claimed the approach did not take power or social structures seriously enough. Acknowledging these criticisms is crucial so that they can be mitigated throughout the research design, data collection and analysis process.

Doing Grounded Theory Research

Jacobson et al. (2009) clearly summarize the purpose of GT with the statement, "The goal of GT analysis is to derive from the data concepts, conceptual categories and linkages between categories; the product is a theory of phenomenon from the point of view of those who have direct experience with it" (725). But, how does a researcher *do* grounded theory research? Of course much can be said to help guide a new grounded theorist embarking on an original research project, but distilling the basics of GT into a concise ‘checklist’ can be helpful initial instruction. The following represents just that, a ‘checklist’ that the analyst can return to in order to be certain that the GT methodology is continually being adhered to. The limitations of this ‘checklist’ concern its brevity. Each of these GT aspects could be elaborated on, and some have been in this review. But for the purpose of being a quick guide, the ‘checklist’ is as follows (Corbin and Holt 2005):

1. Do not embark on the research with an existing theoretical framework in mind
2. Alternating data collection (fieldwork) with analysis in an iterative process
3. Gathering participant feedback throughout the process to inform theory generation and theoretical sampling
4. Keeping a journal for memo writing during all phases of the research process

Grounded Theory Research: A Concise Review

Over the past fifty years, GT has been used widely as the preferred methodology for countless qualitative researchers. What follows is a concise review of GT’s broad scholarly contributions and a more detailed look at how GT has been used as a method by human geographers.

Broad Contributions Using Grounded Theory

Grounded Theory is used internationally across multiple disciplines that conduct social research. Though geographers have engaged in research using GT (Yeung 1997; Jacobson et al. 2009; Lee 2016) the bulk of work that utilizes a GT approach resides is associated disciplines, most notably sociology (Glaser & Strauss 1967; Charmaz 1995) and health (Bowers et al. 2001; Parker and Myrick 2011; Poteat et al. 2013). However, GT has been used to a lesser-extent in the technology (Halaweh 2012; Gandomani and Nafchi 2016) and business and marketing fields (Goulding 2005; Murphy et al. 2017).

Geographical Research Using Grounded Theory

Contemporary (1997-2017) geographic research using GT spans topics ranging from philosophy (Yeung 1997) to urban geography (Jacobson et al. 2009) to Geographic Information Systems (GIS) (Knigge and Cope 2006). In this contemporary period, earlier contributions concern broad methodological questions. Yeung (1997) argues that GT can be used as one guideline for conducting realist research in human geography. Yeung (1997) first summarizes the GT approach and process then, the author argues that GT provides a mid-point between theory and practice for critical realism and realist research for human geographers. Next, Knigge and Cope (2006) explore how both quantitative and qualitative data can be utilized together, using GT and visualization, in GIS to, "construct and integrated analysis strategy that is both iterative and reflexive, both contextual and conceptual" (2021).

Moreover, GT has been relied on by those conducting geographic research. For example, Jacobson et al. (2009) developed a 'taxonomy of dignity' using GT to examine how the phenomenon of dignity can be used to better understand the relationship between cities and the health of their urban populations. Tse (2014) calls for the use of 'grounded theologies' to examine modern geographies of religion. Grounded theologies are defined as, "performative practices of place-making informed by understandings of the transcendent…they are grounded insofar as they inform immanent processes of cultural place-making, the negotiation of social identities, and the formations of political boundaries…" (202). Grounded theory has even been used to better understand the attitudes of geography teachers toward regions around the world (Lee 2016). It's clear from this brief review of the literature that human geography is fertile ground for the use of grounded theory. To explore this point in greater depth, explanation of grounded theory's use in research on the social dimensions of coalbed methane reclamation follows.

Using Grounded Theory to Study CBM Reclamation

This study employed a Grounded Theory methodology (Glaser and Strauss 1967). Prior to entering the field, research design was exclusively informed by the guiding research questions as opposed to presuppositions or assumptions, and not couched in any existing theoretical framework. This allowed for the research to be theory-generating as opposed to theory-verifying. To undertake research of this kind, a qualitative mixed-methods approach was utilized. Document analysis, policy analysis and semi-structured interviews were the primary means of data collection. Documents analyzed include institutional reports, press releases, letters and memoranda, various public records, and legal cases (Paxton Resources L.L.C. v. Brannaman 2004; Pennaco Energy, Inc. v. KD Co., L.L.C 2015; Pennaco Energy, Inc. v. Sorenson 2016)**.** Policy analysis focused on Federal and State environmental policies related to the reclamation of onshore oil and gas production sites (U.S. BLM 2005; WY Statute 30-5-401).

Thirty-six semi-structured interviews were conducted with a diverse sample of forty stakeholders involved in all aspects of coalbed methane production activities (Table 5.1). Specifically, the sample includes thirteen surface owners that hosted CBM development on their property; six oil and gas attorneys based in Sheridan, Buffalo, and Gillette, WY; five industry personnel that have been involved in the extraction of CBM in the region; six local government employees; an employee from a regional NGO; a reclamation contractor based in the Powder River Basin; and eight State and Federal Officials representing the Wyoming Oil and Gas Conservation Commission, WY Department of Environmental Quality, WY State Engineer's Office, and the BLM.

In the context of Grounded Theory, it is critical to note that the interview sample was not predetermined. Instead, theoretical sampling guided the interview process. Meaning, based on the guiding research questions, an initial sampling frame of PRB surface owners with CBM development was selected. As the research proceeded, the sampling frame expanded due to the initial data collected from landowners. For example, when questioning landowners about the informational resources they used to learn about the nature of CBM and how best to plan for its development and eventual clean-up, I heard that many consulted legal counsel. Based on this new data, the sampling frame expanded to include WY oil and gas attorneys that had experience in legal matters related to CBM. While interviewing these attorneys, it became apparent that Federal and State officials play a significant role in the governance of CBM and the eventual reclamation activities and outcomes. Therefore, the sampling frame shifted yet again to include BLM officials (Federal) and various State agents. When surveying the data after these interviews concluded, it became apparent that the research lacked perspective from industry personnel. In response, a final round of data collection commenced focused on recruiting individuals that worked for CBM companies.

The data analysis process followed the tenets of Grounded Theory. First, data collection and analysis proceeded in an iterative fashion. After an initial phase of data collection, analysis began. What was gleaned from this period of analysis then informed future sampling and was used to modify the interview guide be best aligned with the developing theory. Second, data analysis was done using a conceptual coding strategy. The relevant documents, policies and interview transcripts were coded using conceptual codes that were not predetermined and instead defined by the data. Data was coded using the software program NVivo. After an initial phase of open coding, the data was condensed into broader conceptual categories. A core category emerged in this phase: mutual respect. Once this core category was identified, a round of selective coding was undertaken, where the data was read and in some cases re-coded in light of the core category. Data collection, and therefore analysis, ceased once theoretical saturation had been reached. In this case, theoretical saturation was reached when categories were data-rich and additional data collection produced redundancies. Lastly, a hallmark of Grounded Theory methodology is memoing – or meticulously keeping a research journal. This is used to track observations, theory developments and general notes throughout the full course of the research process. In this case, the researcher's memos – or fieldwork journal – was used daily in the field and during analysis. In fact, entries in the journal, or specific memos, were coded to track theory development and researcher insights in the analysis phases.

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