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THE IMPACT OF INDUSTRIAL AGRICULTURE ON SOCIAL-ECOLOGICAL RESILIENCE: A CASE STUDY OF THE FAIRFIELD BENCH, MONTANA

By

ANNE PRESTON HARNEY

Bachelor of Arts, Transylvania University, Lexington, Kentucky, 2014

Thesis

presented in partial fulfillment of the requirements
for the degree of

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in Environmental Studies

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Approved by:

Scott Whittenburg, Dean of The Graduate School
Graduate School

Neva Hassanein, Chair
Environmental Studies, College of Humanities and Sciences

Laurie Yung
Society and Conservation, W.A. Frank College of Forestry and Conservation

Bruce Maxwell
Land Resources and Environmental Science, College of Agriculture, Montana State University

ABSTRACT

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The Impact of Industrial Agriculture on Social-Ecological Resilience: A Case Study of the Fairfield Bench, Montana

Chairperson: Neva Hassanein

Agricultural systems can be understood as social-ecological systems, in which humans and the natural world interact with and influence each other. The concept of resilience within social-ecological systems has gained considerable attention in recent years. Resilience is generally defined as the system's ability to absorb and adapt to stressors while still maintaining a similar functioning state. With the major challenges created by the overarching system of industrial agriculture, such as weed resistance to herbicides, water pollution, market consolidation, and declining numbers of farmers, resilience in agricultural systems is a critical concept to explore and understand. However, despite the popularity of social-ecological resilience research, there are major criticisms of resilience theory, including its limited study of the role of agency and power in social systems. Additionally, there are relatively few studies that attempt to understand resilience within a particular context. This project fills this gap by providing a descriptive case study of social-ecological resilience in a rural agricultural community in Montana. Data was collected through document review and in-depth interviews with 12 malt barley farmers. The analysis reveals multiple challenges facing the community, including weed pressures, frustrations with major brewing companies, and a changing community structure. Farmers also identified capacities for resilience, including knowledge and learning, access to water, and place attachment and identity. These challenges and capacities, however, have been influenced by the larger industrial agriculture system, which has limited the farmers' individual decision-making power. Social-ecological resilience theories largely fail to account for the relationship and tension between individual agency and structural constraints. Future research in which the social dimensions of agency, choice, and power are included within resilience frameworks is needed.

Acknowledgements

This paper is the culmination of many hours spent dreaming, planning, interviewing, writing, and editing. The final product and the work behind it, however, would not have been possible without the assistance and encouragement of many others. First, I would like to thank the farmers and community members on the Fairfield Bench for their time, hospitality, and kindness. They welcomed me into their homes, answered my many questions, and guided my research in new directions. For the laughs shared over kitchen tables, thoughtful and honest conversations, and tours of their land, I am forever grateful.

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Map of Montana

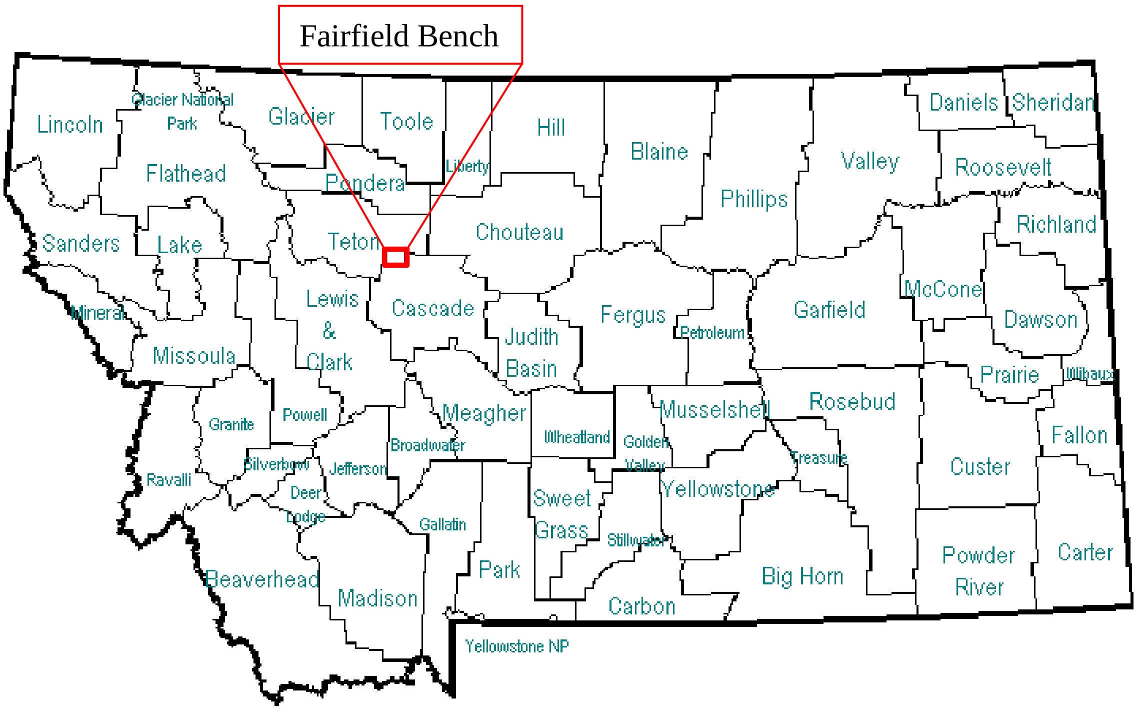

Figure 1: Map of Montana showing the location of the Fairfield Bench. Most of the Fairfield Bench is located in Teton County, with a small portion crossing over into Cascade County. Image from the Montana National Register of Historical Places (2019).

Chapter 1: Introduction

Purpose of Study

On a blustery day in March, I stopped by the Freezeout Lake Wildlife Management Area, just over the western edge of the Fairfield Bench in west central Montana. After a long day of driving and interviews, I welcomed this brief moment of quiet to gather my thoughts. I drove slowly along the gravel road next to the wetlands, hoping to catch a glimpse of the hundreds of thousands of snow geese and other waterfowl that use these grounds as a resting place in their annual migration. According to locals, in the evenings, after feasting on the leftover grains in the malt barley fields on the Fairfield Bench, the birds flock back to the water in impressive numbers. It was late afternoon, and I was disappointed as I neared the end of the loop around the management area, as I had only seen a few birds. As I headed back towards the highway, however, a noise in the distance made me stop. The honking calls grew louder, and all of the sudden, thousands of snow geese were flying overhead, piercing the otherwise quiet evening. I watched as more and more snow geese found their way back to the water from the east, where the grain fields lie in wait for spring planting. This impressive show of wildlife stands in sharp contrast to the industrial agricultural landscape that sits just above Freezeout Lake.

Looking across the Fairfield Bench’s 83,000 acres, one can see pivots and wheel lines dotting the fields, evidence of the impressive, century-old irrigation system. The Greenfields Irrigation District manages the water and is one of the main local governing bodies on the Fairfield Bench. The District, as a federal Bureau of Reclamation irrigation project, is subject to land lease and ownership limits, which has helped to limit farm sizes, although not completely, as we shall see. Farmers benefit from this irrigation system by producing large quantities of malt barley. The combination of the access to water, warm summer days, cool nights, and a reliable breeze make the Fairfield Bench an ideal place to grow high-quality malt barley. As I drove back and forth across the Bench in the early spring of 2019 conducting interviews, field after field exhibited the remnants of intensive malt barley production, the thick golden stubble covering the soil. Grain storage bins owned by two major brewing companies, Anheuser-Busch and MillerCoors, are positioned in small towns on either edge of the Bench, further evidence of this crop's mark on the landscape. These companies contract with farmers on the Bench to produce and supply their malt barley.

As I learned more about this landscape and its agricultural system, the interactions among key elements of the system – irrigation, land, water governance, climate, malt barley production, and major brewing companies, among others – became clear, creating a web of complex relationships, outcomes, and challenges. These elements also interacted with and were influenced by outside forces of economics, politics, and industrial agriculture. Accordingly, this thesis explores these complexities and challenges and investigates the Fairfield Bench as a case study of a social-ecological system.

The term "social-ecological systems" (SES) refers to the complex and intertwined nature of our human-constructed social, economic, and political systems and the natural world (Berkes and Folke 1998, Folke 2006). Scholars have developed the concept of social-ecological resilience as the ability of a system to absorb and adapt to challenges or disturbances, and to still maintain a similar functioning state (Walker and Salt 2012). Knowing the industrial agriculture construction of this landscape, I applied this concept of social-ecological resilience to this case study of the Fairfield Bench. Specifically, this research takes a qualitative, descriptive case study approach to the concept of social-ecological resilience, working largely from the perspectives of the individuals who live on and work the land – the farmers. What could these farmers tell me about the challenges they are facing and the capacities for social-ecological resilience that are already present in this system? Within this study, I also considered my findings in light of the vast array of social-ecological resilience literature, so as to further our understanding of social-ecological resilience and what is needed in future research.

In order to explore these ideas, I reviewed a variety of documents about the Fairfield Bench and collected original, qualitative data from 12 in-depth interviews with Fairfield Bench malt barley farmers. The documents collected and reviewed include reports published by several Montana state agencies and federal agencies, journal articles, and Census of Agriculture data. The interviews, document review, and existing statistical data allowed me to immerse myself into this system as an outsider to this landscape and to Montana. Throughout the research process, I became increasingly fascinated with how landscape shapes and molds us, and how outside forces and structures beyond our control influence our decisions. While the inherent complexity of social-ecological systems renders them challenging to study, this complexity captivated me, driving me to this research.

A quick search in the database *Web of Science* reveals the explosion of resilience literature across disciplines. The keyword “resilience” generates over 70,000 journal articles, spanning over a century of scholarship. The bulk of this research has only been done in the last 20 years, with over 68,000 papers published since the year 2000. The ubiquity of the term "resilience" means that it is a popular concept for researchers, but the sheer number of published papers also results in differing definitions of the term, making it challenging to study. In addition to the differing definitions, much of the literature on social-ecological resilience is conceptual and theoretical. Comparably few studies exist that attempt to understand resilience within a particular context (Carlisle 2014). Of these case studies, even fewer investigate social-ecological systems in high-income countries. This case study is just one attempt to fill this gap in the literature. By attempting to investigate resilience through an inductive, descriptive case study method, this study adds another important research approach to the resilience literature.

Overview of Thesis

This thesis is divided into five chapters. After this chapter, the introduction, I provide an overview of the key areas of literature used in this study. In Chapter 3, I give an explanation of my methods, which include a list of the secondary sources about the Fairfield Bench and a description of the interview guide used in this study. I then provide an in-depth description of the Fairfield Bench in Chapter 4, in which I outline the essential elements of this social-ecological system using the documents gathered about the Bench and interview data. In Chapter 5, I present an analysis and discussion of the challenges facing the Bench according to malt barley farmers and their connection to the industrial agriculture system. I provide the final portion of my analysis in Chapter 6, in which I analyze the capacities for resilience, their potential, and their limitations on the Fairfield Bench. In the final section, Chapter 7, I discuss the implications of my results and offer ideas for future social-ecological resilience research.

Chapter 2: Literature Review

This literature review explains and discusses the key ideas drawn upon in this study. These include a history of industrial agriculture and the challenges and vulnerabilities it creates; properties of social-ecological systems; the key dimensions to social-ecological resilience; and the criticisms of overuse, power, and agency that have been raised around the resilience concept. I then discuss the relevance of these ideas to this project and present my research questions for this case study.

History and Challenges in Industrial Agriculture

A little over one century ago, agricultural production in the United States was dominated by small, diversified farms (Lyson 2004). Most rural families were involved in agriculture, and rural, agricultural communities encouraged social connection and attachment to place (Lyson 2004). Agriculture began a transformation in the early 20th century with the development of new technologies, establishment of land grant universities, and an increased focus on maximizing productivity to keep up with a growing population. Agricultural production became focused on maximizing outputs and profits, encouraged by the United States Department of Agriculture, universities, and increasingly large agribusinesses (Lyson 2004).

Ultimately, this focus on maximizing productivity encouraged monocultures rather than diversified farming systems. By specializing in just one crop, farmers could focus their energy and knowledge to maximize their production and efficiency (Johns Hopkins Center for a Livable Future N. d.). In order to truly maximize productivity, federal policies and land grant universities encouraged farmers to mechanize and adopt the newest available technologies. The adoption of machinery, such as tractors, reduced labor needs, but it also reduced the number of farms and farmers, as the machines allowed one farmer to do the work of many on larger and larger tracts of land (Lyson 2004). With increasing emphasis on efficiency and productivity, farmers had to adopt these new technologies to meet the production demand, a situation called the technological treadmill (Lyson 2004).

With its emphasis on specialization, industrial agriculture also encouraged use of chemical inputs. The rapid adoption of synthetic fertilizers after World War II allowed farmers to increase their yields and further encouraged monocropping, as farmers no longer had to rely on rotations for soil fertility (Guptill et al. 2013). Farmers also began to rely on chemical inputs to control pests and diseases, as monoculture systems are susceptible to weeds and other pests because of their lack of diversity (Kremen and Miles 2012).

Chemical use and adoption of efficient technologies contributed to increasing farm sizes and fewer farmers in the United States (Lyson 2004). Federal policies also encouraged farmers to increase the size of their operation (Johns Hopkins Center for a Livable Future N. d.). In addition to consolidation among farmers, food and agriculture businesses have consolidated as well, creating market concentrations in seed, chemical, and food distribution companies (Johns Hopkins Center for a Livable Future N. d.). These large companies have gained power in the agriculture sector as competition has decreased and farmers' reliance on them has grown (Johns Hopkins Center for a Livable Future N. d.).

With its emphasis on maximizing productivity, along with the consolidation among farmers and businesses, industrial agriculture has helped to provide an abundance of cheap food in the United States and across the globe (IPES-Food 2016). However, it has also resulted in environmental, economic, and social costs. The spread of monocultures and its reduced diversity has increased weed and pest challenges for farmers and has impaired soil quality (Kremen and Miles 2012). Farmers increasingly rely on technology, like fertilizers and pesticides, to address these problems (Carolan 2012, Guptill et al. 2013). These chemicals can eventually flow into waterways, resulting in toxic contaminants in drinking water and nutrient pollution in rivers and oceans (Guptill et al. 2013). The increased yields that came from chemical and technological adoption has flooded markets with an oversupply of food, resulting in lower prices for farmers' crops (Carolan 2012, Guptill et al. 2013). Lower prices can then encourage farmers to acquire more land to grow more crops to make up for the lost income, changing the social structure of their communities (Carolan 2012). Carolan (2012) notes that industrial agriculture has resulted in declines in agricultural community population, weaker relationships between farmers, and an increase in conflicts between neighbors. Finally, the consolidation among agribusinesses also reduces individual choice for farmers. Massive food companies can dictate how crops are grown, and with farmers having fewer choices for buyers for their crops, they are shuttled into a market where they have limited agency (Center for a Livable Future N. d.).

As Wendell Berry once explained, "Industrialism is a way of thought based on monetary capital and technology" (2002:67). This system – perpetuated by federal policies, international trade agreements, and large agribusinesses – has created a space in which farmers have few choices (IPES-Food 2016). Powerful industries and businesses that emerged from the influence of industrial agriculture have stripped farmers of much of their agency (Rotz and Fraser 2015). As I will describe in later chapters, the environmental, social, and economic challenges of industrial agriculture and this lack of farmer choice has shaped the current system on the Fairfield Bench.

Systems Thinking

Understanding the complex interactions in agriculture described above necessitates a systems approach. Donella Meadows (2008:2) in her book *Thinking in Systems: A Primer* defined a system as "a set of things…interconnected in such a way that they produce their own pattern of behavior over time." In other words, a system has emergent properties, or properties that cannot be explained simply by the sum of its component parts (Meadows 2008). This idea of thinking about our natural world, our communities, and our own behaviors as part of a larger system rather than isolated elements has gained traction in the academic literature. As such, "systems thinking" involves "a set of synergistic analytic skills" used to increase understanding of systems and their behavior (Arnold and Wade 2015:675). Systems thinking requires considering interconnectedness, feedbacks, and non-linear relationships among the components of a system or systems (Arnold and Wade 2015).

This systems thinking approach is particularly encouraged in natural resource management research. Researchers have been moving towards interdisciplinary studies, which require clear and effective communication among researchers, managers, and practitioners of various disciplines. Systems thinking helps bridge the gaps and encourages consideration of the complexities within natural resource management, increasing the likelihood of sustainable land management (Bosch et al. 2007).

Social-Ecological Systems (SES)

The push towards systems thinking has encouraged the development of interdisciplinary approaches to ecological and natural resource challenges. In particular, researchers are increasingly recognizing the interactions between human-constructed social systems and the natural world. As mentioned, the term “social-ecological systems” (SES) refers to the complex and intertwined character of these two types of systems (Berkes and Folke 1998, Folke 2006). Rather than addressing natural resource challenges as single, isolated problems, an SES approach recognizes and assesses the human influences on ecological systems, and the ecological influences on human systems. Elements of SES - including ecological, cultural, economic, and governance components, among others - are considered together and integrated as one system rather than simply separate components of the whole (Resilience Alliance 2010). The development of SES research was influenced by the complex adaptive systems (CAS) literature (Preiser et al. 2018). CAS can be considered a specific kind of system because of their ability to adapt and evolve based on changes to and within the system (Preiser et al. 2018).

In addition to adaptability, researchers have described other characteristics of CAS that can be applied to SES. Some of these characteristics include non-linear dynamics, feedback loops, self-organization and adaptation, and temporal and spatial cross-scalar relationships. Non-linear dynamics between interacting components of SES result in outcomes that cannot be explained by linear models (Levin et al. 2013, Preiser et al. 2018). Feedback loops can reinforce non-linear dynamics in a system. Positive feedbacks in a system can intensify the interaction, and negative feedback loops constrains the interaction (Berkes et al. 2014, Folke 2006). The ability to adapt, the key component of CAS, is influenced by the organization within the system and its ability to self-organize (Folke 2006, Preiser et al. 2018). SES can also be characterized by temporal and spatial cross-scalar relationships (Rivera-Ferre et al. 2013). These relationships are environmental, social, political, and economic (Berkes et al. 2014). The boundaries of any particular system are not closed; elements of the system interact with outside forces either directly or indirectly (Preiser et al. 2018).

SES perspectives have often been applied to natural resource management scenarios, such as water management in irrigation systems, fisheries management, or forest management, but this perspective can, and should, also be applied to agricultural systems. In particular, Rivera-Ferre et al. (2013) argue that agricultural systems contain the elements of SES and should be considered as such in management and policy decisions. They state, "As a complex system, agriculture is an expression of certain human-environment interactions in a dynamic process shaped by uncertainty, errors, learning and adaptation" (Rivera-Ferre et al. 2013:3861).

SES Frameworks

The complexity of SES, however, renders them challenging to study, model, and analyze. Multiple frameworks to assess SES have been developed. Binder et al. (2013) analyzed ten frameworks and discussed their potential strengths and uses in studying SES. One popular framework was developed by Elinor Ostrom (2007) to help identify and analyze the interactions among the variables in SES. This framework aims to connect variables in both human and natural systems, particularly recognizing that humans can make deliberate choices both as individuals and as a community, and that these choices result in particular outcomes (McGinnis and Ostrom 2014). In their updates to this framework, McGinnis and Ostrom (2014) identify eight first-tier variables within the socio-ecological system framework: social, economic, and political settings; resource systems; governance systems; resource units; actors; interactions; outcomes; and related ecosystems. Under each of these tiers, they identify multiple second-tier variables, resulting in a complex and integrated system that incorporates multiple variables into the entire social-ecological system framework.

While this study does not rigidly apply Ostrom's framework in analyzing the Fairfield Bench, I drew inspiration from it as I attempted to understand this system and its complexity. The purpose of this framework is to organize the variables of SES into nesting hierarchical tiers, enabling researchers to identify specific variables in a particular case study (Binder et al. 2013). Using McGinnis and Ostrom's (2014) framework as a general guide encouraged me to think with a systems perspective and allowed for a better understanding of the Fairfield Bench's elements and interactions, especially as an outsider to this community.

Additionally, there is precedent to applying Ostrom's SES framework to an irrigation system. Cox (2014) applied this framework to an *acequias* irrigation system in New Mexico and found that it was a useful framework for its conceptualization and analysis. Hoogesteger (2015) also applied this framework to an irrigation system in Ecuador. Other studies (Cifdaloz et al. 2010) have applied different SES frameworks to irrigation systems with similar success. These studies support the characterization of the Fairfield Bench as a social-ecological system and the use of Ostrom's framework as a guide, which is particularly helpful in accounting for the cross-scalar interactions and relationships that may be present in SES. The framework also assisted me in creating a conceptual map of the Fairfield Bench that shows examples of the interactions and complexities of the various system components at multiple scales (see Appendix A). I describe the social-ecological system on the Fairfield Bench in depth using secondary sources and interview data in Chapter 4.

Social-Ecological Resilience

The concept of social-ecological resilience has emerged from the study of SES. Scholars often point to Holling's 1973 paper, "Resilience and Stability of Ecological Systems," as the inception of resilience studies in ecology. He writes, "Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling 1973:17). Multiple definitions for resilience began to emerge across disciplines, including engineering, psychology, and anthropology (Folke 2006). These definitions of resilience differ widely. Some, primarily within engineering, emphasize efficiency and stability within a system and define resilience as the ability of a system to return to equilibrium (Holling 1996). In contrast, definitions for ecological resilience underscore the ability of a system to absorb and adapt to internal and external disturbances (Gunderson 2000), identifying adaptability and transformability as necessary traits for a resilient system (Folke et al. 2010). For the case of resilience in social-ecological systems, Walker and Salt (2012:3) define resilience as "the capacity of a system to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks – to have the same identity." In other words, a resilient social-ecological system is able to cope with shocks, change, and uncertainty (Berardi, Green, and Hammond 2011) and still function in a similar way as before (Walker and

Salt 2012). In this study, I use Walker and Salt's (2012) definition to conceptualize and understand resilience on the Fairfield Bench.

Specified vs. General Resilience

Social-ecological resilience scholars have identified two kinds of resilience. First, 'specified resilience' refers to the ability of a specific part of the system to respond to a specific shock or disturbance (Walker and Salt 2012). This kind of resilience is important to consider when attempting to measure resilience; in other words, "Resilience of what to what" (Carpenter et al. 2001:765). A more metaphorical approach to resilience is referred to as general resilience, which is concerned with understanding a social-ecological system's ability to respond to any disturbance, include unknown and unplanned ones, so that the system continues to function (Walker and Salt 2012). Because of its theoretical and conceptual nature, general resilience has received less attention than specified resilience in the literature (Walker et al. N. d.). In this study, when I discuss resilience, I am referring to general resilience unless otherwise stated. While I did construct my interview guide around specific challenges or disturbances as examples, this was primarily a way to make my questions more accessible to the farmers. In this case study, I aimed to understand the system as a whole and its general capacity to respond to challenges, rather than narrowly focusing on its response to a specific disturbance.

Resilience Concepts

Given how extensive the literature on social-ecological resilience is, I discuss below the key conceptual dimensions that directly relate to this study and its purpose. The most relevant concepts include disturbance, vulnerability, stability, adaptation, transformability, and identity. Other less relevant concepts related to resilience – such as thresholds, panarchy, adaptive cycles, regime shifts, and others – will not be discussed here (Walker et al. 2004, Folke et al. 2010).

Disturbance and Vulnerability

The term "disturbance" is used widely in the social-ecological resilience literature, but few provide a definition for what exactly a disturbance is. A commonly-used definition in ecology comes from White and Pickett (1985:7): "Any relatively discrete event in time that disrupts ecosystems, community, or population structure and changes resources, substrate availability, or the physical environment." Notably, disturbances are not only ecological but also economic and social in nature, such as dips in market prices or political disruptions (Anderies et al. 2004). Disturbances can also be internal to the boundaries of the social-ecological system in question, or external, originating from outside the decided boundaries of the system (Anderies et al. 2004). Disturbances, also called shocks and stresses, are the events that help to reveal resiliency within a system (Walker and Salt 2012).

Disturbances also reveal the vulnerabilities within a system. Adger (2006:268) defines vulnerability as "the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt." In other words, vulnerabilities are the weak points in a system, and when pressed, these weak points can impact its overall function. Adger (2006) notes that the vulnerability of a system is related to the strengthening or weakening of social-ecological resilience. When systems have the ability to absorb or adapt to shocks, they tend to exhibit fewer vulnerabilities (Adger 2006).

In this study, I largely use the word “challenges” to talk about both disturbances to the system and its vulnerabilities. I use this term because it seemed to be more accessible when talking with farmers about the difficult events or situations they have faced. Some of these challenges, like a major rainstorm or other weather event, would be considered disturbances, while I would consider the farmers’ situation of being dependent on malt barley companies a vulnerability. For simplicity, I largely use the term ‘challenge’ in the rest of the paper, but these distinctions are present in the literature and should be noted here.

Robustness, Adaptability, and Transformability

As Folke (2006) pointed out, social-ecological resilience does not only refer to the robustness of the system, or its ability to simply absorb shocks and maintain the same function. This component of resilience has been frequently studied (Folke 2006). The other two components of resilience, as noted in multiple studies, are adaptability and transformability, which are described below (Anderies et al. 2006, Folke 2006, Walker and Salt 2012, Meuwissen et al. 2019).

Robustness, also called persistence (Folke et al. 2010), refers to the ability of a system to absorb disturbances with little to no change in the system. Some papers (Folke et al. 2010) refer to this as engineering resilience. This term appears in Holling (1996), who notes that engineering resilience is the capacity of a system to resist disturbance and return to a previous state of equilibrium. The ability to resist disturbance is an important component of social-ecological resilience theory.

Adaptability has multiple definitions in the literature, like most elements of resilience. One definition from social-ecological resilience literature refers to adaptability, or adaptive capacity, as “the capacity of actors in a system to influence resilience” (Folke et al. 2010:20). Carpenter et al. (2001) refer to adaptive capacity as a learning ability of the system in response to disturbance. A more recent definition from Meuwissen et al. (2019:4) define adaptability, specifically within farming systems, as “the capacity to change the composition of inputs, production, marketing and risk management in response to shocks and stresses but without changing the structures and feedback mechanisms of the farming system.” Walker et al. (2004) note that adaptability is primarily a function of the social component of the system, as humans make choices that impact the system, its elements, and its overall trajectory. Adaptability involves actors making changes according to the system’s inputs and disturbances, without changing the system’s “stability domain” (Folke et al. 2010). Stability domain is a conceptually challenging term, but it refers to a system retaining certain structures and feedbacks. I do not use the term “stability domain” in this study because of its conceptual and operational challenges, but instead refer to it here to distinguish adaptability from the last element of resilience, transformability.

According to Folke et al. (2010:19), transformability refers to the capacity of a system to “create a fundamentally new system when ecological, economic, or social structures make the existing system untenable.” In the transformation of a social-ecological system, it enters a new stability domain with new variables and feedbacks (Walker et al. 2004). Within the context of a farming system, Meuwissen et al. (2019:5) provide the following definition of transformability: “the capacity to significantly change the internal structure and feedback mechanisms of the farming system in response to either severe shocks or enduring stress that make business as usual impossible.”

These elements of resilience – robustness, adaptability, and transformability – provide a sample of the concepts present in the resilience literature. In my reading of the literature, these are the fundamental dimensions of social-ecological resilience. It is important to note that none of these concepts – robustness, adaptability, and transformability – are inherently positive or negative. Therefore, social-ecological resilience as a concept is neither positive nor negative (Walker and Salt 2012). A system that is undesirable in terms of sustainability or social and ecosystem health can be highly robust and resistant to change; exhibit high adaptability but low stability; or transform into a more undesirable state. It is important to question the desirability of the current state of the system when considering these attributes of resilience (Cote and Nightingale 2012).

Identity

The final concept of social-ecological resilience, and one of the most challenging, is identity. Walker and Salt (2012:215) define this fundamental aspect of resilience as "the essential nature of a system (an individual, an ecosystem, a society) based on the way it functions and on its defining structural characteristics." Identity is a key component of resiliency, as Walker and Salt (2012) note that systems can experience a lot of change without fundamentally altering who or what they are.

As I situated my own case study within the resilience literature and investigated these definitions, however, I noted some confusion over this concept of identity, Walker and Salt's (2012) definition of resilience, and the ideas of adaptability and transformability. Specifically, in Walker and Salt's (2012) definition, they say that resilience is when the system maintains *essentially* the same structures, functions, and feedbacks. Yet, they also state that *change* to these structures in the form of adaptation and transformation is a critical aspect of social-ecological resilience. If resilient systems must change, is maintaining a stable identity incompatible with ideas of adaptation and transformation? Rotarangi and Stephenson (2014) also puzzled over this apparent contradiction in their case study of resiliency in a tribal group in New Zealand. They concluded that a stable community or cultural identity was key in understanding the adaptation and transformation components of resilience, as it provided a "resilience pivot" for the system (Rotarangi and Stephenson 2014:1). In other words, adaptations and transformations revolved around these resilience pivots of identity as the stable core of the system (Rotarangi and Stephenson 2014). In my case study, I attempt to maintain a focus on the identity of the Fairfield Bench based on the perspectives of the farmers I interviewed. Their own portrayal of the land and community constitute my description of this system's current identity.

Criticisms of Resilience

In addition to the somewhat challenging concept of identity, researchers have raised other criticisms of the resilience concept. As mentioned above, resilience research spans disciplines, resulting in varied definitions and a fragmented body of literature (Cretney 2014, Rotarangi and Stephenson 2014, Lade and Peterson 2019). Lade and Peterson (2019) also note that different terms are often used to describe the same concept, adding to the confusion. This makes the vast body of literature about resilience challenging to sift through, understand, and apply empirically. Throughout the research process for this project, I continuously encountered this challenge and often felt overwhelmed by the breadth of theories and definitions. While I do not attempt to redefine any resilience terms through this particular case study, I do discuss the relationship of my findings to the social-ecological resilience literature, which provides some clarity on these concepts.

Additionally, numerous scholars have recognized that social-ecological resilience concepts, assessments, and frameworks do not adequately account for power dynamics, inequality, or justice in social systems. Cote and Nightingale (2012), for instance, argue that social-ecological resilience researchers have relied on ecosystem dynamics to explain social dynamics, which, in turn, has buried important questions about the role of power in the social realm. They call for research on actors' adaptive capacities to be analyzed within their cultural, historic, and institutional contexts within a defined period of time, focusing on the structures, processes, and relationships that support the institutions within and outside of the system. Cretney (2014) also notes that resilience frameworks have been used to encourage the continuation of dominant political powers and ideologies, namely capitalism and neoliberalism. Resilience frameworks have not adequately addressed how political power and institutional structures influence individual agency. Without an explicit theory linking these concepts to resilience, frameworks will continue to promote stability and persistence of the status quo (Carr 2019). As I discuss in Chapters 5 and 6, the issues of power and agency of the Fairfield Bench farmers within the larger industrial agriculture system emerge from my data, providing an example of why this critique of agency in the study of social-ecological resilience is needed.

Finally, operationalizing, measuring, and quantifying resilience constitute significant methodological challenges. Carpenter et al. (2005) assert that there are difficulties in measuring resilience because in order to do so, one would need to intentionally manipulate the system. Given the nature of SES with their complexity and unpredictability, this would be exceptionally difficult, not to mention unethical, as the impacts of system manipulation would be nearly impossible to predict (Carpenter et al. 2005). The concepts involved in social-ecological resilience studies are also largely theoretical and conceptual, rendering them difficult to assess, measure, and operationalize in particular places at particular times (Quinlan et al. 2016).

Assessing Resilience

Despite the challenges associated with measuring social-ecological resilience, scholars have theorized or created various frameworks for its assessment (Anderies et al. 2006, Biggs et al. 2012, Carpenter et al. 2005, Cumming et al. 2005, Folke 2006, Janssen et al. 2006). Operationalizing resilience, however, remains challenging (Cumming et al. 2005), and scholars have largely emphasized different attributes, capacities, or indicators of resilience. Some of these include knowledge and learning (Faulkner et al. 2018, Lisa et al. 2015, Biggs et al. 2012); diversity and flexibility (Lisa et al. 2015, Walker and Salt 2012); leadership, social networks, and trust (Walker and Salt 2012); place attachment (Faulkner et al. 2018); adaptive governance (Anderies et al. 2006); self-organization (Carpenter et al. 2001); and access to capital (Kerner and Thomas 2014). A few studies or assessments on resilience (Kerner and Thomas 2014, TANGO International 2018, Meuwissen et al. 2019) have organized their identified resilience capacities or attributes according to the three components of resilience discussed above – robustness, adaptability, and transformability.

Faulkner et al. (2018) note, however, that resilience is contextual, dynamic, nuanced, and socially contingent. As an emergent property, resilience is shaped by the interacting components of a complex system (Walker and Salt 2012, Faulkner et al. 2018). Resilience is dependent on the particularities of the system itself; therefore, using the same standards to measure resilience in different cases may miss critical aspects and interactions within the system (Ungar et al. 2018). Carlisle (2014) acknowledged this challenge in her study of social-ecological resilience among farmers in the Northern Great Plains. Rather than applying a specific framework to her case study, she used an inductive approach and attempted to understand resilience within a particular place and context.

This study aims to examine the particular dynamics of the social-ecological system on the Fairfield Bench as a means of understanding resilience. Borrowing from Carlisle's approach, this case study aims for a greater understanding of resilience within a particular context. To do this, I identify capacities for resilience on the Fairfield Bench from the perspective of malt barley farmers. Capacities comprise the resources, assets, and abilities that the farmers possess to resist, cope, and recover from challenges or disturbances in the social-ecological system (Gaillard 2010). Identifying capacities rather than measuring or quantifying resilience allows for the recognition that resilience is a dynamic and emergent property shaped by system processes and outside interactions with other connected systems (Quinlan et al. 2016). In many cases, reducing resilience to a unit of measurement may miss critical aspects of the system and prevent a more holistic understanding of its functions and interactions (Quinlan et al. 2016). Additionally, Whiteman (2010) impresses upon qualitative researchers to understand the ecology and landscape of their research site. She says, "An explicit sense of ecological *place* can…enrich qualitative inquiry by adding a more ecologically-embedded interpretive lens" (Whiteman 2010:129). By immersing oneself into the place and location of one's research, the data gathered can take on a deeper meaning, as the researcher will have a better grasp on connecting people, their perspectives, and their values to the landscape (Whiteman 2010).

I then compare my results, gathered primarily from interviews, to the body of social-ecological resilience literature to inform my understanding of resilience in this context. While case studies on social-ecological resilience exist, many are focused on low- or middle-income countries (Castonguay et al. 2010, Linstadter et al. 2016, Ruiz-Mallen and Corbera 2013). This case study adds to the literature on social-ecological resilience by exploring and analyzing an industrial agriculture landscape.

Research Questions

In summary, industrial agriculture has helped create multiple environmental, social, and economic challenges for farmers and has externalized its costs. Understanding these challenges requires a systems thinking approach; that is, an analysis that enables identification of the relationships among interacting elements of a system. In other words, a description and analysis of the Fairfield Bench as a social-ecological system makes up the underlying structure for this case study. The concept of resilience has emerged from the social-ecological literature and exploded into the consciousness of not only researchers, but also governments and practitioners as well. With the recognition of the criticisms associated with social-ecological resilience, I pursued a contextual, inductive approach to understanding this concept on the Fairfield Bench. My research questions for this study are:

1) *What are the challenges facing malt barley farmers on the Fairfield Bench?*
2) *Given these challenges facing agriculture on the Fairfield Bench, what capacities for resilience are identified by malt barley farmers?*
3) *How can this case study inform our broader understanding of social-ecological resilience?*

The discussion in this chapter on the challenges created by industrial agriculture, characteristics of social-ecological systems, and resilience theory provide an outline of the frameworks and theories I drew upon in the creation of this project. In the next chapter, I outline the methods used to answer these research questions.

Chapter 3: Research Methods

This chapter begins by explaining my approach to this case study and creates justification for the data collection methods of document review and in-depth interviews. I then explain my interview process, including recruitment and selection of farmers, and the topics covered in these semi-structured conversations. I then describe the process of analyzing the interview data and provide an overview of the farmer demographics who participated. Finally, I explain my role as the researcher, as well as the barriers and limitations to this project.

Research Approach

This study aims to provide an in-depth understanding of a particular social-ecological system and its capacities for resilience from the perspective of farmers and previous studies on the area. Because the research questions and data analysis are context-specific, I used a case study approach which incorporates a variety of quantitative and/or qualitative methods in order to arrive at a "holistic understanding" of a particular place, issue, or problem (Hesse-Biber 2017:221). Because a case study strives for holistic understanding, it is a particularly useful approach for investigating systems (Hesse-Biber 2017). Additionally, describing and explaining the physical and social context of a particular case is critical to extracting meaning and understanding (Hesse-Biber 2017). My research questions situate the Fairfield Bench as a social-ecological system with complex and interacting elements; therefore, the case study method was the best research approach for this project.

Data for this case study was collected through document review and in-depth interviews. Several important documents already existed about the Fairfield Bench, and these became helpful sources of data. These documents include: reports published by several state and federal agencies (Montana Department of Agriculture N. d., Montana Department of Environmental Quality 2004, Miller et al. 2002, Nimick et al. 1996); Census of Agriculture data and agriculture surveys (National Agricultural Statistics Service 2017, National Agricultural Statistics Service 2019); newspaper articles about fluctuations in the malt barley industry (Jacobson 2013, Murry 2017); agronomic research from Montana State University (Malchow 1995); and documents from the Greenfields Irrigation District (Greenfields Irrigation District 2019). I also found and reviewed several works about the history of the Greenfields Irrigation District and the Fairfield Bench (Autobee 1995, Brown 1934, Fabry 1994, Fairfield Times 1978). Reviewing these documents provided me with a greater understanding of the physical area, its history, and its governance. I also gleaned quantitative data from these documents, which includes several water quality parameters, such as nitrate and pesticide concentrations, and land use and agricultural production data.

This document review supplemented my main source of qualitative data, in-depth interviews with malt barley farmers. I chose in-depth interviews as the primary method of data collection because I had a particular topic – the capacities for resilience that are identified by the farmers – on which I wanted to focus and gain information. In-depth interviews are well-suited for this type of inquiry (Hesse-Biber 2017). Additionally, in-depth interviews allowed me to understand the perspectives and acquired knowledge of individual farmers, gathering a range of thoughts and ideas about my chosen topic.

I set the spatial boundaries for this case study using the borders of the Greenfields Irrigation District. Only farmers who lived and worked within these boundaries were selected for interviews. I narrowed my focus further by only interviewing malt barley farmers. I chose this particular focus for several reasons. First, as I designed the study, I quickly realized the need to put strict boundaries on my research. Studying this system and its complex elements, actors, and interactions quickly became confusing and overwhelming. By limiting myself to malt barley producers, I came to a more realistic and achievable research focus. Second, malt barley has been the primary crop on the Bench for several decades (Montana Department of Agriculture N.d.), creating a community based around its production. The presence of two major brewing companies on the Fairfield Bench has shaped the farmers' production and sense of security from the reliable contracts. The malt barley industry has played a major role in influencing this place and its people. Its impact appeared significant, and by only interviewing malt barley farmers, I hoped to understand and analyze the details and complexities of the malt barley industry. Finally, this research highlights the importance of context in understanding a social-ecological systems' property like resilience (Carlisle 2014, Ungar 2018). By focusing on a specific subset of farmers within a community, I was able to generate in-depth and rich meaning from the data I gathered. Rather than broad, surface level descriptions of the Fairfield Bench, I was able to capture a holistic and rich picture from these farmers and learn about their perspectives on resilience in a particular place at a particular time.

Data Collection

Considering the popularity of malt barley production on the Fairfield Bench, my selection criteria still provided a substantial list of potential farmers to interview. The 2017 Census of Agriculture identified 91 malt barley operations in Teton County

(National Agricultural Statistics Service 2017). Within the subset of malt barley producers, I hoped to capture the perspectives of farmers at different stages of experience. Given that the average age of farmers in Montana is 58.2 (National Agriculture Statistics Service 2017), I anticipated that many, if not most, of the farmers would be in their 50s and 60s. I also hoped, however, to identify and interview younger farmers to see how age and farming experience shaped the perspectives of these farmers. This proved to be a challenging task. As one farmer warned me, many of the young farmers were busy with children and caring for their families, making them somewhat difficult to contact.

Farmers were selected for interviews using a snowball selection method. After conducting preliminary research on the Fairfield Bench in the spring of 2018, I had a short list of initial contacts. I contacted four people from this list by phone or email and asked for names and contact information of malt barley farmers who might be interested in participating in this project. These initial contacts included two farmers, an employee with the irrigation district, and a former coordinator for the Sun River Watershed Group. These four individuals gave me the names of 14 farmers. I then began contacting these farmers by phone to explain the project and ask if they would be willing to participate. Often, it took several phone calls and messages before I connected with the farmer. The farmers who agreed to be interviewed generally gave me several more names to consider, allowing me to compile a list of 30 names. I did not find contact information for three of these names. I contacted 27 farmers in total, and 12 of these agreed to participate, giving a response rate of 44%. With an estimated 91 irrigated malt barley operations in Teton

County (National Agricultural Statistics Service 2017), I interviewed approximately 13% of malt barley farmers on the Fairfield Bench.

I made two trips to the Fairfield Bench in March and April of 2019 to complete these interviews in person. All interviews except one were only with the farmer contacted. The one exception included the primary operator, his spouse, and his adult son, who was farming with his father. When I made contact with a farmer, and they agreed to be interviewed, I allowed them to pick the location where they were most comfortable. Ten of the interviews took place at the farmers' home. One took place at a local pizza restaurant, and one farmer kindly squeezed the interview into his busy March afternoon of hauling grain, and we talked in my car as we watched his son fill their truck with grain to be hauled to Choteau.

I used a semi-structured interview approach for this project. I approached each interview with a series of questions that I wanted to ask, but I also wanted to create the space for other topics and ideas that were important to the farmers to surface (see Appendix B for interview guide). I used probing follow-up questions to gather more detail in their answers and to explore the themes and ideas that the farmers raised on their own. Before each interview, I read a statement about the purpose of my research project and the kinds of questions I would be asking in the interview. I informed them that their identity would remain confidential and their name would not be attached to any part of this project. I also informed them that they were able to refuse to answer any question that they were not comfortable with, and if they wanted to end their participation at any point in the interview, they were free to do so. Finally, I asked if they would be comfortable with me recording the interview so I could accurately capture their words and ideas. As I read the statement, I made sure to look for signs of consent, which included verbal and non-verbal understanding in the form of saying “yes” or “ok”, as well as nodding. All gave consent and agreed to be recorded. The farmers were not compensated for their participation in this project.

Before I turned on the recorder, I asked if they had any questions. A few of the farmers used this as an opportunity to ask about my own background, such as where I was from and why I decided to pursue this research project. Answering these questions gave me an opening to build rapport with the farmer and to begin the interview process from a place of openness and sincere interest in their perspectives. I digitally recorded each interview using the Voice Memo app on an iPhone. In all but one of the interviews, this application worked well. Unfortunately, I lost a few minutes of one interview due to a technical issue, and I was unable to recover them.

I began each interview by asking about how they would describe the Fairfield Bench to an outsider. In addition to beginning with easier descriptive and background questions to build rapport with the farmer, I wanted to understand the farmers’ perspectives of this community’s identity. I then moved on to background information including how long they had lived on the Bench and how long they had been farming. Generally, the conversation here would steer towards personal life – their spouse, children, parents, and family history. I also asked about their land and if their families had also farmed. I then asked questions about their current operation – what they grow, what rotations they use, and if they have any livestock.

I then moved on to asking about challenges that the farmers had faced with their operation and their responses to these challenges. My questions revolved around three main challenges –malt barley production and its industry, climate change and natural resources, and the irrigation district/governance. These questions included asking about challenges they have faced growing and marketing malt barley, how their operation faired in a recent drought year, the most pressing natural resource challenges they are facing, and governing bodies that impact the decision making for their operation. In asking these questions, I listened for what they believed were the most critical challenges that they were facing on the farm. Coming into the interviews, I had my own ideas of the challenges I thought they would discuss and designed my questions around those. However, as an outsider to this community, and large-scale industrial agriculture production in general, I wanted to listen carefully to these farmers and make their perspectives and lived experiences the priority.

In asking about challenges, I also asked how they have responded to these challenges in the past, and how they will respond to challenges in the future. In their answers, I listened carefully for the assets, resources, and abilities that they noted. I have identified these as capacities for resilience in my analysis. At the end of the interview, I returned to the question of identity and asked what they hoped this community would look like 50 years from now. In asking this question, I aimed to understand the farmers' perspectives of the key structure and elements of the Fairfield Bench, the ones of most value to these farmers.

During each interview, I took notes on our conversation and wrote down my impressions of the farmers, such as their body language or tone of voice as I asked my questions. After the interview, I spent a few moments reflecting on the interview and my own actions as the researcher, noting if I was uncomfortable, tense, or particularly engaged at any point in the conversation. I also noted the physical description of the interview environment. These memos became parts of the thick description that I include in my analysis. The interviews lasted between 45 minutes and two hours. In total, I gathered 16 hours of interview recordings from 12 interviews. Each interview was saved to my computer and a flash drive. I uploaded each interview to Temi, a transcription software website that gave me an initial transcription of every interview. I then listened to each interview again and corrected any mistakes made by the software. The interviews were transcribed in full, including verbal pauses and silences. As I transcribed, I wrote down instances where I, as the interviewer, asked a potentially leading question or phrased a probe poorly. These instances may impact the data in certain ways, and I have noted any of these possible problems in the analysis.

Data Analysis

The documents and statistics gathered about the Fairfield Bench were examined and included in my analysis. These documents primarily served to supplement the qualitative interview data, as well as inform the description of the Fairfield Bench as a social-ecological system. These documents provided a richer understanding of the context and history of the Bench.

After transcribing the interviews, I began to analyze the content in the qualitative interview data. I carefully read each interview and looked for themes and patterns to emerge. Next, I organized the themes into analytical categories and subcategories. These categories were separated or combined as I analyzed the interviews, resulting in 16 unique categories. These categories helped me organize and understand the perspectives that I had gathered and allowed me to create a story from the data in an attempt to answer my research questions. I analyzed the data through an iterative process, returning often to the literature to see how it might inform my data. I also worked to practice reflexivity throughout this process, asking myself often how my own experiences and biases affect my analysis and discussion of the data.

Farmer Demographics

The farmers who participated in the interviews primarily grew malt barley. The percentage of their land in malt barley production ranged from 30% to 100%. In addition, many grew winter wheat, spring wheat, alfalfa, canola, green peas, and other pulse crops. All of the farmers contracted their malt barley with Anheuser-Busch in Fairfield, MillerCoors in Power, or Malteurop in Great Falls. Eight farmers maintained contracts with two or more of these companies, while the rest grew exclusively for one. Seven farmers also had cattle. While I did not specifically ask, four farmers also mentioned that they own or lease some dryland outside of the Greenfields Irrigation District boundaries. Winter wheat was the main crop for this dryland. One farmer also had land on the Fort Shaw Irrigation District, a neighboring district that also draws its water from the Sun River.

The farmers ranged in age from late 20s to early 70s, estimated from the length of time they had been farming. Their years of farming experience ranged from four to 48. A natural division in years of experience emerged, with four farmers having 12 years or less, and eight farmers having 25 or more. The former group is identified as ‘younger farmers’ and the latter as ‘experienced farmers’ in my analysis. All but one were 2nd, 3rd, or 4th generation farmers on the Bench, meaning their experience farming is greater than simply the number of years as the primary operator. The one farmer who was not originally from the Bench married into a farming family and now farms full-time. Two younger farmers were only farming on leased land, while the rest owned and leased their farm ground. All farmers interviewed were white men. Additionally, all except one interview took place with just the primary operator, all of whom were men. In one interview, the farmer's wife and adult son sat in on the conversation. While the wife was an active participant and frequently offered her opinions and insight, the son only spoke a few times. In total, I conducted 12 interviews with 14 participants.

Most of the farmers had some college education. Many completed an associate's or bachelor's degree and immediately came back to the Bench to farm full-time. One left the Bench for several years and pursued another career before coming back to take over his father's operation. One farmer spent a year or two using his undergraduate degree – education – to take a break from farming to be able to earn more income during the challenging farm years. The farmers that were interviewed span a range of ages, years of experience, and education, adding a variety of perspectives to this research.

Barriers and Limitations

There are limitations to this study that should be noted. I only interviewed 12 farmers, a relatively small number compared to the approximately 91 malt barley farmers on the Fairfield Bench. While I aimed to capture a wide variety of perspectives within this sample, this small sample size inevitably excluded other perspectives. Additionally, the Census of Agriculture data presented in this study is for the entirety of Teton County. While most of the Fairfield Bench lies in Teton County, a small section crosses into Cascade County. Teton County is also much larger than the land encompassed by the

Greenfields Irrigation District boundaries. Therefore, these quantitative data should be regarded as estimates, with the recognition of the limitations present.

Additionally, there are some limitations to the case study approach. Case studies have been criticized for their inability to address the issue of generalization and generate theories or propositions than can be applied to other cases (Flyvbjerg 2006). While there is truth to these criticisms, I also realize that reaching a generalizable theory is not the purpose of this case study. Case studies seek in-depth, context specific knowledge about a specific problem or phenomenon. As Flyvbjerg (2006) notes, case studies are critical to the development of knowledge, particularly in the social sciences. He explains, "Human behavior cannot be meaningfully understood as simply the rule-governed acts found at the lowest levels of the learning process and in much theory" (Flyvbjerg 2006:223). In other words, understanding social phenomena and theories, like the theory of social-ecological resilience, is dependent on the context of a particular case. This study does not aim to produce a new theory on social-ecological resilience; rather its goal is to produce meaning and understanding to this concept in small, agricultural community in Montana. Case studies can also be used to elaborate or speak back to existing theories, refining and deepening them. In this way, case studies can be generalized to wider bodies of literature (Buraway 1998).

The data also does not capture the experiences of many or even most farmers in Montana. The Fairfield Bench is a unique area because of the irrigation district and the heavy presence of the malt barley industry. These farmers' perspectives therefore may be different from other farmers who operate in different contexts.

I also recognize some personal barriers to this project. I am not from Montana, nor did I grow up in a farming family. Indeed, the extent of my farming experience is keeping a small, personal garden. I am also an Environmental Studies student living in a more liberal area compared the rest of Montana, and I am a woman. These personal characteristics make me an outsider to these farmers. My outsider status, at times, might have created barriers in building rapport with the farmers. Perhaps the largest barrier of all was my program of study. In general, I did not tell the farmers what program I was in unless they specifically asked. I did not want this to become an unnecessary barrier in the interview process. However, most farmers asked, and when I answered, I often sensed a slight change in the farmers' comfort, whether it was a short, nervous pause, fidgeting, or a lack of eye contact. As the interview progressed, these generally faded and the farmers appeared to relax. This illustrates, however, how my personal background might have shaped the interviews and the farmers' comments.

I also came into each interview with my own beliefs and convictions about sustainability in agricultural production and the importance of environmental awareness and conservation. Often in the interview, farmers would express a view that was quite different than my own. In these moments, I had to consciously practice the act of listening to foreign perspectives and lived experiences that I do not share. I began to value the experiences of these farmers and how the context in which they lived and worked - this social-ecological system of the Fairfield Bench - shaped their responses. As the researcher, my role was to listen for meaning in the farmers' words and probe for understanding. This process required diligence in recognizing where my own lenses and experiences shaped the questions that I asked and the interpretation of their responses.

One particular comment after my very first interview reinforced the importance of my role as the researcher. My interview with David was my first one for this project, and I grew nervous as I drove down the gravel road towards his home. Would my questions fall flat? Would he be open and willing to share his honest opinions? The dreary, cloudy sky did little for my confidence as I pulled into the driveway of his ranch house. The nerves eased as he and his wife warmly welcomed me into their home and their children greeted me from the kitchen table, with a fresh pot of coffee brewing on the counter. David led me to his office, and as we settled in, he asked me the question I had hoped to avoid: "So, what program are you in again?" After I responded, his body language changed slightly. He became a little more stiff, a little more formal. This dissipated after the first few questions, and he began to visibly relax and use more casual language. I finished the interview, and as I was gathering my things to leave, he made a comment that stuck with me throughout this process. He said, "When you came in here and said you were studying environmental studies, I got afraid that you were coming here to tell me what to do and how to farm. But it wasn't like that at all. I actually had fun."

As I designed this project, I held my own ideas about these farmers and industrial agricultural production that have been shaped by my own physical, social, and economic contexts. As the researcher, I cannot remove myself from the data; I was the one who designed the project, and who wrote and asked the questions. I am also a participant in this research, but I am not the focus. As the researcher, I had a responsibility to be aware of how my own beliefs and ideas would impact the project, and to ensure that the farmers I talked to felt respected, heard, and valued. While I noted several blunders in my interview with David as I transcribed, I am grateful that he felt appreciated and valued, and that he even enjoyed the process. I am grateful for these 12 farmers and their willingness to participate in these interviews, in which they shared their perspectives on agricultural challenges and capacities for resilience that are presented in the following chapters.

Chapter 4: The Fairfield Bench as a Social-Ecological System

Snow still lined Highway 200 as I drove up and over Rogers Pass towards Fairfield, Montana. It was late March, and spring was on its way, leaving trails of melted snow running down the steep hillsides. This was my second time visiting the Fairfield Bench after conducting preliminary interviews last spring, but the exit from the pass onto Montana's high plains still came as a shock. The landscape abruptly changed from the tree-covered mountains to grasslands, opening up to reveal the Montana sky. I felt exposed, as though the winds that blow across the plains would pick me up and take me with them. I grew up in West Virginia among the old Appalachian Mountains, surrounded by narrow valleys and hidden hollows. This flat country with its vast open spaces was unnerving. Along the Rocky Mountain Front, buttes jut out from the ground proudly, and I somehow felt even smaller here than when surrounded by the mountains in Missoula.

The landscape and its ecological elements profoundly impact us and our social systems. In this first chapter of the data analysis, I provide a thick, in-depth description of the Fairfield Bench. I began each of my interviews by asking the farmers how they would describe the Fairfield Bench to someone who was not familiar with the area. I use their answers to that question to help build the description, in combination with the numerous documents I have gathered about the area. The data illustrate the Fairfield Bench as a social-ecological system, including its major elements and some associated complex interactions. These elements and interactions will be further explored in the subsequent chapters of the analysis. After describing the geographic and physical ecosystem components of the Bench, I then provide a brief history of settlement and agriculture on the Bench, followed by a description of water and the irrigation system. Finally, I elaborate on the current local governance system, agricultural production, and social and community structures on the Bench.

The Landscape

The Fairfield Bench is located approximately 30 miles northwest of Great Falls and 20 miles southeast of Choteau, encompassing both northern Cascade and southern Teton Counties. About 30 miles east, the Rocky Mountain Front creates a stunning backdrop for this region of Montana's high plains. Heading east from the Rockies, the rolling hills begin to disappear, and isolated buttes rise up occasionally from the ground. The Fairfield Bench sits atop one of these formations approximately 4000 feet above sea level and 300 feet above the surrounding plains (Miller et al. 2002). The Bench covers approximately 130 flat or gently sloping square miles (Montana Department of Agriculture N. d.). To the south of the Bench, the Sun River flows east, away from its headwaters in the mountains towards the city of Great Falls, where it joins the Missouri River. The Bench is bordered by Muddy Creek to the east, and the high plains lie to its north.

To the west of the Bench, before the mountains, is Freezeout Lake Wildlife Management Area, which consists of 12,000 acres of wetlands. The area promotes waterfowl and game-bird production, bird hunting, and bird watching opportunities. It is a major stopping point for millions of waterfowl in their annual migration patterns, particularly snow geese and swans (Nimick et al. 1996). In the spring, birdwatchers congregate to watch this impressive show of wildlife. These birds benefit from the agricultural production on the Bench, feeding on the leftover grains in the fields. One farmer told me how he loved being able to look out of his farmhouse window and see the birds in his fields. “That’s beautiful,” he said. “Beautiful.”

The Fairfield Bench and surrounding lands are classified as Great Plains mixedgrass prairie (Montana Natural Heritage Program 2017). Western wheatgrass is usually the dominant vegetation, with high forb diversity. Wildlife such as antelope, mule deer, and sage grouse are common in uncultivated sections. Fire, grazing, and drought are the primary drivers for this ecological system (Montana Natural Heritage Program 2017). The area has a dry continental climate with significant variation in seasonal temperatures. It receives about 12 inches of rain a year, with typically warm, dry summers and cold, severe winters. Monthly average temperatures range from 23 to 66 degrees Fahrenheit (Miller et al. 2002), with a growing season of about 115 days (Montana Natural Heritage Program 2017). The wind blows frequently across the elevated surface of the Bench (Montana Department of Agriculture N. d.).

The Fairfield Bench formation actually consists of three benches that decrease in elevation from north to south (Miller et al. 2002). Gravel deposits cover the Bench, creating a shallow aquifer above the bedrock and relatively porous topsoil. The soils on the Bench are in the Rothiemay clay-loam series, which is a well-drained, alluvial soil (Montana Department of Agriculture N.d.). According to the NRCS Soil Data Access tool, the soils on the Fairfield Bench are generally classified as ‘prime farmland if irrigated’ and ‘farmland of statewide importance.’ Prime farmland means that the soils have adequate structure and moisture to produce high-yielding, high-quality crops with proper management. Farmland of statewide importance does not quite meet the soil quality requirements for prime farmland but is still considered critical for the state crop production (NRCS 2019). These classifications designate the Fairfield Bench as an important agricultural area for Montana.

When asked to describe the Fairfield Bench in the beginning of the interview, five farmers included comments about the soils and climate. One farmer, Bill, commented on how the Fairfield Bench was “fair to good productive ground.” Chris, who lives on the edge of the Greenfields Irrigation District, similarly said the Bench has “good, fertile ground.” Ethan, who described himself as “environmentally-minded,” described the soils as “gravelly to sandy loam type soils.” A few other farmers described the soils as gravelly or thin at other points in the interview. One farmer, Alex, took this question as an opportunity to describe the typical weather on the Bench: “Climate wise, it's kind of extreme. We get a lot of wind, cool nights typically, hot summers…pretty nasty winters, especially with the wind. We don't get tons and tons of snow like some…But the problem is the wind blows so much we get these huge drifts.”

History

Before white settlers moved into the area, the Fairfield Bench and the surrounding land was occupied by a few Native American tribes - the Blackfoot, Salish-Kootenai, and Sioux (Native Lands Digital 2019). The Bench and the surrounding lands were part of traditional tribal hunting grounds for the plentiful game, primarily buffalo, that roamed the plains (Division of Indian Education N. d.). The arrival of white people on their land in the 1800s brought disease and violence, forcing the tribes out of their native homeland and onto reservations (Autobee 1995).

With the start of the 20th century, the area began experiencing significant changes in population and agricultural production. In 1902, the federal government of the United

States passed the Reclamation Act, which created the Bureau of Reclamation (formally the United States Reclamation Service). The Reclamation Act allowed the government to claim what they deemed “unsettled” or “unused” land in the West (Bureau of Reclamation 2016). This land, however, was not “unused” as it had provided for the needs of the tribes for many years. It was simply “unused” by white settlers.

With the power of the Reclamation Act, the Bureau of Reclamation then created large water storage and irrigation projects to provide a reliable and consistent source of water for those lands. The goal of funding these projects was to encourage settlement and homesteading (Bureau of Reclamation 2016). The City of Great Falls, believing that an irrigation project would boost the area’s economy, lobbied for the Bureau of Reclamation to construct a project that would store and divert water from the headwaters of the Sun River for agricultural production outside of the city (Fabry 1994). In 1906 the Sun River Project was approved, and construction began the following year. Three major reservoirs – Gibson Dam, Pishkun Reservoir, and Willow Creek Reservoir – were built to hold over 175,000 acre-feet of water, and hundreds of miles of canals and ditches connected the water supply to the soon-to-be irrigated fields on the Fairfield Bench and surrounding land (Autobee 1995).

Two challenges almost resulted in the closure of the project. First, the federal government required water users to pay back the Bureau of Reclamation for the costs of the Project’s construction. Many farmers were unable to pay these required fees, and questions arose about the Project’s long-term viability (Fabry 1994). Second, farmers resisted the construction of the Project, desiring instead to preserve their current dryland farming and way of life. High yields of wheat had been achieved on the Bench during years with good rainfall, and this success made it difficult for farmers to want to transition to a new system with which they were unfamiliar (Brown 1934). Farmers from the Fairfield Bench protested the Sun River Project for several years to no avail (Autobee 1995). In 1926, the Greenfields Irrigation District formed to manage the water supply for the Bench's 83,000 irrigated acres (Greenfields Irrigation District 2019a). At the time, farmers grew primarily wheat, oats, barley, alfalfa, and field peas. The Fairfield Bench saw its first glimpses of prosperity in the next decade, with farmers flocking to the irrigated acres as the Dust Bowl roared across the arid plains of the West (Autobee 1995).

Of the 12 farmers I interviewed, only one did not grow up on the Fairfield Bench. The others were 2nd, 3rd, or 4th generation farmers, with many proudly explaining that their parents or grandparents arrived on the Bench during the Dust Bowl. Five farmers mentioned the history of the Bench, such as settlement or the age of the irrigation project, in their description of the area. For instance, David, a 3rd generation farmer, said: "It was settled largely in the 1930s, 1920s…people arrived earlier, but then when the irrigation came, then a lot of people started flowing in and my grandparents came in the 30s." These farmers are proud of their history and family farms on this irrigated Bench, and many, particularly the experienced farmers, appeared to be aware of its settlement and irrigation history.

Water and Irrigation

In their initial descriptions of the Fairfield Bench, all of the farmers mentioned water or irrigation. According to Rick, a 3rd generation farmer, irrigation is what made the Fairfield Bench into the community that it is today: "We're all irrigated ground here…otherwise it should be two big dryland farms now. And now it's a huge community, or a small community, of a lot of farmers." Similarly, Dan explained: "It was a settlement for the irrigation water. That's how it brought it all about." Other farmers simply mentioned the presence of irrigation or water in their description of the area. Clearly, water is a defining feature of this area to the farmers, as each farmer brought this forward in the first few sentences of the interview. The irrigation system is the aspect of the Fairfield Bench that differentiates these farmers from the surrounding dryland, thus constituting a core part of their identity as farmers.

In the past several decades, however, both water quality and water quantity have emerged as concerns. Because of the shallow, gravel aquifer underlying the Fairfield Bench, agricultural chemicals can easily travel through the soils and into the groundwater, which is this community's source of drinking water. (Miller et al. 2002). Groundwater wells range in depth from about 15 to 50 feet (Miller et al. 2002). The aquifer is also highly dependent on recharge from irrigation, and water levels fluctuate greatly depending on the growing season cycle (Miller et al. 2002).

Several state agencies have studied the agricultural contamination of groundwater on the Bench. Most recently, the Montana Department of Agriculture monitored 21 groundwater wells from 1992 to 2015. During this 23-year sampling period, 10 of the 21 sites had nitrate concentrations of five parts per million (ppm) or greater, with one of these locations measuring over 10 ppm, which is the Montana Human Health Standard limit for nitrates in drinking water (Montana Department of Environmental Quality N. d.). Levels greater than 10 ppm in a public drinking water system require action to be taken to reduce nitrates to an acceptable level (Montana Department of Environmental Quality N. d.). Nitrates, which originate from commercial fertilizers or animal waste, are important to monitor because of their documented impacts on human health, particularly for infants and children. Additionally, the presence of nitrates in drinking water supplies often suggests the possible occurrence of other contaminants, including agricultural chemicals and harmful bacteria (McCasland et al. 2012).

The Montana Department of Agriculture also monitored for pesticides on the Bench. These residues were generally low, but several classes of pesticides were detected with high levels of frequency, which indicates they are widespread throughout the Bench's groundwater system (Montana Department of Agriculture N.d.). The documented pesticides in the groundwater are those used in malt barley production, which include imazamethabenz methyl, the active ingredient in the herbicide Assert, and pinoxaden, the active ingredient in the herbicide Axial (Montana Department of Agriculture N. d.).

The presence of nitrate and these herbicides in the groundwater suggests that this pollution is linked to agricultural practices unique to the Bench. According to the report, the Montana Department of Agriculture discontinued this groundwater monitoring program because the nitrates could not be directly linked to agricultural chemical use, and no other chemical detected exceeded the 50% threshold of the groundwater standard. The report states that the nitrates may come from sources other than agriculture, like septic systems; however, this is highly unlikely based on the low density of septic systems and the industrial agriculture practices in the area (B. Maxwell, telephone communication, Feb. 28, 2018).

While this monitoring by the Department of Agriculture has ceased, there is still evidence regarding poor drinking water quality. The Montana Department of

Environmental Quality found that the levels of nitrate in the public drinking water supply in Fairfield exceeded 10 ppm in 2018 (Montana Department of Environmental Quality 2018). This indicates that close monitoring of groundwater quality is still necessary on the Bench.

Climate change may also bring changes in the water supply available for irrigation. The 2017 Montana Climate Assessment predicts that most regions in Montana will experience hotter, drier summers, as well as changing precipitation patterns that will likely make droughts more frequent and more severe. Declines in snowpack levels, which feed the water supply for the Greenfields Irrigation District, may also impact the water available for the irrigation system (Whitlock et al. 2017). With one of the largest and most senior water rights on the Sun River, however, the District may be shielded from mild to moderate snowpack level declines (Montana Department of Natural Resources and Conservation 2019).

Farmer perspectives on water quality and water management will be further discussed in the next chapters. For one farmer, the changes in technology for water management was a topic he brought up in the first few sentences of his interview. Charlie, a 2nd generation farmer, said:

> Back in the 80s, we started putting in cement ditches and leveling land, which really improved our ability to irrigate faster or not waste water…and lose your nutrients. And then when the pivots and the wheel lines came in, that was just a kind of a godsend to us, you might say."

Of the farmers I interviewed, Charlie had been farming the longest. Born and raised on the Bench, he started farming on his own and with his father in 1971. When I think about the changes that he must have experienced in irrigation technology and water management in his 48 years of farming, I am not surprised that this is one of the first topics he discussed in the interview.

Current Governance, Agricultural Production, and Community

Today, the Greenfields Irrigation District (GID) supplies water to over 500 water users on the Fairfield Bench (Greenfields Irrigation District 2019a). The main local governing body on the Fairfield Bench, the District was tasked in 1926 with the management of the federal irrigation project, and they were responsible for collecting payments from farmers to pay their debt for its construction. This debt has since been repaid, and the GID and the Bureau of Reclamation now co-own the irrigation project's water right (Greenfields Irrigation District 2019a).

The District is tasked with managing the water supply, delivering the water to the farmers' fields, and maintaining the extensive and aging irrigation infrastructure, which includes the reservoirs and lengthy canal systems. The GID is run by a Board of Commissioners, the five of whom are elected for a three-year term by the water users in the District. The board members are required to be water users themselves and active farmers (Greenfields Irrigation District 2019b). The GID also stipulates that farmers are limited to owning and irrigating 960 acres, and leasing and irrigating 960 acres, putting some limits on how much land one water user can control (Greenfields Irrigation District 2019b).

The GID also has a manager, who is hired by the board and carries out the day-to-day tasks of the irrigation district. In addition to the manager, the GID staff includes a GIS manager, a dam manager, and ditch riders. The ditch riders are responsible for the delivery of water within their assigned division of the project, resolving water disputes among users, and reporting abuses of project rules to the manager (Greenfields Irrigation District 2019b). According to one farmer, the ditch riders are nearly always local and understand the system well. While the GID maintains federal ties with its water right, the day-to-day management of the irrigation district appears to be exclusively under local control.

In less than a century, the flat, prime-if-irrigated soils combined with the reliable irrigation helped to build a prosperous agricultural community. These valuable natural resources influenced the establishment of malt barley production in the area. The access to water, warm days, cool nights, and reliable breeze on the Fairfield Bench are ideal conditions for high-quality malt barley production. Both Anheuser-Busch and MillerCoors, the two largest brewing companies in the United States, exhibit a strong presence on the Bench. Together, they dominate over 60% of the beer market in the United States, with Anheuser-Busch controlling 40% of the market and MillerCoors 23% (National Beer Wholesaler’s Association 2018). One farmer remembers malt barley taking off on the Bench as early as the 1960s, but it was in the 1980s when Anheuser-Busch began contracting with Fairfield Bench growers (Autobee 1995). According to agricultural surveys and census data collected by the United States Department of Agriculture, malt barley has been produced on over 50% of the cropland on the Bench every year from 1989 to 2015, with one dip in 2007 according to the Census of Agriculture (National Agricultural Statistics Service 2019, Montana Department of Agriculture N. d.). In some years, particularly in the mid- to late-1990s, malt barley production covered over 75% of the Bench’s cropland (National Agricultural Statistics Service 2019).

Anheuser-Busch operates a grain storage and handling facility and a seed plant in Fairfield (Legislative Hearing on Economy/Jobs 2011), providing an accessible local market for Fairfield farmers. In 2013, Anheuser-Busch faced some competition when MillerCoors built their own grain storage facility on the other end of the Fairfield Bench in the town of Power (Jacobson 2013). The presence of these two companies have helped Teton County, where most of the Bench is located, become the largest producer of malt barley in the state of Montana (Teton County 2016). The profitable crop and easy access to markets resulted in heavy malt barley production in the area and earned Fairfield the title of 'Malting Barley Capital of the World' (Lutey 2014). However, both Anheuser-Busch and MillerCoors have recently cut contracts with growers and lowered prices because of an oversupply of barley, creating some financial uncertainty for barley growers on the Bench (Murray 2017). The most recent Census of Agriculture in 2017 shows that malt barley production that year only covered 45% of cropland in the area (National Agriculture Statistics Service 2017). The following graph shows the land in malt barley production on the Fairfield Bench and the mean price received for malt barley between 2008 and 2018, according to the National Agriculture Statistics Service (2019):

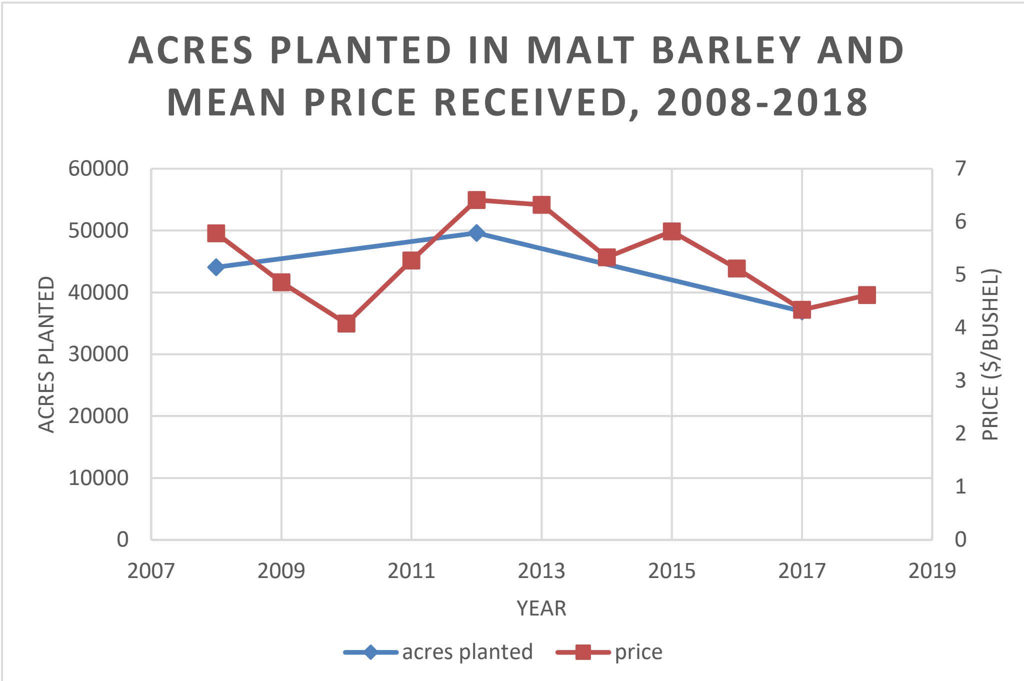

Figure 2: Estimated acres planted in malt barley on the Fairfield Bench and mean price received for malt barley in Montana from 2008-2018. Acres planted data was generated from Census of Agriculture and USDA survey data for irrigated malt barley production in Teton County. Mean price received for malt barley is an average for the state of Montana (National Agriculture Statistics Service 2019).

Figure 2 shows that the area of acres planted in malt barley declined by over 10,000 acres between 2012 and 2017, and the mean price received dropped almost $2.00 per bushel, which supports the experiences of the farmers interviewed. It should be noted that the graph above presents estimated data for Teton County as noted in the caption, according to the best available data from the National Agriculture Statistics Service (2019).

In addition to malt barley, other crops currently grown on the Bench include spring and winter wheat, alfalfa, and canola. Cattle production is also common among these farmers. The following page compares two maps of the Fairfield Bench showing their crop production in 2008 compared with 2018, revealing the decline in malt barley production occurring in the area.

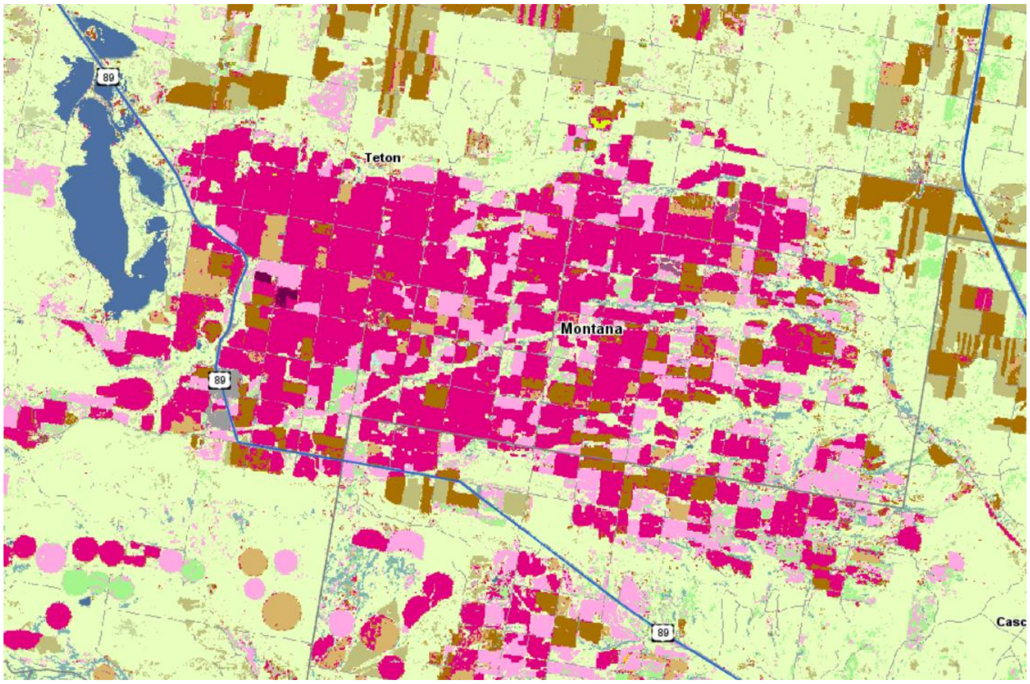

Figure 3: Crop production on the Fairfield Bench in 2008. The area is dominated by malt barley (bright pink), with alfalfa (light pink) and winter wheat (brown) constituting the other major crops (CropScape, USDA National Agricultural Statistics Service 2019).

Figure 4: Crop production on the Fairfield Bench in 2018. There is overall less malt barley production (bright pink) than in 2018, and a more diverse array of crops is present as well (CropScape, USDA National Agricultural Statistics Service 2019). A full list of land cover categories can be found in Appendix C.

Unsurprisingly, all of the farmers mentioned agriculture when asked to describe the Fairfield Bench, either by the word "agriculture" or "agricultural," or listing specific crops. Surprisingly, however, only half of the farmers specifically mentioned malt barley. Nate, who began farming on his own four years ago, said: "Fairfield, I would describe as…a small rural agricultural town, very proud of their malt barley…They have a sign outside that says malting barley capital. So that tells you a little bit about how they would describe themselves." Jordan said: "Our bread and butter up here was and is malt barley." Another four also mentioned malt barley as a feature of the Fairfield Bench. Given the extent to which malt barley seems to be present in this place, I was somewhat surprised that only half of the farmers specifically mentioned this crop. This hints at a change that seems to be occurring in agricultural production on the Bench, which will be further discussed in the following chapters.

Other descriptions of the Fairfield Bench largely revolved around the community and social dynamic of the area. According to the 2010 United States Census, approximately 900 people call the Fairfield Bench home (U.S. Census Bureau 2010). Four farmers mentioned "family" or "family farms" as a defining characteristic of the Bench. Four also mentioned that the area had "good schools." Three farmers identified the Bench as "rural." Two described the area as "safe."

While some of the farmers talked about the social relationships after being asked to describe the Bench, others did not talk about this initially. Therefore, I generally followed up this question by asking about the relationships among people on the Bench. In response, five farmers said that they were "good" or "tight-knit." Five farmers also said that people were helpful and rely on each other during hard times. For example, David said, “They're very proud of their community mindedness and how they help each other out.” Bill described the relationships between people in a similar way: “We all rely on one another for our livelihoods and it's [a] pretty symbiotic relationship with everybody.” Three described their fellow community members as successful and hardworking. Three also used “proud” as a descriptor of Fairfield Bench farmers, and three joked that everyone knows everyone else’s business.

Logan was among these jokers. One of the younger farmers on the Bench, he began farming six years ago after receiving his associate degree. He said, “Everybody knows everybody's business. Pretty much like every small town I bet. But sometimes I think Fairfield is a little worse.” He laughed as he continued. “Especially like in the farming community…if you get a new tractor, everybody knows.” Yet, half of the farmers also talked about changes in community structure currently taking place on the Bench as they described the social dynamics. These changes were generally about the influx of commuters to Great Falls who want to live in a rural environment, or about the increasing farm sizes. Additionally, three farmers used the word “competitive” to describe the changing relationships among farmers. These changes represent significant challenges for these farmers, which I will talk about in greater detail in the following chapter.

Together, the farmers’ descriptions of the Fairfield Bench and the numerous documents collected create a rich description of the area as a social-ecological system. The elements of the system described, including geography, the irrigation system, the irrigation district, and the brewing companies, and the relationships between them are further explored in the following chapters. The complexity of this social-ecological system and its feedback loops emerges as the farmers reveal the challenges they are facing and this system's capacity for resilience.

Chapter 5: Challenges on the Fairfield Bench

Charlie, with over 45 years of farming experience on the Bench, was one of the first farmers to call me back and agree to an interview. He apologized for missing my call. He was at the vet dealing with a dead calf, he explained. As I described my project, he interjected. “Well,” he said, “I can tell you now that our major problem out here is wild oats. They are a major challenge.”

After reading extensively about the Fairfield Bench and conducting preliminary interviews in the area one year ago, I was already familiar with their weed challenges and associated issues. The weeds exist because of the continuous cropping of malt barley; the malt barley exists because of the irrigation, favorable soil, climate, and the contracts from major brewing companies; and the irrigation flushes the agricultural chemicals from barley production and weed control into the shallow aquifer.

Of course, the elements of this social-ecological system do not exist in isolation of each other. They are interconnected. One piece of the social-ecological system impacts the others, for better or for worse. Forces outside of the system, like the industrial agriculture system, climate change, and consumer demand, also play a role in how the elements of the system interact. The interacting elements of this social-ecological system and outside forces create challenges that are connected and complex. This interacting nature of any social-ecological system means that understanding challenges cannot be done in isolation of the rest of the system. This interconnectedness became clear in my interviews with these farmers as they explained to me the challenges that they faced in their agricultural production and in their community.

Several different challenges emerged in my preliminary research of the Fairfield Bench, and I structured my interview guide around these challenges accordingly. These included agricultural challenges with malt barley production, the malt barley industry, climate and natural resources, technology, and governance. I purposefully chose a wide range of challenges because of my focus on general resilience, as discussed previously. However, two other major challenges that I did not specifically anticipate in my interviews became apparent throughout the coding process. These included financial challenges and changes in community structure. In this chapter, I begin by discussing the challenges presented by the farmers about malt barley production and the brewing industry. I then discuss ecosystem and natural resource problems, followed by technology and governance challenges. I end the chapter with the discussion of the challenges that emerged from the interviews: financial problems on the farm, and changes in social relationships and community structure.

Malt Barley Production

As he sat at his kitchen table overlooking a section of his fields, Charlie talked passionately about the Fairfield Bench, his home for 66 years. As the oldest and most experienced farmer I interviewed, he spoke with me for nearly two hours as he explained his operation and the challenges he has faced over his lifetime of farming. Malt barley, he said, is what made this Bench. "It started to blossom into a malt barley area because of the climate, the weather, the water - we could raise good malt barley." In the next breath, he jumped right into what he sees as the biggest challenge for the Fairfield Bench – weeds:

> But that being said, it has got us into a bind because we've been so dependent on chemicals to stop the wild oats that now all the wild oats have gotten resistant to

> all the chemicals out there. There isn't a chemical out there that…the wild oats don't have a resistance to.

Aggressive cropping of malt barley for several decades on the Bench has resulted in weeds that are resistant to chemicals used in malt barley production. With no other crop in between plantings of barley for years, Fairfield Bench farmers are now seeing the consequences of this monoculture. Charlie continued by describing specific instances of challenges with the wild oats: “So yeah, last year, this home place here, I seeded it and the wild oats got so thick, the end of May, I sprayed it all out and started all over.” He described years in which he has seen as many as seven flushes of wild oats in a growing season. “That’s our biggest nemesis right now on the Bench,” he sighed.

Every farmer mentioned weed challenges at some point in the interview. The widespread nature of this problem according to these twelve farmers suggests that most, if not all, malt barley farmers have been impacted by weeds. Alex, the only farmer who did not grow up on the Fairfield Bench, talked about Japanese brome in addition to wild oats. Other farmers also mentioned cheat grass and blue barley as problematic weeds. For Logan, a young farmer, these weeds presented a major challenge for his budding operation: “Weed control's a big deal because with all the irrigation you never get rid of them. So no matter what you're doing there are seeds, and the water you're putting on your field and then they're growing and you know, it's tough. What do you do? Keep spraying.” Logan’s comment provides an example of a feedback loop between two elements within this social-ecological system – weeds and irrigation. Weed seeds settle into the irrigation system and end up in farmers’ fields when they open their headgates. The water then flushes more seeds from the fields into the irrigation system, and the cycle continues. Because of this interconnection, spraying weeds in the field does not eliminate the problem. Weed challenges on the Bench have to be understood in relation to the other elements, like irrigation, on the Bench.

The challenges with weeds on the Fairfield Bench have been documented, particularly by Malchow (1995). In the early 1990s, he found that 64% of fields sampled contained chemically-resistant wild oats, and 99% of those had been planted with barley for the last four or more growing seasons. Decades later, these farmers are still struggling. When talking about weeds, a couple farmers used the term “dirty” to describe weedy fields, and “clean” to describe fields free of weeds. These felt like somewhat clinical terms to describe their land. Weeds are unsavory, a blemish on their operation. They aim for perfection, and weeds ruin this ideal.

Weed pressures and chemical resistance are hallmark impacts of industrial agriculture. With its emphasis on increased yields and efficiency, industrial agriculture has encouraged monoculture cropping. Monocultures, because of their lack of diversity, are more vulnerable to disease and weed pressures (Carolan 2012). This leads to the “pesticide treadmill,” in which weeds and pests become resistant to chemicals, leading to a greater number of applications or a switch to new chemicals, which only continues the resistance cycle (Carolan 2012). The resistant wild oats and other weeds on the Fairfield Bench demonstrate how this social-ecological system is embedded within the larger industrial agriculture system. Farmers are pressured to adopt new technologies (in this example, chemicals) to stay in business, putting them on the pesticide treadmill. This can make farmers dependent on technological solutions for production challenges. For example, Charlie stated that they have been “dependent” on the chemicals to control their weeds. The treadmills of industrial agriculture result in fewer choices for farmers as they are constantly squeezed to adopt the new technologies offered by the industrial system to solve their production problems.

Another major malt barley production challenge mentioned by eleven farmers is rain events during harvest season. For Ethan, this was the biggest challenge he faced. He explained why this was such a threat to his malt barley:

> Some years we'll get rain at harvest…but then you have to get the crop off in good time so that you can avoid those rains. Otherwise the barley…starts the germination process and then stops or it'll just full out germinate. And then you get rejected for malt standards and you have to sell your barley as feed.

In other words, by the time malt barley is ready for harvest, it is sensitive to moisture and can begin the germination process in the field. This negatively impacts the quality of the malt and makes it tough for farmers to sell. Bill also talked about this challenge as he supervised his son filling a truck with grain from his storage facility. A situation like that – even just a one-time event, could be financially devastating to a farmer, he explained.

A weather event like this seems inescapable when it happens. When farmers talked about this challenge, most of them referenced a particular rain event that happened several years ago (Lutey 2014). Farmers reported working day and night before the storm hit to try and harvest all of their barley and the urgency that accompanies a situation like this. Rick spoke of trying to instill that urgency in his son, who has just started farming on his own. Of his kids, he said, "They don't understand the old man's intensity of like, 'Let's go. Quit screwing around.' You know, because of the past experiences [I know] it can start raining any second and all of a sudden, not so fun."

Weeds and weather events were the challenges identified by farmers that posed the greatest threat to malt barley production. Other agronomic challenges that farmers discussed included fungal disease in their barley fields, another outcome of monoculture cropping (Kremen and Miles 2012). Eight farmers mentioned disease as a challenge in barley production, the severity of which is impacted by weather. If the growing season is cool and rainy, fungal diseases become a greater challenge. To combat disease, nearly all of these farmers said that they turn to burning the previous season's barley stubble before planting a new crop. Most farmers said they did not enjoy burning, a challenging and dangerous operation that requires ideal weather conditions to maintain control of the fire. As Bill stated, "If we don't mind our p's and q's and go along with Mother Nature, we could find ourselves in trouble." In addition to being a dangerous task, one farmer, Jack, also pointed out that burning, while it controls fugal disease, could lead to increased weed pressures. He explained, "You have more challenges with weeds because of the burning. The burning will warm your ground up. It'll promote germination faster." Chris and Alex also commented on the impacts to air quality caused by the burning.

Farmers generally discussed these challenges after I asked them to describe a challenge they have faced in malt barley production. Two farmers, however, answered this question a little differently. David, who has been farming for about 25 years, said that every year is challenging in its own way. He mentioned the same kind of challenges that other farmers discussed, but he said that he has not faced any major threats to his farm's viability. "Every time that kind of stuff [rain during harvest] happens to me, it's always worked out," he said. Another farmer, Nate, insisted he has never faced a challenging situation growing malt barley. While Nate mentioned weeds and disease as issues in malt barley production, he claimed he has not experienced anything he would consider a challenge. The least experienced farmer of the group, Nate said:

> Growing it, not really. I mean, my dad has been growing it forever and my grandpa grew it forever before him, so I have not been surprised by anything…it's

> very predictable. It's a ritual that we've been doing for a long time. So that's the one thing I'm never surprised by. Even with newer varieties of barley you usually know exactly how they're going to act on certain pieces of ground or even parts of the field. Very little challenge with that stuff.

Several of the production challenges mentioned by farmers, such as weed and disease pressures, are a direct result of the drivers of maximizing production and efficiency within the industrial agriculture system (Carolan 2012). The Fairfield Bench illustrates a social-ecological system that is experiencing the impacts of industrial agriculture, as it is firmly embedded in the overarching industrial agriculture system.

The Malt Barley Industry

As one drives north into Fairfield on Highway 89, the grain elevators owned and operated by Anheuser-Busch rise up on the left. The buildings cast their shadows over the small town of Fairfield. On the east side of the Bench, another set of grain elevators dominates the skyline. These are owned by MillerCoors. The malt barley industry and these companies, with their domination of the beer market, have shaped both the people and the landscape on the Bench.

Coming into this project, I was somewhat familiar with the influence these companies have exerted in the area. I wanted to learn about the malt barley farmers' perspectives of these companies, their contracts, and their relationship with the farmers. In a few cases, these topics ended up dominating the interview, and most farmers shared with me their thoughts on and challenges with the malt barley industry.

In 2017, Anheuser-Busch and MillerCoors both cut contracts with growers by up to 60% because of an oversupply of malt barley (Murray 2017). Oversupply is another challenge created by increased yields and production that is demanded by industrial agriculture (Carolan 2012). Knowing this history, I asked the farmers if they were impacted by these contract cuts. The farmers' answers to this question varied. Seven farmers said that their production of malt barley was heavily impacted by these cuts. Two farmers, Nate and Bill, said that they used to raise malt barley on all of their fields, every year, until the contract cuts occurred. Nate said, "Well, at the end of 2017 they [Anheuser-Busch] said we're going to cut contracts by 70%…I didn't have that big of contract with them anyways because I was new. So basically it took all of my contract and just made it nothing…rounded to zero."

A few farmers said that they also had their Anheuser-Busch contracts cut significantly, but that they were able to pick up contracts with MillerCoors in Power or with Malteurop, the malting plant located in Great Falls. These other contracts allowed them to continue to produce near normal levels of malt barley. One farmer, Logan, only contracts with MillerCoors and received a smaller cut of 11%. Another farmer, Jordan, said that, luckily, he broke ties with Anheuser-Busch a few years before these major cuts occurred:

> We made a decision six, seven years ago to pull away from Anheuser-Busch. Just didn't like the feeling, the relationship, the business end of it. And at this point it was a smart move on our part. It allowed us to keep in the game, and Malteurop has been very good to us.

This kind of contract farming has increased with the rise of industrial agriculture (Carolan 2012). When fewer companies dominate more of the market share, as Anheuser-Busch and MillerCoors have done, farmers are left with fewer options to sell their crop and become locked-in to contracts as the only option for a market (Carolan 2012). The market power increasingly lies with these major companies and limits farmer choice and agency (Rotz and Fraser 2015).

As farmers discussed the contract cuts, the conversations often drifted towards other challenges with the brewing companies. Every farmer expressed some frustration with the companies, ranging from their lack of loyalty to the farmers to their rules and reporting requirements. Six farmers talked about how they felt the companies were no longer loyal to the farmers, particularly Anheuser-Busch. Most of these farmers mentioned the 10-year-old merger with Belgian company InBev as the beginnings of this frustration (Merced 2008). Alex, who used to grow exclusively for Busch until five or six years ago, said, “One of the big things that I think has really hurt us the last few years, is Budweiser's Belgium takeover. And ever since that, I don't think we have the local control and the local care for the growers…we're just a number, man.”

These farmers explained that this change in the company, going from a national to an international business, resulted in a change in the relationship between the brewer and farmer. Jordon explained his feelings in a similar way to Alex: “It is not what it was 20 years ago where you walked in and your name was on the contract. You're a number now.” Another farmer, Bill said, “Loyalty has gone out the door long time ago…there used to be a lot of loyalty to the grower producers, but that has waned a little bit over the years…they're more big business, more about their own bottom line.”

Because of this consolidation, five farmers explained that they felt the companies had become difficult or frustrating to work with at times. Chris explained that he used to grow barley for Anheuser-Busch until he became too frustrated with their tactics:

> They were kind of hard to get along with because I knew they had a monopoly on the market here. If they needed barley, they would take anything and the next year you could have the same quality of malt barley, and they didn't need it. They [would] find something wrong with it.

Chris said that they would change their quality requirements depending on their supply, which he found frustrating. Dan also experienced a challenging situation regarding quality requirements with MillerCoors, which effectively ended his relationship with the company.

Of the nine farmers that currently contract with MillerCoors, three of them also expressed their frustration with the extensive reporting they require. Logan explained that MillerCoors requires detailed reporting on their malt barley production, including what chemical was used and when, fertilizer rates, and water applications. He clarified that he does not mind reporting what he puts on his crops – he simply does not want to be told how to farm.

During our conversations, it became clear that these farmers felt as though they had lost – or were in the midst of losing – a business relationship in which they had previously felt respected and valued. Alex sighed as he explained, "We care…we pride ourselves in raising a good product, but it doesn't matter." In nearly every interview, I sensed a similar frustration at the lack of respect for their work by these major companies. Of the many challenges that these farmers discussed, this appeared to be one of the most disheartening.

Most farmers also noted changes in consumer demand that were impacting the malt barley industry on the Bench. Ten farmers pointed out the growing popularity of microbreweries and how this has impacted their production for major brewing companies. Charlie recalled listening to a speech at the MillerCoors facility in which the speaker stated that microbreweries are like "mosquitoes" to the company. Jack also pointed out that the microbreweries are currently their main competition. Eight farmers also said that beer sales are down overall in the United States. Several talked about how the culture around drinking has changed and people are not consuming beers like they used to. These industry-related and societal changes are felt by these farmers.

Other data support the farmers' claims. According to the National Beer Wholesaler's Association (2018), the market share for small domestic brewers and importers has increased by 10% since 2008, while the market share for Anheuser-Busch InBev and MillerCoors has fallen. A 2018 report by the National Institutes of Health also shows that beer consumption has fallen 15% since 1977 (Haughwout and Slater 2018). A decrease in consumer demand for beer, particularly for non-craft beer, has impacted malt barley production and the security of the contracts on the Bench.

Over half of the farmers acknowledged their dependence on the malt barley companies and malt barley production in some way. When Nate received the devastating 70% contract cut from Busch as a new farmer, he struggled:

> I went from being over-reliant on malt barley as a steady - every year we do this, every year we sell it to them. Some price variation, but it's always going to go there. And I went from that to, well, what should I plant? Or where's it going to go?

His only farming experience up to that point had been with malt barley because of the contracts and accessible market in Fairfield. He could only recall a few years growing up when his father had raised something other than barley. He assumed that this opportunity would always be there, until it disappeared. When he was offered a larger contract this growing season, he jumped at the chance, putting all his acres into barley production once again. "We didn't want to go all barley," he explained. "But you feel like you have to take that contract so that next year hopefully you have more ground and can use the barley and something else." Growing for the brewing companies felt like his only option in an uncertain economic climate. David described being at the “mercy of the brewing companies” for price and production amount, and Ethan felt as though Fairfield Bench farmers have had a “tunnel vision type mentality” around malt barley, which he felt would be a challenge moving forward in the future.

These farmers have largely been dependent on the malt barley industry for years. This dependence on the industry has resulted in a knowledge gap in knowing how to grow other crops. When the malt barley industry cut contracts with producers, farmers like Nate were left with empty fields and unanswered questions. This dependence on the malt barley has impacted other elements of this social-ecological system, as noted by the pervasive weed problem mentioned by the farmers. It has also left the malt barley farmers vulnerable financially, as they wrestle with the brewing companies and contract challenges. The market concentration by Anheuser-Busch InBev and MillerCoors has left farmers with fewer choices for buyers for their crops and results in diminished negotiating power for the farmers (Carolan 2012). With fewer choices, producers are less likely to change their production or practices in a way that jeopardizes their access to the market (Rotz and Fraser 2015). This was evident in several of the interviews, particularly when Nate described jumping at the chance to increase his contract. If he turned it down to grow other crops, he was afraid it would not be offered to him again. The forces of industrial agriculture, which has encouraged consolidation among agribusinesses and the food industry, have influenced the social-ecological system on the Fairfield Bench, limiting farmers’ power and choice.

Despite these challenges with malt barley, some farmers were not too worried about the future of malt barley production on the Bench. Farmers like Ethan and Jack believed malt barley production to be secure because of the investment the brewing companies have made in constructing their facilities in the area. Over half of the farmers expressed some uncertainty over malt barley production on the Bench in the future. They all believed it would still be produced there in some capacity, but predicted that the production levels and markets may be different.

Climate and Natural Resources

In addition to malt barley, I also wanted to learn about the farmers' perspectives on ecosystem and natural resource challenges. Given the irrigation system and its dependence on snowpack, the amount of water quality data that has been collected, and predicted climatic changes, I wondered what these farmers would say about these elements of the social-ecological system.

Over half of the farmers talked about challenges with water management and supply. Both Bill and Dan talked about managing wastewater that comes off the end of the project. Bill said, "The biggest one is the reclamation on the tailings of our water. If we could find a way to efficiently pump it back and reuse it, it would probably help a lot." Two farmers also talked about increasing water use efficiency because of projected population growth. Dan said, "I think water, and maybe it'd be a hundred years, but someday water's going to be like gold as our population grows…And so we've got to show that we're using it as efficiently as possible." Two farmers brought up potential issues with water supply due to concerns about the snowpack. Ethan, the self-proclaimed "environmentally-minded farmer," said with the potential for climate change, there's always the concern about water supply. For Charlie, managing his water use efficiency is important so as not to lose critical nutrients in the soil. Nate's concern with water management revolved around the delivery of the water and maintaining efficiency in the irrigation system.

Two farmers also talked about the challenges of water management when growing other crops besides malt barley, particularly wheat. David explained this challenge to me as we sat shielded from the gloomy, rainy day in his office. The two things needed for protein development, he explained, are “nitrogen and stress.” Malt barley, which must be low protein for malting standards, thrives on the Bench because of this. The irrigation system reduces water stress on the plant, and the farmer needs to apply less fertilizer. Wheat markets, however, want high protein grain. David says, “When you're irrigating it [wheat], you're never going to stress it and so it's going to have a low protein.” In wheat production on the Bench, the water at times can be more of a hindrance than an asset.

A couple of farmers also brought up challenges with groundwater quantity because of changes in irrigation management. Chris explained:

> When we first moved here, there wasn't any center pivots on this Bench. I think there was one or two is all, but now, I think we have 10 on our place and the water level was going down in the wells. Because flood irrigation floods water back into the aquifer, down the wells, the levels stay high…Ours has gotten so low, we've had trouble with it…Drinking water is probably one of the big things.

Pivots only put small amounts of water on the fields at a time to ensure that the water is being used most efficiently by the plant. This means that less water is seeping below the soil into the aquifer. Because of the aquifer’s porous nature, the groundwater levels are heavily dependent on irrigation. According to Miller et al. (2002), the aquifer receives 70% of its recharge from irrigation. Chris talked about how a public, rural drinking water system would probably be the only long-term solution, but that it would be a major challenge to construct. With many of the farmers mentioning how they wanted to transition their remaining flood irrigated fields to pivots, it does not seem likely that groundwater supply will improve. If this recharge amount continues to decrease, the drinking water supply for the Bench may be at stake. The concern over groundwater supply shows that the irrigation system, irrigation equipment, and groundwater supply are closely connected elements of this social-ecological system.

In addition to water management and supply, I also specifically asked farmers about groundwater quality concerns because of the multiple reports on water quality on the Fairfield Bench. Three farmers said that they were concerned about the groundwater quality on the Bench. Two of these three were younger farmers. Logan explained his concerns were largely due to unexplained health issues that he has witnessed on the Bench, including within his own family. He has seen four or five local people in the same age group, young adults, who have experienced sudden, unexplained seizures. “There are so many people having this issue,” he says, as we sit at his kitchen table drinking glasses of tap water. “I'm not saying that's [groundwater quality’s] the problem. I'm not saying it's not the problem. I don't know. But it makes you think.” A couple farmers mentioned that water quality had been a concern a decade or more ago, but that they believed it was no longer an issue. Over half of the farmers did not express any concern about the drinking water quality. Perhaps the farmers’ reliance on chemicals to control weeds and increase yields results in a blind spot regarding these chemicals’ potential impacts on the ecosystem.

Over half of the farmers also talked about issues with the soil when asked about natural resource challenges. Four farmers mentioned soil health on the Bench as a challenge, and three of these were younger farmers. Ethan mentioned several times how he believes the conventional farming practices of tilling and burning were detrimental to the soil. Nate and Jordan also talked about how they were concerned about soil health on their farms and how improvement was one of their goals moving forward. Alex was the only older farmer who mentioned soil health. The other younger farmer I interviewed, Logan, did not talk about soil health specifically, but he did talk about how the soils on the Bench were challenging to manage because of their porosity. He said, “There's just nothing hanging out in there. You got to give the plant everything it needs.” Three other farmers talked about how the soil was shallow or gravelly, which made crop production a challenge.

Finally, I asked every farmer if they are planning to make any management changes with the predictions of hotter, drier summers and more erratic weather. While I did not use the term climate change, the farmers understood the unspoken phrase in my question. Eight farmers said they were not worried about climate change or denied it outright. Charlie, the most experienced farmer, was one of the most passionate deniers: “I've been on the farm all my life. I have seen the bitter cold. I have seen the heat in the summers. I have seen hail storms…I don't think it's any worse now than it ever was.” Nate, one of the younger farmers, said he was skeptical of climate change claims and was not worried about it for the future of his farm. One young farmer, Jordan, chose his words carefully as he answered the question: “At this point, we have not seen enough shift up here to have to make that call. When we see that shift, yes, we may have to change, but at this point we've not seen enough weather change…we aren't growing bananas yet, put it that way.” Jordon did not deny the science of climate change, as he mentioned that snow pack could be a possible challenge in the future if the climate did shift, but he also did not appear too worried about the potential impacts it could have for his production. Three farmers expressed some concern about climate change and management practices. Surprisingly, only one of the young farmers, Ethan, said he was worried about climate change. The other three young farmers expressed little concern.

The environmental impacts of industrial agriculture, including water pollution from agricultural chemicals and declining soil quality and fertility, are well-documented (Kremen and Miles 2012). Industrial agriculture practices such as fertilizer application and tilling reduce nutrient retention in the soil and negatively impact overall soil health (Kremen and Miles 2012). Fertilizer and pesticide use, encouraged by the pesticide treadmill (Carolan 2012), can leach into water systems, polluting drinking water sources. As discussed previously, farmers have relied heavily on chemicals to solve weed challenges, and these chemicals have shown up in the groundwater. These impacts indicative of industrial agriculture are present on the Bench, further revealing how this social-ecological system is impacted and influenced by outside forces.

Technology

The Montana Department of Agriculture (N. d) report discusses the adoption of irrigation technology on the Bench. Traditionally, irrigation was done by flooding the fields. Laborious and time-consuming, this involved constructing dams to force the water to move through the fields and carefully tracking its progress. In the last couple of decades, farmers have invested in less labor-intensive sprinkler systems, primarily pivots. With many of these farmers witnessing this transition, I wanted to ask about their perspectives of technology and its impacts on their operation. Many of the following perspectives were shared after I asked about technology, but farmers brought up technological challenges at other points in the interview as well.

Challenges with equipment breakdowns and servicing were on the minds of many farmers. According to Alex, “We have to have efficient equipment. We can't have breakdowns. Our biggest thing is breakdowns. And when we have breakdowns, it doesn't only cost us the time, but it costs us money because we're not getting the crop in.” Logan also mentioned frustrations with broken equipment and in particular, fixing broken equipment. He said, “We can't fix it if it goes wrong. ‘Cause it's all computerized and technologies, like, how do you even fix those? You can't unless you have a computer hooked to it.” As the equipment used by the farmers on the Bench becomes more technologically advanced, it becomes more challenging to maintain, and it is associated with a heavier price tag if it fails.

In addition to breakdowns and servicing, several farmers also discussed the challenges associated with new seed technologies, specifically with malt barley. Jack was one of these farmers:

> What I see happened is a lot of these varieties are bred so much more superior than they used to that you can go out on the dryland and throw in some seed real early, get a couple spring rains and you got malt barley. And that floods the market.

Similarly, Jordan said, “As technology has changed around the world, we're finding other areas they can grow it [malt barley] whether it be somewhere in Africa…Ukraine…Great Britain.” Like these farmers pointed out, the Fairfield Bench is facing increasing competition in malt barley production. Until now, the Bench has maintained a comparative advantage in the production of malt barley with its favorable climate and access to water. With new seed technologies that improve malt barley production in other climates, however, it may be losing this comparative advantage.

Adoption of new technologies has been encouraged by the forces of industrial agriculture, as previously discussed with the pesticide treadmill. These new technologies are promoted as the solution to agricultural problems (Guptill et al. 2013). As these malt barley farmers continue to adopt new machinery, however, they are noticing significant drawbacks. In particular, the inability to repair farm machinery, which was once undertaken by the individual farmer, is no longer an option. Some equipment manufacturers require owners to have their equipment serviced at a certified dealer and forbids them from doing their own repairs, costing the farmer time, energy, and money (Hirsch 2019). Once again, we see that farmers' power and agency, even with something as simple as fixing their machinery, has been reduced in part due to the technological treadmill of industrial agriculture.

Governance

Towards the end of the interview, I transitioned my questions from technology to governance. Because I believed the Greenfields Irrigation District was the main governing body for this community, I focused my questions on this institution, asking about the GID's role and influence in the farmer's operations. I also asked about other governing bodies that impact the decision-making for their farm.

Even though irrigation benefits these farmers with a reliable access to water, it can sometimes be a drawback, particularly in terms of crop insurance options. Seven farmers mentioned federal crop insurance or lack of adequate disaster payments through the Farm Service Agency as a challenge. Jack explained that because he was an irrigated farmer, he did not have access to the same kind of insurance coverage as non-irrigated farmers: “We're supposed to be perfect because we got water. A lot of them programs are not geared to an irrigated farmer, and we don't see a lot of the financial help that the dry landers do.” Charlie made a similar statement: “Federal crop insurance has never done me one bit of good. Never. It is not designed for us irrigated people.” Ethan called his insurance coverage options “inadequate,” and Dan said that he has never been able to win “playing the crop insurance game.” All farmers who talked about insurance challenges also discussed concerns about weather events, such as rain or hail during harvest, that can devastate their crops. These farmers feel as though their risk in production is just as large as it is in dryland farming, but they have few options to ensure adequate compensation if something goes wrong.

State and federal environmental rules and regulations also caused frustrations for some farmers. A few of these farmers expressed concerns that burning may be banned in the future because of environmental issues. Rick said, “It will definitely be an issue for Jay [son] and his generation of farming. And they'll shut us down. I mean, they shut Washington down. They used to burn their grass fields and stuff. They shut them down. They can't do it anymore.” Other farmers expressed their frustrations with environmental regulations related to chemical use. As one farmer, Charlie, lamented that there were no new chemicals on the market for weed control in malt barley, he also expressed his frustration at the long wait times for testing and approving new agricultural chemicals: “We’re almost too cautious in this country, you know?”

Some of the farmers mentioned local governance challenges specifically with the GID. A few of the farmers talked about the need to update the aging irrigation infrastructure system. The operation and maintenance of the irrigation system is one of the responsibilities of the GID. While farmers were generally positive about the management of the District, a few acknowledged that a challenge for them is finding the money to pay for needed upgrades. According to Bill, the upgrades include fixing and lining dirt ditches to reduce leaks in the system. He noted, “Our distribution system is probably about 20 years behind where it needs to be.” For these upgrades to the irrigation system infrastructure, Alex said, “There's never enough money obviously to do everything you want to do.” Nate and Dan also talked about the financial challenges for the District to upgrade the system. As the irrigation system was designed and built a century ago, the maintenance of the infrastructure is bound to create significant challenges for the GID.

In addition to the aging irrigation infrastructure, a couple of the farmers also mentioned the challenge of enforcing the GID’s land size regulations. The Greenfields Irrigation District, as a federal Bureau of Reclamation irrigation project, has a size limitation for water users within its boundaries. Farmers are restricted to only owning and irrigating 960 acres, *and* leasing and irrigating 960 acres (Greenfields Irrigation District 2019b), bringing the total acreage that producers can farm to 1920 acres. Logan and Dan both talked about how there are ways around this regulation, allowing farmers to acquire more and more land. For example, Logan said that farmers are buying land using the name of family members to circumvent the rule.

Dan and his family, in particular, talked at length about the land ownership regulation. My interview with Dan included his wife, Sarah, and son, Bryce. The topic of bending the land size rule came up within the first few minutes of the interview as Dan, Sarah, and I sat around their dining table with Bryce chiming in from the kitchen. Dan mentioned how some farmers were putting their land into corporations or the names of other family members that do not even live on the Bench. “So there is a limit,” Dan summarized. And Sarah clarified, “But you can work the limit.” The acreage limitation has historically allowed farms to stay relatively small and family-owned, but it seems as though it is becoming more and more challenging for the District to enforce this particular regulation. This is resulting in what farmers feel is a changing community structure, which will be discussed more at the end of this section.

Finally, a couple of farmers mentioned perceived challenges with water rights. Charlie said:

> We have a really good watershed. Provided the Native Americans don't get control of it. And that's a worry too, because there's these water bills that are going through the House and Senate, you know, from west of the mountains and they think they have the right to control our water. And that's a scary thought.

Rick also talked about how there is always a “water rights battle” going on with environmental groups about retaining adequate water levels for fisheries in the Sun River.

The governance challenges discussed were at multiple scales, from local to federal, and they impacted various elements of this social-ecological system. Federal crop insurance, a product of United States agricultural policies outlined in the Farm Bill, affects farmers’ response to agronomic challenges like a severe weather event. Federal and state environmental regulations influence farmers’ production practices and their impacts on the environment. Local rules enforced by the GID impact the community structure and relationships among farmers. In particular, the growing number of farmers who are finding ways around the land size regulations suggests another influence of industrial agriculture – the pressure to scale up production (Carolan 2012). This will be discussed more below. These governance interactions across scales help to demonstrate the complexity of social-ecological systems and the relationships between their elements.

Finances

The challenges previously discussed – malt barley production, malt barley industry, natural resources, technology, and governance – were anticipated in my interview guide. The nature of the semi-structured interview, however, allows for other topics and themes to surface from the open-ended questions. From this process, two other major types of challenges, finances and changes to community structure, emerged in my interviews.

At the end of every interview, I asked the farmers if there were any other challenges they were facing that we did not discuss to ensure I had not left out any critical piece of the farmer's perspective. In my very first interview with David, he pointed out one of these pieces: "Well, one thing you haven't asked me about, I thought you would, was on financing." He continued on to say that while that has not been a particularly challenging issue for him, it is for a lot of farmers on the Bench. David brought my inexperience, and perhaps ignorance, about one important aspect of farming life to light. "A friend of mine once said [that] we're two failed crops away from going bankrupt," David explained. David's observation of the gap in my interview questions was correct, as the financial risk of farming surfaced repeatedly throughout the interviews.

Every farmer talked about or mentioned the cost of farming. These references to high costs revolved around three aspects of production – equipment, chemicals, and land. Every farmer mentioned or discussed the high prices of equipment. This was a challenge for beginning and experienced farmers alike. Bill, a 3rd generation farmer, said, “It's this equipment just getting outrageous on their prices, on the values, and it's hard to update equipment when it's got such a hefty price tag to it.” David also talked about the challenge of updating equipment, specifically as it related to growing new crops. He said, “It'd be a total adjustment to switch over to alfalfa. Alfalfa uses completely different equipment.” Similarly, the expense of shifting to new management practices was also pointed out by a couple farmers. Rick explained to me how working the barley stubble into the soil is an alternative to burning. Because the stubble is so thick, however, he would need to purchase a new plow at a cost of $150,000. He shook his head in frustration. That’s a major financial barrier to a lot of farmers, he explained.

Irrigation equipment, while it improves water use efficiency and yields, is also not without a price tag. A few farmers discussed this cost. Nate said, “We still do a lot of flood irrigating…An obvious technological advancement, which helps a ton, is pivots. But they're too expensive for me to just put pivots on everything all at once.” Investing in new equipment is a slow and financially challenging process for these farmers. This is in part due to the size limitation imposed by the GID, as David pointed out. This limitation, David said, means that “we can't buy brand new equipment and justify it like the big farms can.” In David’s view, their size limitation coincides with a limitation in potential income. The farm can only grow so much.

Seven of the twelve farmers also mentioned the price of chemicals. As Rick simply put it, “Chemicals are expensive.” Ethan also talked about how the price of chemicals can be a challenge for his disease management: “Is what I'm going to spend on a fungicide worth it?...A lot of times I don't spray it because I just don't have the money just to do it at the time or don't feel like I do."

Half of the farmers also talked about the price of land on the Fairfield Bench. For Logan and Nate, the two newest farmers, the cost of land is particularly challenging. When we talked, Logan said he was in the process of buying his grandparents' land: "But it's so expensive…It's just like, how are you supposed to buy this? That's the biggest issue around here is young farmers finding land and trying to buy it." Nate found himself in a similar position trying to financially access land: "I think $3,000 an acre or $3,500 an acre used to be like, 'Whoa, that's pretty high.' But you know, you could do it. And now I know some people that have offered like $5,000 or $6,000 an acre." That kind of investment would take a long time to pay off from farming the land, he said. For experienced farmers like Alex and Jack, the high cost of land is also preventing them from growing their operation. For example, Alex looked into purchasing more land last year, but the price was prohibitive.

According to the 2017 National Young Farmers Survey completed by the National Young Farmers Coalition (2017), land access is the number one challenge for young farmers. Fairfield Bench farmers are not unique in experiencing high land prices or intense competition for land. The land prices on the Bench are influenced by several other community factors, which I will discuss below.

The high cost of farming is currently coinciding with low crop prices according to seven farmers. The price for barley in the contracts offered by Anheuser-Busch and MillerCoors was low at the time of the interviews, and according to Jack, "Everybody's nervous." Jack said that usually, the prices for malt barley and feed barley have a wide margin. Right now, however, this is not the case: “I noticed right now that open market barley and open market feed are not even hardly a dollar apart, you don't see that very often.” Wheat prices, which nearly all farmers interviewed were growing this season, are also low. A few farmers, like David, opted to tie the barley prices in their contract to the wheat market, hoping for better prices. Unfortunately, at the time of the interviews, wheat prices were also quite low.

Low prices and high costs often mean borrowed money. About half of the farmers mentioned their debt load or the challenge with cash flow. Charlie emphasized that farming is a tough business: “You have to be willing to have to borrow money to just operate on, ‘cause you only get paid once a year.” Alex talked about his desire to get out from under his debt load: “A big goal of mine [is] to get more liquid as far as cash so that, we get these hard times, we're not just totally reliant on our operating note that we still have…so we're not all borrowed money.” Chris talked about how this debt is prohibitive in his operation and ability to experiment: “If it was me, I'd be trying all kinds of stuff if I didn't have payments. I'd be trying corn and soybeans. Right now I'm tied to making my payments…that's all I can think about right now.”

A few farmers also mentioned the financial burdens posed by taxes, including personal income tax, property tax, and the GID’s water tax. Jack said he is shelling out $74,000 on taxes, and he sometimes has to borrow money just to pay them. The high cost of taxes was a challenge for Rick as well. He explained, “Like ours last year was like 4,500 bucks for personal property. That doesn't count property tax which is huge. And then income tax. So it's like, why are you taxing me?” Charlie mentioned how the tax burden not only impacts their pocketbook but also their management practices. The GID charges $22 an acre for water users (Greenfields Irrigation District 2019a). For a farmer with 800 acres, the price of water is nearly $18,000. Charlie said, “We continuous crop every year. If we were able to do like you do in the dry land and only seed half of it, but we can't. Our taxes on irrigated land is so high that we cannot afford to leave it set idle. We just cannot.” He notes that this tax burden has encouraged continuous cropping of malt barley and dependence on the malt barley industry, which has increased weed pressures on the Bench, another major challenge noted by the farmers.

The high cost of inputs, farmland, and taxes coinciding with low crop prices has been termed the “cost-price squeeze” of industrial agriculture (Rotz and Fraser 2015). Farmers are faced with increasing costs, and the price they receive for their crops has not kept up with these higher expenses. Carolan (2012) notes that the cost of inputs has more than doubled since the mid-1970s, but market prices have remained relatively stable. This financial squeeze means that farmers are forced to scale up their production to cover the costs of inputs, but the higher production levels flood the market, leading to lower prices (Carolan 2012). When Anheuser-Busch and MillerCoors cut contracts in 2017, it was largely due to an oversupply of barley (Murray 2017), which was a function of increased production on the Bench and in other barley-growing regions. We can also connect this need to scale up production with the agricultural treadmills discussed earlier. With the promise of new technologies that increase yields and therefore profits, farmers are pushed onto the technological treadmill and forced to keep up or go out of business (Carolan 2012). A few malt barley farmers talked about the ever-increasing yields they are expected to produce in their contracts, and that they have to produce, to remain a viable farm. As farmers continue to expend more financial resources on farm inputs, they increase their debt loads (Rotz and Fraser 2015), as several farmers on the Bench noted.

The cost-price squeeze of industrial agriculture emerged as a major challenge on the Fairfield Bench. This social-ecological system is connected to and impacted by the outside forces of industrial agriculture and results in financially-stressed farmers. The farmers' dependence on increasing production to cover input costs limits their decision-making power as they are forced to contend with the forces of industrial agriculture beyond their control. Heavy debt loads continue to firmly embed them in this system as they strive to pay bills and stay in business (Rotz and Fraser 2015). This cost-price squeeze means that money is often the primary factor when farmers make their production decisions, as multiple farmers pointed out. For example, Nate said, "The dollar speaks pretty strongly" when making his decisions for his farm. Similarly, Jack stated, "It [decision] boils down to the dollar, you know. Most stuff does." With industrial agriculture's cost-price squeeze, the small, family-oriented farmers on the Fairfield Bench have lost some of their economic power.

Changes in Community Structure

The last challenge that concerned the farmers was the social and community dynamic on the Fairfield Bench. Eight of the twelve farmers discussed how the influx of commuters has changed the social dynamic. Great Falls, one of Montana's largest cities, is only a 30-minute drive away from the Bench, and farmers have been noticing more commuters moving into the area. Bill called the Bench "a bedroom community to Great Falls." This changing population structure was a major concern for Jack, who talked about the "urban sprawl" from the nearby city. He said, "I think we're outnumbered as farmers now, so that changes a lot of dynamics. They're too far removed from the actual farming part to even know what goes on out here. You see that everywhere. It's just, kind of feel like a dying breed sometimes."

Jack's feeling of being a "dying breed" was echoed by other farmers. Nate and Jordan, two younger farmers, also noted this change on the Fairfield Bench. For Dan and Sarah, this change in the community dynamic posed a major challenge in their hopes for the Fairfield Bench. They talked back and forth, finishing each other's sentences, about the influx of commuters on the Bench. Dan said that the commuters are not participating in the community life on the Fairfield Bench, which has an impact on the social dynamic. Sarah agreed: "Commuters don't partake. So you've lost that comradery that people used to have during his parents' generation where, you know, they were family, they helped each other. You're losing that 'cause we don't even know the people around us." Farmers who mentioned this changing dynamic often talked about how the commuters complained about various aspects of agricultural management, such as burning or slow-moving equipment on the roads. A few of these farmers also mentioned that the influx of commuters was driving up the price of land and homes, making it harder for farmers to access new land for production.

The growing commuter population was not the only social change on the Bench. Eight farmers also mentioned how farm sizes were increasing. Alex explained to me: "Everything costs money…I think that tension right now is that in order for farmers to survive, we're going to have to get bigger." This echoed David's comment about the challenge of investing in new equipment when Fairfield Bench farmers are technically limited in farm size. To justify these kinds of expenses, some farmers on the Fairfield

Bench are finding ways to access more land, which is causing frustration among other farmers. As Logan talked about the increasing price of land, he said:

> How do you survive? And dang, you can't. So that's why it's getting to be a lot of these bigger farmers…[who] can have thousands and thousands [of acres] in the one family, you're taking it from a small person who's going to sell it to you for way more than the other guy can pay.

A few farmers talked about how this was making the Bench a more competitive place. Rick, who has an adult son interested in finding his own land to farm, said, “There's a lot of big farmers on the Bench that have kind of started paying some ridiculous amounts of money for land and it's kind of hurting.” He said his son is having difficulty accessing affordable land because the competition is “cut-throat.” The farmers’ comments suggest that it is not just the social dynamic between farmers and commuters that is changing. The relationships between farmers are changing as well.

Increasing farm sizes is another result of the industrial agriculture system. Mechanization of farming reduces the need for labor, which allows fewer farmers to manage increasingly large tracts of land (Carolan 2012). The cost-prize squeeze, as discussed above, also forces farmers to scale up their production to meet rising input costs (Carolan 2012). The Fairfield Bench, with its land ownership limits imposed by the GID, has somewhat shielded farmers from this effect. These outside forces of industrial agriculture, however, continue to influence this system, and farmers are feeling the pressure of economies of scale.

About half of the farmers also talked about the aging population of farmers on the Bench. Only one young farmer, Nate, talked about how “aging out” of farming has changed. He explained that with the adoption of pivots on the Bench, farmers were physically able to farm as they got older, and they have held onto their land much longer than previous generations. Additionally, he said, it seems like young people are not coming back to farm like they used to. Several of the older farmers were very concerned about the lack of young families moving back to the area. Chris, who has children nearing adulthood, was worried about the future of his farm if his children choose not to come back. For him, this is one of his biggest challenges as he nears the end of his career.

The future of the Bench without the influx of young farming families also concerned Charlie. “We're just not getting young people home to these farms to take them over,” he said. “And so what few young people are here just gobbling up more and more ground, so we're getting less young people.” Logan, one of the young farmers, believed that there were some young families coming back to the Bench. Not many, he noted, but in the past couple of years, he has seen an increase of young farmers moving back to manage the land.

This challenge of finding young adults to farm is not unique to the Fairfield Bench. Agricultural communities across the United States are seeing similar trends. Katchova and Ahearn (2015) note that there has been a decrease in young farmers in most areas, as children in farming families move away for college or choose other career paths.

From Challenges to Capacities

The farmers shared many of their challenges throughout the interviews, providing a more detailed picture of life on the Bench. Of these many challenges, the ones that were described with the most concern, urgency, and frequency were persistent weed problems, challenges with the brewing companies, the high cost of farming, and the changing social fabric on the Bench. In analyzing these challenges, several key ideas became clear. First, these challenges are not isolated from one another. They are connected across the various elements of this social-ecological system. For example, the presence of the brewing companies and their contract offers have encouraged farmers to continuously produce malt barley every growing season. This has resulted in prolific and resistant weeds that threaten farmers' yields. The cost of weed control, equipment and land; the contract cuts and low prices; and changes in relationships with the brewing companies have placed farmers on alert as their financial futures become more uncertain. The high costs of farming are contributing to farmers' quest for more land, changing the social structure and community dynamic on the Bench. These challenges facing the Fairfield Bench cannot be completely understood without aiming to understand the system as a whole.

Second, the forces of industrial agriculture have encouraged and created many of these challenges. Industrial agriculture encourages economics of scale, adoption of new technologies by farmers, and consolidation among agribusinesses (Carolan 2012). These aspects of industrial agriculture are present on the Bench and have influenced the elements of this social-ecological system.

The third observation from the data is that the structure and forces of industrial agriculture have limited the agency and economic power of the farmers (Rotz and Fraser 2015). A beer market dominated by Anheuser-Busch and MillerCoors reduces their market power and gives them fewer choices when selling their malt barley. The forces of industrial agriculture push farmers to either adopt new technologies or fall off the technological treadmill. The cost-price squeeze results in higher farm debt loads and constant financial challenges as these farmers attempt to keep up with rising input costs. This reduces their economic power as they struggle to survive.

The discussion of challenges facing malt barley farmers ended up dominating many of my interviews. My goal in asking about challenges, however, was to discover how farmers have responded or plan to respond to these challenges. In the next chapter, I discuss the capacities for resilience that I identified in my interviews - the key resources, attributes, and assets that may help the farmers respond to existing and future challenges on the Fairfield Bench.

Chapter 6: Capacities for Resilience

When I left the Fairfield Bench after my first round of interviews in late March, snow was falling. The air was damp and cold. Low-lying clouds hid the views of the Rocky Mountain Front. The highway towards the mountains was snow-covered in places, and the wind whipped the snow across the road. Several inches had fallen by this point, and the drive up the pass was slow and slick.

Just a few days later, I was on my way back to the Bench to conduct more interviews. The sun was shining, and the snow at the top of the pass was melting quickly. The reservoirs of the Greenfields Irrigation District would soon be full of this melting snow, ready to be released at the beginning of the growing season. As I exited the mountains, moving from the trees to the open plains, the first thing I noticed was not the shock of the open sky. Instead, I noticed that there was just the slightest hint of green in the fields, dotted with white patches of snow. Less than a week ago, these plains had been brown, still waiting for the arrival of spring. After a late spring snow storm and a few days of sunshine, the grasses began their transformation, growing and alive, displaying their capacities for resilience.

As explored in this chapter, a variety of capacities for resilience emerged from interviews with malt barley farmers on the Fairfield Bench. In some cases, farmers directly explained how a certain resource or asset allows them to respond to challenges. In other cases, multiple farmers alluded to a theme that was latent. Seven capacities for resilience emerged from the interview data. These capacities are knowledge and learning, technological innovations, access to water, place attachment and identity, local governance, networks and partnerships, and psychological resilience. The capacities identified are compared to the resilience literature and discussed in terms of the three components of resilience – robustness (or stability), adaptability, and transformability. These capacities for resilience, however, exist within the larger industrial agriculture system, and in some cases, its forces are clearly present in these capacities.

Knowledge and Learning

The Fairfield Bench has been in intense malt barley production for decades. This long history of production has resulted several challenges as noted in the previous chapter, but it has also allowed farmers to gather a wealth of knowledge around malt barley growing requirements. Every farmer interviewed has been growing malt barley since they began their operations, and over half of the farmers acknowledged how this history has resulted in accumulated knowledge in the interviews. Logan, six years into running his own operation, said: “I've grown it my whole life. I grew up with my dad doing it, so I knew how to do it…I know how to grow barley. Always have.” Ethan, another young farmer, echoed Logan’s statement: “We're an experienced group of growers around here. We know how to raise malt barley and how to do it efficiently.” Rick similarly emphasized that Fairfield Bench farmers grow malt barley really well, and Jack acknowledged that growing malt barley was just “the thing to do” on the Bench.

With the long history of malt barley production on the Bench, these farmers have in-depth knowledge of the growing requirements for this grain. Nearly every farmer talked about some aspect of barley’s growing requirements, such as the best timing for planting and irrigation, or the plant’s reactions to certain environmental conditions. Chris, for example, explained that the barley plant does not “stool out” in response to heat stress, which means that “when the plant comes out of the ground…it [the heat] dries the grain more, the plant more, to get the one stalk up and make a seed." Charlie explained how the timing of irrigation was critical to maintain the quality necessary for malt barley. He said, "Too much water at the wrong time when it's actually setting [will affect] how big the head is going to be…we'll wind up, 20, 30 Bushel less. It can make a big difference." Jack also explained how he handles harvesting and storing a crop if it is wet in order to prevent sprouting: "Main thing if you had a wet bin is cone it down so that it will dry better…pull a little load or two out of it and run your fans."

The above statements show that these farmers have in-depth knowledge on malt barley production, harvesting, and storage. They know from years of experience at exactly what stage to irrigate, when to apply inputs, and how to handle harvesting and storage challenges. This knowledge can help them withstand production challenges that they face, allowing them to continue successful production despite the obstacles. In conjunction with learning and adaptation, which I will discuss below, this in-depth knowledge provides a potential capacity for resilience by increasing the robustness of the system. If they can continue producing a crop they are familiar with while also learning how to grow new ones, it may enable them to remain confident in their production and financially viable. Additionally, Sumane et al. (2017) state that experimental and local knowledge is often seen as far more valuable to farmers than other forms of knowledge that come from outside of the community. This knowledge of malt barley production is a kind of local knowledge that has been passed down through generations of farmers on the Bench. The wealth of knowledge about malt barley production and years of successful, high-quality crops has contributed to a sense of pride in their abilities among these farmers.

The in-depth knowledge of malt barley production, however, is a result of monoculture production practices, encouraged by ideas of efficiency and high yields found in the industrial agriculture system (Carolan 2012). While farmers have accumulated in-depth knowledge of malt barley production, this has resulted in a knowledge gap in which farmers have little knowledge of or experience with other crops. The system may be stable in terms of knowledge of malt barley production, but it leaves it vulnerable to major production shocks or changes within the malt barley industry.

Fairfield Bench farmers, however, did express interest in learning to grow other crops. As I discussed in the previous chapter, weed management and frustrations with the brewing companies were among the most pressing challenges facing malt barley farmers on the Bench. Farmers' responses to these challenges demonstrate their capacity to learn and adapt, which have been identified as key attributes for resilience in the literature (Biggs et al. 2012).

Of the twelve farmers I interviewed, only one said he was growing exclusively malt barley for the 2019 growing season. This outlier was Nate, the youngest farmer in terms of experience, who was afraid to lose the contract amount he was offered. However, even Nate, like the other farmers, demonstrated the ability or desire to learn how to grow other crops.

Every farmer mentioned that their decision to grow other crops was largely due to the weed pressures on the Bench. The primary rotational crop for these farmers is wheat, but a few farmers also mentioned alfalfa, canola, and green peas. For about half of the farmers, this change happened within the last five growing seasons. David commented that he thinks he has seen most farmers growing something besides malt barley at this point, and for his own operation, rotation "dramatically helps with my wild oat control." Jordon, one of the younger farmers, also said, "We're seeing our ability to kill weeds has been better as we rotated." Chris also commented that he likes rotating crops to control the weeds on his land. "It seems to be our best bet," he said about incorporating rotational crops into his growing cycle.

A few farmers, however, talked about the benefit of rotation in terms of their ability to spray a different chemical, rather than the inherent agroecological benefits of diversity and rotation. Diversity in agricultural systems reduces pest and disease pressures, improves soil fertility and quality, and helps control weeds (Kremen and Miles 2012), as well as buffers against climate change impacts (Lin 2011). While some farmers mentioned these benefits, others did not. Logan, for example, said, "It [rotation] definitely helps because you put different chemicals [on your fields] than you would with the barley." Bill also talked about the benefits of rotating in terms of chemical use: "[We're] trying to use different chemicals, different groups of chemicals…with different crops to get a better control on the weeds." The focus for learning about weed control tactics for some farmers is still largely on the quick chemical fix rather than the long-term benefits of diversifying. This short-term focus is encouraged by the treadmills of industrial agriculture that promote technological fixes to agroecosystem challenges (Carolan 2012). The treadmill becomes the only option for farmers to solve agricultural challenges when they are embedded in this system (Carolan 2012), limiting farmers' choices.

In addition to the agronomic benefits of rotation, most of the farmers also said that the changes with the brewing companies, such as the contract cuts and challenging working relationships, have influenced their decision to begin growing other crops. This was generally a financial motivation. Bill perhaps said it most succinctly: “But the barley markets have changed so much lately that we just got to learn how to grow other crops now.” Rick also commented on Fairfield Bench farmers’ recent learning experience with the decline in the malt barley industry. When talking about how he would react to the disappearance of contracts, he said, “We can grow a competitive wheat crop, now that everybody's kind of learning how to do it a little better.” Jack also talked about how he began learning how to grow wheat and canola when he faced the financial, as well as agronomic, challenges: “When the price went down and the cheat grass and wild oats came in, I figured it was time to do something.” Alex, who used to grow exclusively malt barley until recently, talked about the importance of diversification for financial reasons. As he mused over the recent contract cuts by Anheuser-Busch, he said, “We can't put all our eggs in one basket.”

When agronomic and financial challenges threatened their farm’s financial viability, these farmers learned how to respond. Some of these farmers had rarely, if ever, experienced growing anything besides malt barley. They were able to tackle this learning curve and begin experimenting with other crops, primarily wheat and canola. However, alfalfa, green peas, and other pulse crops were also mentioned as farmers talked about their current operations. For the long-term adaptability and survivability of these farms, learning how to grow other crops is an important capacity for resilience to on-going and future challenges.

Learning has been discussed in multiple frameworks and theories on resilience. Indeed, of the attributes or capacities of resilience in the literature, it is one of the most prevalent. Biggs et al. (2012:434) define learning as “the process of modifying existing or acquiring new knowledge, behaviors, skills, values, or preferences.” Learning is essential in social-ecological systems because changes and new challenges constantly arise. Finding new ways to combat these challenges and adapt to new system paradigms is an essential capacity for resilience (Biggs et al. 2012, Walker et al. 2006). The ability to experiment, problem-solve, and learn are key processes for adaptation (Berkes 2017), an important component of resilience theory. When Fairfield Bench farmers faced a disturbance in their system in the form of uncontrollable weeds, they were able to respond and change their practices, demonstrating learning and innovation (Walker and Salt 2012). Learning can be on an individual level or social level (Armitage et al. 2008, Briggs et al. 2012), and both of these processes are important for system resiliency. The data from the Fairfield Bench also show, however, that this capacity to learn and adapt exists within the larger industrial agriculture system, as demonstrated by farmers who focused on the use of new chemicals as the primary benefit of rotation. This suggests that adaptation on the Bench, and therefore resilience, may be constrained by the outside structures of industrial agriculture.

In addition to this demonstrated *ability* to learn in response to challenges, nearly half of the farmers stated that they *wanted* to experiment and diversify their production. While a couple of farmers appeared to feel as though they were forced to change their production, other farmers demonstrated a clear desire. Alex was one of these farmers. He said plainly, “We need to diversify,” citing financial and agronomic benefits. Nate also expressed interest in experimenting and diversifying, even though he was growing all malt barley this season. He said that when his contracts were cut several years ago, he grew spring wheat and canola because he "just wanted to try it." Later in the interview, I clarified and asked him if he would be interested in experimenting with other crops. He enthusiastically replied, "Yeah. Yup." There's always something else to try, he explained. Ethan, another young farmer, also was interested in diversification and experimentation with new crops. "In a perfect world," he said, "it'd be one third of my acres in malt barley. And I guess what I would love to do at some point is just be one third cereals, one third oil seeds, one third pulse crops."

Three of the four younger farmers expressed interest in diversification. The other young farmer, Logan, said experimenting would probably only be out of necessity. David had an interesting and somewhat contradictory statement about diversification. David was one of the farmers I kept hearing about on the Bench who was always experimenting with different crops. Several other farmers told me to talk with him, and I was curious to hear what he would have to say. He had indeed grown the widest variety of crops of any of the farmers – barley, wheat, canola, alfalfa, peas, chickpeas, and even garlic. David expressed the desire to see more diversity on the Bench and less reliance on the malt barley industry, but he also said he would prefer to grow all malt barley because of the ease of only having one crop. I had the sense that he wanted a different future for the Bench than just malt barley – he just did not believe he would necessarily be the one to help his community reach it. Jack seemed to express a similar sentiment. He hoped there would be "a little more diversity" on the Bench, saying that change could be beneficial, but he also stressed that he would be retiring soon to let someone else take the reins.

Farmers also talked about how their desire to learn about and adopt other farm management tactics, such as soil and residue management and chemical use. Seven farmers talked about new ways of managing their land for both environmental and financial motivations. Jordan mentioned wanting to better manage for soil health through diverse crop rotations. Ethan, the self-titled environmentally-minded farmer, also had a lot of ideas about how to change his operation. He said, “I don't necessarily agree with the way we've been farming, tilling the soil, burning crop residue, that kind of thing.” Ethan was particularly interested in changes he could make to improve the health of his soil: “If we could go no-till and have more diverse crop rotations, or cover crops with multispecies in it and that kind of thing,” he mused as he told me his dreams for his farm. Ethan went on to say, “I’ve been reading a lot about regenerative farming practices…I’d love to at least try that on a small scale.”

For a few farmers, moving away from burning was the next important management step for their farms. For example, Rick talked about how incorporating the barley stubble into the soil instead of burning would be beneficial for his fields. He said, “There's so much nitrogen, phosphate and potash left in that stubble, you think it's just straw, [but] there’s a ton of nutrients left in it.” These nutrients could be added back into the soil with the right management. Jack also talked about other options in lieu of burning, including incorporating grazing on his harvested barley fields. One farmer, Dan, also mentioned his interest in changing his grazing management with his cattle to a more intensive grazing management on his pastures.

A few farmers also talked about changing the ways that they use chemical inputs. The most dramatic desired change came from Ethan, who said, “I would love to get to the point where I had to use very, very little commercial fertilizers” to protect the health and safety of the Bench’s groundwater supply. While no other farmer discussed limiting inputs to this level, a few others did express wanting to be more careful with their inputs. Bill, in particular, discussed how he wanted to begin using site specific application of inputs again. Technological and equipment servicing challenges, discussed in the previous chapter, have made it difficult to do on his land. However, he expressed interest in managing his inputs in this way in the future. Jordan also discussed how he has already begun to shift the way he thinks about and applies his chemical inputs.

These farmers expressed both an ability to learn and a desire to diversify their production. Diversity, like learning, has been discussed extensively in resilience literature, particularly ecological diversity. Folke (2006) synthesizes that diversity regarding species function, not simply the number of species, is key for resilient ecosystems. Fischer et al. (2006) add that having multiple species with similar function enhances a system's ability to recover from disaster should one species fail. The authors continue to argue that resiliency can be possible in commodity agriculture and provide a set of guiding principles for agricultural managers, which include maintaining species diversity and aggressively controlling weeds and invasive species. Diversity in agroecosystems, as previously mentioned, provides pest suppression, disease control, and a buffer for climate change impacts (Lin 2011).

The malt barley farmers on the Fairfield Bench talked about increasing diversity in their operation, which was possible through the farmers' demonstrated capacity to learn and adapt. However, this capacity is still rooted in the industrial agriculture system. A few farmers discussed crop rotations just in terms of applying a new chemical fix, and farmers may need to invest in new equipment to change management practices, squeezing the farmers' financial viability. The ability to learn and adapt, however, is enhanced by other capacities for resilience, as explored below.

Technological Innovations

When asked about the role of technology in their production, most farmers talked about how it has played an important role their response to challenges. This question was perhaps less relevant for the older, more experienced farmers compared with the younger ones. Rick explained, "I think it's big for the future, but…I hate technology because I don't know how to run it." Despite this perspective from a few of the older farmers, most farmers talked about how future technological advancements would play a big role in their production in the future.

Nearly all of the farmers interviewed still had some fields that they were flood irrigating, a more laborious and less exact method compared to sprinkler irrigation systems, such as pivots. All of the farmers mentioned wanting to put pivots on flood irrigated fields or update their current pivot systems. Farmers who wanted more pivots acknowledged a potential a boost to their production. Nate said, "It increases yield and it helps with water management and things like that." David also explained, "The bad soil will produce way better on a pivot than it will with flooding." For farmers like Logan and Alex, adding more technological improvements to their pivot systems is on their minds for future technological changes on their farm. Logan mentioned adding more advanced pressure systems to pivots to prevent wasting water. Alex was interested in technology that would allow him to target sections of a field with individual nozzles to water crops even more efficiently. With their reliable access to water, it is not surprising that they are interested in technological improvements to irrigation equipment. Technological advancements like these can improve their water use efficiency and help these farmers respond to future climatic changes.

There are tensions, however, between improvement to irrigation technologies and the aquifer on the Bench. Walker and Salt (2012) provide a cautionary note on new technology and its relationship to resilience, citing that new technologies can have unintended consequences within or outside of the system. As a couple of farmers on the Fairfield Bench mentioned, implementation of new irrigation technologies, primarily pivots, has resulted in declining groundwater levels, negatively impacting the drinking water supply. This is one example of an unintended consequence, an unforeseen interaction between elements of a social-ecological system. While technological improvements are held to a high standard in their ability to solve challenges in the industrial agriculture system, there can be significant drawbacks and harmful feedback loops from their adoption.

Over half of the farmers mentioned seed technology as a way for them to increase yields and resist diseases. A few farmers talked about new varieties of wheat, one of the most common rotational crops grown on the Bench. Alex said he is always on the lookout for new varieties and experimenting with ones that work the best in his fields. Chris also is interested in new wheat varieties that will thrive on the Bench. He said, “They’re getting varieties that can produce better under irrigation.” Jack also mentioned interest in winter seeding crop varieties, particularly canola. Other farmers also mentioned improved barley varieties that can withstand heat or disease. This, however, is stifled by the fact that when growing barley under contract, they must grow the varieties that the brewing companies want. Logan explains, “The seed variety thing is probably huge…They're

[MillerCoors] constantly upgrading. There seems like every couple of years they come out with a new seed variety that's more disease-resistant, and it bushels better, and it takes the heat better.” Farmers have little control over the barley variety they produce when growing under a contract. A product of industrial agriculture forces, contract farming limits farmers’ agency and decision-making power (Carolan 2012). Additionally, improvements to seed technologies in malt barley increases the competition these farmers face in their production, as high-quality malt barley can now be grown elsewhere.

Nearly all farmers expressed interest in new technologies with farming equipment. Nine had recently made changes in their operation or had desires for equipment upgrades in the future. Most of the farmers talked about how autosteer equipment has made a major difference in their production, cutting down on wasted inputs and seeds. For example, Charlie said, “The autosteer, it's amazing how when you're not doing Z’s and W's out there, you don't use as much seed or you don't use as much chemical.” Nate also praised autosteer technology and expressed interest in learning to use more of his equipment’s computer capacity.

Other farmers mentioned variable rate technology that would allow them to change the amount of fertilizer or chemicals applied to different parts of their fields. For Dan and his son, this kind of rate control with their sprayers was the next item on their list of future technology for their farm. Alex also discussed the benefits of this technology to his production. He said, “We can variable rate all of our fertilizers now…We can even adjust it to different parts of the fields that we want to…We can apply for fertilizer on spots that need it…That’s huge.” He explains, “We’ve adapted that way [adding technology]…and I think we’ve become better farmers because of things like that.” Alex continued on by crediting these new technologies for “keeping us alive.” He said, “That's what's kept us alive because the prices haven't gone up... the yields [are] keeping us alive. Because instead of relying on 100 bushels, now we're getting the 130s, 140s.”

Six farmers also talked about satellite imaging, mapping, and weather monitoring on their fields. Ethan talked about using drone imaging to help reduce chemical use. He said, “I think we can cut down on those [chemicals] using technology, whether it’d be sending a drone out that gets imagery to tell you where pests are, weed problems, or disease and you just go out and spot spray.” Bill has already made use of satellite imagery and mapping to help with this operation. He said, “The fields are all zoned. Using yield maps, using satellite imagery, using soil samples from year to year…which has helped in understanding fertilizer rates.” Logan also mentioned the potential benefits of drone imaging in the future. Jordon, one of the younger farmers, talked about instant weather monitoring on his fields. He explained, “We do have different weather stations set up on our farm remote that can send us what's going on right there…You'll see thunderstorm rolling and two miles from here, I'll get an inch of rain…here I get nothing.” This information helps him make management decisions, such as when and how much to irrigate.

A few farmers also talked about instant access to off-farm information as being a key technological benefit for their farms. Nate and Rick brought this up in their interviews. For Nate, this instant information access was particularly important for marketing. He said, “I have an app on my phone, I can watch it [wheat price] change every second. So I can say, ‘Oh we made a nickel on spring wheat today.’” Three other farmers did not talk about information access, but they did demonstrate its use in the interview. David, Alex, and Jack all pulled out their phones and checked the current wheat prices at some point in our conversation. This demonstration of information access offers an example of how this technology allows them to track prices and potentially plan their marketing.

The interview data revealed the tension between the benefits and costs of technology in malt barley production on the Bench. Farmers praised new technologies and their ability to help increase their yields, as evidenced by Alex's emphasis on technology "keeping us [farmers] alive." A few researchers have acknowledged the role of technology in social-ecological resilience. For example, Stokols et al. (2013) note that technological capital is an important resource that can contribute to resilience in social-ecological systems. New technologies, such as variable rate fertilizer equipment and satellite imagery, can help farmers adapt to and use their resources wisely to reduce inputs, which may help create a more ecologically resilient system.

Technologies also have significant drawbacks. As previously noted with the implementation of pivots for irrigation, new technologies can have unintended negative interactions among elements within and outside of a system (Walker and Salt 2012). Additionally, the farmers' descriptions of the benefits of technology reveal the forces of industrial agriculture. Bill and Charlie, for example, often used the word "efficiency" when explaining how technologies, such as autosteer, have improved their production. Efficient production through mechanization and economies of scale is a key element of industrial agriculture (Carolan 2012). These farmers' interest in adopting newer and better technologies also reveals the technological treadmill of industrial agriculture

(Carolan 2012). They are relying on these technologies to increase their yields and keep them in production, as demonstrated by Alex's explanation of how higher yields are "keeping them alive." Finally, access to this technology is also a challenge because of the high costs of equipment, as noted in the previous chapter. In terms of the social-ecological resilience of this system, Berardi et al. (2011) assert that industrial agriculture forces, such as the technological treadmill, emphasize stability and continuity within the system rather than change and adaptation. While some technologies, such as variable fertilizer rate equipment, can reduce inputs and therefore pollution impacts, other technologies (e. g. pesticides and herbicides, new seed varieties) ultimately still appear to encourage farmers to maintain focus on high levels of production rather than ecological or social health. This focus helps maintain the stability and continuity of the larger industrial agriculture system and structure, forces that can limit the potential for farmers to adapt and transform their own farming practices.

Access to Water

The irrigation system and reliable access to water are clearly important features on the Fairfield Bench. With this in mind, I asked the farmers about the value of the presence of irrigation water for their farm. The aim of this question was to understand how the irrigation system impacted their perspectives on their operation.

When answering this question, nearly every farmer gave some sort of variation on this answer: Without the irrigation system, this farm would not be here. Rick was somewhat flummoxed by this question, because to him, the answer was obvious. He said, "I mean, without it, we wouldn't have anything. I don't even know how to answer that one because - if you didn't have it, this wouldn't be here. It's that simple…that's pretty much it.” Bill answered with a similar statement: “If it wasn't for the irrigation, we wouldn't have it. We wouldn't have the farm. It'd be a dry land farm.” Chris also talked about how this place would look quite different if the irrigation system did not exist. He said, “There wouldn't be near as many farms. It would be just several big farmers, dry land farming…We wouldn't be doing what we're doing.” Nate called the irrigation system the “keystone” of the community. He said, like the other farmers, “If we didn't have it…most of this wouldn't be here.”

Farmers also discussed how the irrigation system helps them plan and respond to weather events and associated disturbances. In the summer of 2017, Montana experienced a flash drought, a sudden onset of hot, very dry weather that left most of the state in severe or extreme drought (Maneta N.d). I asked farmers about this event, wanting to find out how they responded to such a rapid change in weather patterns. Eleven farmers said that this flash drought made no difference in their yield or quality of malt barley. For example, when asked this question, Jordan responded, “No. No. We have plenty of water. We're pretty fortunate that way…We can usually handle the heat and the drought because we got the water.” Nate chuckled when I asked him about his experience with the flash drought a couple of summers ago. He said, “Actually I remember reading an article, someone by Power was mentioning it and I thought it was hilarious because I didn't understand that it even had happened…We still got the water we needed even though it was rationed.…you get pretty spoiled from being where there's irrigated ground.” David also said he did not remember anything different about that summer. He said, “No, I don't even remember it. Our irrigation system is very good, and I have never not been able to raise a crop because of lack of water.”

Only one farmer, Ethan, said that the flash drought had any impact on his crop. Even then, it was minimal. He said, "It'll hurt our yields when we get hot flash droughts like that, but we have such a good irrigation system here, we usually raise good crops anyways." Most farmers mentioned how they have a good water supply and generally are not too concerned with impacts of drought on their crops. The Greenfields Irrigation District does have one of the largest and most senior water rights on the Sun River (Montana Department of Natural Resources and Conservation 2019), which provides up to two-acre feet of water for these farmers (Greenfields Irrigation District 2019b) and a kind of insurance against some weather-related challenges.

Irrigation also provides these farmers with some flexibility. Three farmers talked about how the presence of the irrigation system gives them options when thinking about diversifying their production. Two of these farmers were younger farmers. Nate said:

> If I'm considering a new crop, usually it's a positive thing. The first thing the agronomy guy says, 'Well, are you going to put this on irrigated or not? Oh, is it going on irrigated ground? Oh, you can do that.' Whatever you want to grow, 'Oh, you can do that.' So it's usually a positive influence.

Jordon also said that since they have water, he feels more comfortable trying to grow other crops. Jack called the irrigation system a "safety net." He said, "I feel that I got a little bit more safety net…and I can grow more things." With a reliable access to water and prime-if-irrigated soils, the Fairfield Bench is rich in natural capital for agriculture.

As a variety of scholars and practitioners have explained, access to natural resources constitutes a critical aspect of a social-ecological system's resiliency. Stokols et al. (2013) and Walker et al. (N. d.) noted that access to natural resources is an important asset for resilient social-ecological systems. Similarly, in their guide of resilience capacities and measures, TANGO International (2018) included access to natural capital as one attribute of resilience. The access to water on the Fairfield Bench is an important capacity for resilience for these farmers as it provides them with the ability to experiment and grow new crops – they are not constrained by low moisture levels like their dryland neighbors.

The irrigation system also shields the farmers from adverse weather events like drought and high heat. In fact, it was during the Dust Bowl in the 1930s when the population on the Fairfield Bench began to grow. Farmers flocked to the Bench because it was an oasis in the midst of the dust (Autobee 1995). With two acre-feet of water allotted in normal water years, farmers within the Greenfields Irrigation District generally do not have to worry about having enough water to get through the growing season. A couple farmers said that even when the snowpack was 60% of normal levels, they still had access to enough water for their crops. This essential natural resource, combined with prime-if-irrigated soils, enables these farmers to respond to some weather-related challenges. The access to water, however, does not protect farmers from other weather and climate impacts, such as extreme rain or hail storms, which are predicted to increase in the future (Whitlock et al. 2017).

Access to water provides stability in agricultural production for these farmers and allows them to continue normal or near-normal levels of production despite disturbances to the social-ecological system. While this stability is important in maintaining production, the water may help hide other ecological damages that occur in industrial agriculture systems, like declining soil quality. This stability effect of the water, therefore, may either enhance or diminish overall system resilience over longer time scales.

The irrigation water also provides the opportunity for farmers to adapt. As a few farmers noted, the water's presence gives them the opportunity and flexibility to learn how to grow other crops, enhancing their operation's diversity. The water also has the potential to encourage transformation of the system into a diversified agricultural landscape. Because these farmers rely on this natural resource, however, it could hinder their ability to adapt in the future if less water becomes available. According to the 2017 Montana Climate Assessment, researchers have observed a pronounced decline in snowpack levels since the 1980s, and climate projections indicate that these levels will continue to decline (Whitlock et al. 2017). As the water is an important aspect of their agricultural practices, it is unclear how this future change will impact the social-ecological resilience of the system.

Place Attachment and Identity

Each interview ended with the question of what farmers hoped Fairfield Bench would look like in 50 years. This question aimed to uncover the farmers' thoughts on the key components of this system's identity. I was mainly curious to discover if farmers would mention malt barley production when asked this question. Is malt barley a key feature of this system, part of its identity? Or are other features of this system more important?

Remarkably, not one farmer specifically said that they hoped malt barley production would still be around. A few said that they believed it would always be produced on the Bench, but they acknowledged the changing industry and expected it to look quite different than it has in the past, both in size and with the markets. Most of these farmers, instead, discussed other hopes for the Bench. Overwhelmingly, farmers hoped that the Fairfield Bench would stay the same in terms of number of farmers and family-owned operations. Jack, Jordan, and Alex all said they hoped that there would not be any more houses or subdivided farmland. Others talked about how they hoped there would still be the same number of farmers on the Bench, and that the farms would remain in their family. Alex said, “I don't want it to be a bunch of big farmers. You know, it needs to be family farms and that's kind of what it is now.” Chris, Dan, and Ethan also mentioned how they hoped small, family farms would continue to thrive. Ethan said, “It would be nice to see some of the same names that have been here stick around and continue farming.” Charlie also hoped to see more young families coming back to farm. As the most experienced farmer I interviewed, Charlie spoke at length about his plans to turn over the farm to his daughter and son-in-law in the near future. For their sakes, he said, “I hope it's a thriving community. I hope it's got young people on the farms. I hope that our churches are still going. Our schools are still going.”

These farmers did not seem to hope for any particular crop to be grown on the Bench; rather, they simply hoped for continued agricultural production on small, family-owned farms. They wanted this area to remain a thriving agricultural community. This, I believe, is the key component of this system’s identity – agricultural production on small family farms. In addition to this shared identity among interviewed farmers, many also expressed concern and care for this place, and a love for and pride in the community. Logan said, “I love the place. It’s where I grew up.” Alex and Charlie both expressed that the Fairfield Bench was a fantastic place to live. Ethan talked about how he wanted his kids to grow up like he has, in a community that is safe, rural, and thriving.

The positive emotion towards a particular landscape that is formed from personal interaction is referred to as place attachment (Clarke et al. 2018). In their surveys of residents in two coastal communities in the United Kingdom, Faulkner et al. (2018) found that community members perceived place attachment as the most important capacity for community resilience. They found that place attachment acts as a backbone to the other resilience capacities. When there is a care for the landscape and its community members, the capacity for locals to come together and take action in the face of disturbances or challenges increases (Faulkner et al. 2018). A strong sense of identity encourages this attachment to place and is also an important element of resilience. For instance, Rotarangi and Stephenson (2014) found that a strong and shared sense of identity, reinforced by care for and protection of their sacred lands, was essential to the social-ecological resilience of a tribal group in New Zealand. While social-ecological resilience requires the ability to adapt and transform in response to challenges, a stable identity enhances resilience (Walker and Salt 2012).

The care for this community that was expressed by these farmers amplifies their desire for learning and diversity in their operations. These farmers, particularly the younger ones, are looking for ways in which their farm can remain viable and healthy for their children. They want to see the land and the community thrive, with a clear vision for their desired future for the Bench, and they are willing to learn and adapt to the challenges that they face in order to make that happen. Research has shown that one motivating factor for farmers to incorporate sustainable agricultural practices is attachment to the land (Ryan et al. 2003). These capacities for resilience, learning and place attachment, feed off of each other to enhance the process of adaptation, and therefore resilience, on the Bench. Additionally, the shared identity of the system among these farmers provides a point of stability as they resist, adapt, or transform in response to challenges.

Another major component of these farmers' identity is the presence of the irrigation system, as evidenced from their discussion of water. They are not just farmers – they are irrigated farmers. Because of this importance, the water has helped these farmers develop an attachment to this place and to the stability that the water provides.

Limitations of place attachment for resilience have also been noted. Zwiers et al. (2016) found that feelings of nostalgia for the past may hinder an individual's ability to respond to challenges and therefore negatively impact community resilience. In other words, a focus on social-ecological system stability can reduce the adaptability and transformability of the system. Farmers on the Fairfield Bench did express a desire for the community to remain the same; however, they also showed the capability of learning and experimenting to ensure the continued success of their farms. These farmers, however, must contend with the forces of industrial agriculture that work to reduce the number of farms in operation. Agricultural census data shows a decrease in the number of operations. From 1997 to 2017, the number of operations that harvested irrigated malt barley in Teton County decreased from 161 to 91 (National Agricultural Statistics Service 2019). Additionally, the Bench faces significant challenges to social-ecological resilience in terms of community structure, such as aging farmers and an influx of commuters. While place attachment is an asset for these farmers who want to ensure their future generations will be able to continue farming on this smaller scale, farmers face mounting obstacles to maintaining the system's identity as a community of small, family farms.

Local Governance

The Greenfields Irrigation District provides the main local governance element for these farmers on the Fairfield Bench, as they control the water and, to an extent, land ownership. While a few farmers commented on the loopholes in the GID's land restrictions, as discussed in the previous chapter, all of the farmers generally praised the District's current leadership and organization. David said, "I personally think that they're the most important government body in this community… I think the board is a wise board, so I think they're doing very well in maintaining it [irrigation system] all and improving it." Similarly, Chris called the GID a "very well-run outfit," and praised them for their management. Dan and his wife, Sarah, also applauded the district, with Dan commenting. "Overall, the District's doing a good job in trying to forecast our needs." Sarah added that the GID was running very efficiently now. While she was frustrated with the loopholes in the land regulations, she said that the current manager is trying to get farmers back into compliance with the rules of the District.

Governing institutions that are able to adapt according to the system's needs are a major component of resilience literature (Folke 2006). Governance is often the most important, and yet most challenging, aspect of a social-ecological system to create and enhance resilience (Walker and Salt 2012). The term 'adaptive governance' describes the kind of successful governance needed in a resilient social-ecological system. Elements of adaptive governance include strong leadership for building trust and knowledge of the system, partnerships, and organization of actors (Folke et al. 2005). Overlapping and interconnected layers of governance, called polycentric governance (Biggs et al. 2012), are also key in building the resilience of social-ecological systems. Similar to how incorporating multiple ecosystem functions in a landscape provides resiliency, multiple governance systems can provide the same kind of strength. Finally, participation from stakeholders in the governance systems creates strong incentive for collective action (Folke 2006).

The GID is an important governing body for this community, and this institution does demonstrate some of these aspects of adaptive governance. Farmers are able to participate in its governance, as they are the ones who elect members of and serve on the board. Additionally, the GID's ditch riders are usually local, according to David. Therefore, rules and regulations on water usage are enforced by members of the community. The GID currently also has strong leadership, according to multiple farmers, and this leadership has made changes according to the needs of the producers. Finally, even though the GID paid back the federal government for the cost of the project a couple of decades ago, the Bureau of Reclamation still owns the water storage infrastructures. Bill explained that this division of ownership releases the GID of some of the responsibility of maintenance and funding for upkeep. This is one example of a polycentric system, in which multiple governance systems exist in the same place.

The District controls the main natural resource asset in the community, the water, and therefore strong governance ensures that this resource is managed well and available to farmers when they need it. Additionally, because they control the water, it is important for farmers to trust in the GID's leadership and participate in its local governance. The elements of adaptive governance present in this social-ecological system may provide some capacity for resilience through adaptation of water management to changing conditions, such as snowpack levels.

Networks and Partnerships

The farmers on the Bench are embedded in various social networks. About half of the farmers mentioned either observing or talking to other producers as a means of acquiring new knowledge or information. Three of these individuals were the younger farmers. Logan said:

> You really just talk to other farmers. I try to listen more than I talk…Like my grandpa and my dad, these guys have been farming for 30, 40 years. You learn what to do and what not to do. And if I have a problem, I'm not afraid to just go and be like, 'Hey, why is this not happening or why is this happening?'

Ethan also talked about asking other farmers for advice, particularly when growing a new crop, green peas, for the first time. He said, "There were neighbors that had produced it before. So I had some resources for agronomics, people that I could call to ask questions, so there was that kind of support." Chris joked that because he was not a very good farmer, he often looked to his neighbors for ideas. When I asked him how he determines what his response will be to challenges, he said, "I just watch the neighbors and see what they're doing…because they are a lot better farmers than I am." Ethan also alluded to this idea at the end of his interview. As he talked about his hopes for more diversity in crop production on the Fairfield Bench, he said that when farmers see their neighbors growing other crops successfully, then they are more likely to follow suit. These farmers are watching their neighbors to see what they are growing and what new management practices they are using, asking for advice from fellow farmers when they need it. This suggests that there is a loose, informal network of information sharing between farmers.

In addition to a loose, informal network among farmers, several interviewees also discussed other partnerships that are assets in production. A few farmers talked about how they have strong relationships with the brewing companies. Of Malteurop in Great

Falls, Dan and Sarah said that they have had a good experience with this particular company. Sarah said, “Malteurop has been treating us really good…They've been excellent to us and the way that they treat us.” Bill was one of the only farmers to describe a positive relationship with Anheuser-Busch. This strong relationship was in part due to their sustainability program, according to Bill: “I have such a good relationship with Anheuser Busch and with their sustainability programs that they're trying to get going and stewardship programs that we kind of developed together.”

According to Anheuser-Busch’s website, they have developed several sustainability goals to reach by 2025. One of these goals is smart agriculture, in which “100% of our direct farmers will be highly-skilled, connected, and financially empowered by 2025” (Anheuser-Busch 2018). One of the initiatives under this sustainability goal is “SmartBarley.” This program enables Anheuser-Busch agronomists to connect with and collect data from barley growers to help determine best practices and share these practices with other barley farmers (Anheuser-Busch 2018). In addition to this sustainability program, a couple other farmers also mentioned that the brewing companies were promoting rotations for their growers. Jack said, “They're both encouraging the rotation but Coors has got incentive programs and everything else going now.”

Multiple researchers have identified networks, collaborative capacity, and connectivity as key capacities for social-ecological resilience (Kerner and Thomas 2014). Kerner and Thomas (2014:688) define collaborative capacity as the ability to take action through “coordinated engagement.” This involves significant levels of trust, a common understanding of the system, and strong relationships (Kerner and Thomas 2014). Strong social networks infer motivation for cooperation for actors in a system (Walker et al. 2006). Networks also make it possible for adaptation and learning to have lasting results within a social-ecological system (Walker et al. 2006). Social networks also enhance the system's governance capacity by encouraging participatory opportunities (Biggs et al. 2012). The general resilience of social-ecological systems will be influenced by the strength of the social networks that exist and their ability to assist individuals in their response to challenges (Walker and Salt 2012).

On the Fairfield Bench, the loose network between farmers is critical for knowledge sharing, experimentation, learning, and adaption. The irrigation district provides a governance structure that may encourage this social networking through participating in the governance process. This loose social network and the capacity to learn strengthen one another, potentially resulting in a more adaptive, and therefore resilient, community. This social network of farmers on the Bench, however, is impacted by increasing competition among farmers for land and an influx of commuters to the area. Weakening relationships between farmers has been noted as one social consequence of industrial agriculture (Carolan 2012). The potential for adaptation by transfer of knowledge through social networks may be limited by these social tensions and challenges.

Despite long-term relationships with the brewing companies, trust in them has eroded. Indeed, farmers sometimes described to me at length their frustrations with these companies. Despite these tensions, a positive aspect of this relationship exists, namely encouraging rotations and other sustainable practices. What could this relationship do if rotations and diversity were truly encouraged and assistance in developing on-farm diversity was given? Could these companies positively impact the resilience of this system both economically and agronomically with a strong, loyal relationship? This relationship, however, is contractual, with the power largely resting with the brewing companies. This network between farmers and brewing companies would have to become more collaborative, with major changes to the power structure, which is perhaps an insurmountable obstacle within the context of industrial agriculture.

Psychological Resilience

One interesting capacity for resilience that emerged in my interviews was one of personal or psychological resiliency. Five farmers alluded to this kind of mental or psychological strength. For example, when I asked Alex about his responses to various challenges, like weeds or weather events, he said things like, “A lot of times you just got to pick up the pieces…You can’t look back…We just kind of have to go with it.” Chris and Logan both talked about how they do not stress about challenging situations. As Logan explained, “I kind of deal with things when it comes…take life as it is.” Sarah exhibited a similar attitude as she and her husband talked about a particularly challenging situation with a brewing company that resulted in a major financial loss. Ultimately, they got creative with their finances, allowing them to keep their farm afloat. Sarah ended with, “You just do whatever you have to do to kind of make up when you have those bad years.”

Challenges are an inherent part of farming, and Charlie and Rick both pointed out that the lifestyle is hard. In order to respond to those challenges, some of these farmers described the ability to maintain mental grit or resiliency in spite of the obstacles. This mental strength enables them to keep moving forward. There are some studies on this particular capacity of psychological resilience. Walker and Salt (2012:146) define psychological resilience as the "positive capacity of people to cope with stress and catastrophe." Rather than a static capacity, psychological resiliency can be both encouraged and diminished (Walker and Salt 2012). Studies of resiliency among farming families have found that strong social ties and a sense of belonging in their community encouraged psychological resilience (Caldwell and Boyd 2009, McLaren and Challis 2009).

The attachment to place that these farmers expressed helps fuel this kind of mental resiliency. Without a passion or love for the place, the community, and their profession, it could be more challenging for farmers to maintain this kind of mentality. This mental resilience may also help these farmers learn and adapt to challenges, encouraging adaptation and reinforcing this capacity for resilience. However, the community structure is changing with the influx of commuters and aging farmers, and a couple farmers felt as though the social ties were weakening. These changes may negatively impact the psychological resiliency of these farmers, diminishing their potential to persist, adapt, or transform.

Limitations of Resilience

The interacting capacities identified on the Fairfield Bench include knowledge and learning, technological innovations, access to water, place attachment and identity, local governance, social networks and partnerships, and psychological resilience. Each one of these capacities does not individually give rise to a resilient system. Rather, it is the combination of these capacities and their interactions with one another that may foster social-ecological resilience. The capacity for knowledge, learning, and adaptation is encouraged by place attachment and psychological resiliency. The presence of a significant natural resource capacity, water, further encourages learning by allowing for more opportunities to experiment and grow other crops. The strong sense of place is also influenced and strengthened by the irrigation system, as this natural resource helps define the place and the farmers' own identities as producers. The strong governance component of the Greenfields Irrigation District ensures that the water is available for farmers and provides opportunities for engagement and participation. This engagement can encourage networks among farmers, which further encourages knowledge sharing and learning.

Faulkner et al. (2018) in their study of community resiliency also found that the capacities of resilience they identified worked in tandem to enhance the community's ability to respond to disturbances and challenges. Ungar (2018) argue that resilience is a process rather than a trait or property of a system, and that the process of resilience occurs from various capacities and actions that interact across scales. Understanding social-ecological resilience requires a systems approach that aims to account for interactions among capacities for resilience and elements within and outside of the system.

As discussed in this chapter, however, the identified capacities for resilience do have limitations. For example, while farmers praised technologies for improving practices and yields, the influence of the technological treadmill on their operations was apparent. Many appeared to be looking forward to future technologies, such as new chemicals, to solve their agricultural challenges. Even though technology can be beneficial, it can also create a false state of stability in which production continues as normal while elements of the ecological or economic system falter (Berardi et al. 2011).

For example, herbicides can successfully control weeds for a certain length of time, but the excessive use of these chemicals damages soil and water quality. In other words, the industrial agriculture system has reinforced stability and reduced adaptive and transformative capacities of agricultural systems (Berardi et al. 2011). On the Fairfield Bench, the capacities for resilience identified similarly seem to be currently working to stabilize the system or allow for adaptation within the larger industrial agriculture system. For example, technology can act to stabilize production or allow it to increase without addressing potential underlying weaknesses in the system. Additionally, the learning and adaptation by farmers are largely just allowing them to adapt within the structures of industrial agriculture, as they continue to face the cost-price squeeze in their production. The industrial agriculture system has diminished some of these capacities for resilience as well as the power and agency of these farmers as they contend with agricultural treadmills, rising production costs, and low prices (Rotz and Fraser 2015).

These capacities for resilience, however, may have the potential for system transformation. Transformation, as previously defined, is the capacity of a system to create a fundamentally new system with different feedback loops and internal structures when the existing system is untenable (Folke et al. 2010). Within the definition for social-ecological resilience and its reliance on the concept of identity, transformation on the Fairfield Bench could take the form of the system changing to diversified agricultural production while maintaining its identity as a community of small family farms. A transformation like this could give rise to a system that is less reliant on a few major companies, provide more production options and markets for farmers, and increase the focus on protecting the long-term health of their land and water. These changes could reduce the influence of the industrial agriculture system on the farmers' decisions and increase their agency over their production and marketing. The Fairfield Bench, however, faces substantial challenges to this kind of transformation, such as financial pressures, the farmers' dependence on the malt barley industry, and a changing community structure, which may not be fully addressed by these capacities for resilience. For example, even though some farmers, like Nate, expressed a desire to diversify their production, rising input costs and a lack of experience with other crops inhibit this capacity for resilience. In the conclusion, I situate this case study in the social-ecological resilience literature, address the gaps in capacities for resilience, and discuss future research ideas for the Fairfield Bench.

Chapter 7: Conclusion

Summary of Findings

The emerging literature on social-ecological systems recognizes the importance of understanding the connections and relationships among the environmental, social, economic, political, and cultural elements of a system. Studying agricultural systems, like the Fairfield Bench, illustrates the complex and interwoven nature of these elements, and how they interact with and are shaped by larger structures, systems, and forces. The social-ecological system elements on the Fairfield Bench have been shaped by the larger structures and forces of industrial agriculture, resulting in significant challenges for the system. The purpose of industrial agriculture – to increase efficiency by growing more food on less land with fewer farmers – has encouraged monocropping, intensive chemical use, and an increasing reliance on new technology to solve agricultural problems on the Fairfield Bench.

As a result, malt barley farmers on the Bench are dealing with chemically-resistant weeds, water quality pollution from agricultural chemicals, and increasing costs associated with adopting new technology and rising price of land. Consolidation in the food sector and agribusinesses has resulted in these malt barley farmers becoming dependent on just a few businesses for their market, namely Anheuser-Busch and MillerCoors. The higher costs associated with farming, as well as consolidation among farmers, has impacted the social structure of the Fairfield Bench, with fewer producers farming larger tracts of land (National Agriculture Statistics Service 2019) despite the limits placed by the Greenfields Irrigation District. The challenges facing farmers on the Bench largely stem from this system's embeddedness in the larger industrial agriculture system. The malt barley farmers' production decisions, from the kinds of seeds they grow to the chemicals they use, have been influenced by actors outside of this social-ecological system.

Despite these challenges, capacities for social-ecological resilience are present on the Bench. Farmers demonstrated in-depth knowledge of malt barley production, as well as the ability to learn how to grow new crops. This learning is an essential part of adaptation, a key component of social-ecological resilience (Biggs et al. 2012, Walker et al. 2006). Farmers also exhibited attachment to place, which includes the landscape and community structure. This place attachment is influenced by the strong sense of identity of the system as a community of small, family farms. The commitment to place and strong sense of identity can also encourage resilience (Faulkner et al. 2018, Rotarangi and Stephenson 2014). Access to water, a strong local governing body in the Greenfields Irrigation District, and psychological resilience were other key capacities for resilience that farmers identified.

These capacities, however, exist within the larger context of the industrial agriculture system. Farmers draw on these capacities to encourage stability and adaptability within the structures of industrial agriculture, but this leaves farmers constantly subject to many of the same challenges created by this larger system, such as fluctuating commodity prices, herbicide resistant weeds, and rising cost of inputs. Within this system, the choices available to individual farmers are limited. As previously discussed, the treadmills of industrial agriculture place farmers on decision-making paths that are shaped by industrial agriculture forces. The current understanding of social-ecological resilience theory does not adequately address these issues of decision-making power and agency (Cote and Nightingale 2012). With limited agency over their farming decisions, the farmers' capacities for social-ecological resilience may not be drawn upon to their full potential.

In this conclusion, I address this criticism of social-ecological resilience theory regarding power and agency, and how this criticism emerged from my data. I then discuss the social-ecological resilience concept, its usefulness in my study, and its utility in future research. Finally, I provide ideas for future resilience research.

Resilience for Whom?

Every farmer that I interviewed expressed some frustration with the brewing companies, and over half talked about how dependent they are on these companies and their contracts for their livelihood. When discussing weed control using rotations, a few plainly said that the rotations were beneficial because they could use new chemicals on different crops to control the weeds and did not mention the ecological benefits of diversifying. Despite worries about the rising costs of technology, many credited new technologies, such as autosteer and variable fertilizer rate equipment, for improving their production and increasing their yields. The farmers largely believed technology would be extremely important in the future of farming.

These beliefs reflect some of the hallmark characteristics of industrial agriculture – rise of contract farming (Carolan 2012), chemical use to solve agronomic problems (Guptill et al. 2013), and the technological treadmill (Carolan 2012, Lyson 2004). As I listened to these statements in the interviews and devoted further thought to them in my analysis, it became increasingly clear that the Fairfield Bench is a social-ecological system embedded in the larger industrial agriculture system. Industrial agriculture is focused on high levels of production, high efficiencies, and ultimately, profit (Carolan 2012). Recognizing that their statements reflected this system, I began to question the farmers' power and agency within it and wondered to what extent these farmers are able to exert power over their own production decisions. For instance, the brewing companies tell the farmers what kinds of malt barley to grow and the grain standards they need to meet. Agribusinesses and chemical companies tell them what new technologies or chemicals to use for a supposedly quick fix to their production challenges.

The farmers would likely push back on the above statements, insisting that they are the only ones making the day-to-day decisions on their farm. A few even said that the independence of not having a boss was one of the reasons they enjoyed farming. However, our behaviors and choices do not exist in isolation; they are influenced by outside structures and forces of which we may be unaware (Cote and Nightingale 2012). As an outsider, I had a unique opportunity to question and examine these farmers' decision-making processes and their agency in their farming choices. It appears that the agency of these malt barley farmers on the Fairfield Bench has been limited by the force and influence of industrial agriculture. This larger structure, created and encouraged by federal policies and major agribusinesses, plays a major role in the decision-making processes of these malt barley farmers, influencing their response to production challenges (e. g. chemical solutions to weeds) and their understanding of agricultural systems. The tension between structural forces and individual agency plays out on the Fairfield Bench as farmers confront agricultural and community challenges and must make decisions about how they will respond.

Concepts of power and agency are generally oversimplified and undertheorized in social-ecological resilience research and frameworks, with the assumption that individuals simply have the ability to exert complete control over their decisions (Cote and Nightingale 2012). There is little acknowledgement of the social, economic, and political structures and institutions that might enhance or diminish individual power and agency, a criticism that multiple researchers have identified (Cote and Nightingale 2012, Cretney 2014, Wyborn et al. 2014). Resilience scholars have emphasized the question, “Resilience of what to what?” (Carpenter et al. 2001:765) while ignoring the important normative question of “Resilience for whom?” (Cote and Nightingale 2012:475).

Resilience theories have largely failed to address social constructs of power and agency because they have focused on ecological dynamics to explain social dynamics, which does not capture the complexities of social, economic, and political relationships and interactions (Cote and Nightingale 2012). This case study provides an example of why addressing the tension between structure and agency in individual decision-making and the role that power plays within the context of social-ecological resilience is needed. So, for whom is the Fairfield Bench resilient? As I demonstrated how both the challenges and capacities for resilience are largely grounded in the industrial agriculture system in the previous chapters, I would argue that the current state of the social-ecological system on the Fairfield Bench is principally resilient for industrial agriculture and not necessarily for the farmer.

Usefulness of the Resilience Concept

As I stated previously, academic papers on social-ecological resilience number in the thousands. Numerous definitions for social-ecological resilience and its exhaustive list of dimensions such as robustness, thresholds, adaptability, and transformability create a confusing pool of concepts (Lade and Peterson 2019). The overwhelming number of definitions creates uncertainty over what terms do and should mean. Additionally, Chandler (2019) argues that the concept of resilience has been exhausted as an analytical or governmental framing. He argues that resilience frameworks are focused on what he and others call “coerced resilience,” in which resilience is created through increased anthropogenic inputs such as new technologies and energy (Rist et al. 2014, Chandler 2019). Is resilience simply another term that has been co-opted by those in power?

These criticisms lead me to question the usefulness of the resilience concept. In this particular study on the Fairfield Bench, relating the analysis back to the resilience literature revealed issues of power and agency that have been previously critiqued. This provides an example of a case study in which this issue is present, encouraging the continued conversation on agency, power, and institutional structures in resilience literature. In this way, using the concept of social-ecological resilience in this case study was useful in confirming some of the critiques of resilience.

Social-ecological resilience is also a challenging concept to study because of the complexity associated with the study of systems. Even though the boundaries of SES are fluid and porous (Preiser et al. 2018), artificial boundaries need to be constructed around a system in order for it to be studied effectively. These boundaries, however, can result in researchers missing or reducing the impact of key connections and relationships to elements outside of the system being studied. For example, on the Fairfield Bench, Anheuser-Busch exists within the system boundaries, as they own and operate a grain storage facility in Fairfield. However, they also exist outside of the system, with an expansive global reach and decisions made far away in board rooms. I attempted to describe this connection outside of the system by discussing impacts of corporate consolidation and new seed technology, but the connections and implications of those connections are too complex to fully capture in this study. Researchers must address these limitations and their potential impact on their conclusions.

Resilience concepts and frameworks do exhibit significant challenges and problems as I have previously discussed. I am reluctant, however, to throw away the term and dismiss its potential usefulness. The concept, if nothing else, has generated discussions and research across disciplines and encouraged a systems thinking approach to problems (Chandler 2019). As our environments and societies become more interconnected, thinking about challenges, such as climate change, using a systems approach is critical. Careful consideration is needed, however, when defining resilience and its concepts, with more focus at the root of environmental and social problems (such as power, profit, etc.) rather than temporary fixes.

Future Research

This case study raised multiple questions for future research. Most importantly, ideas of power, agency, and the influence of institutional structures on individual decision-making are undertheorized. Future research could explore how these concepts can be more fully incorporated into social-ecological resilience concepts and theories. Additionally, as Linstadter et al. (2016) pointed out, greater emphasis should be placed on how structures and systems at greater scales can be incorporated into social-ecological resilience studies. For instance, the farmers on the Bench are embedded in the industrial agriculture system; therefore, understanding how political structures and outside powers impact the daily decision-making of individual actors is an important area of future resilience research. This research would require asking normative questions about resilience rather than only understanding the concept as a property of social-ecological systems (Cote and Nightingale 2012). Resilience research must ask questions about the desirability of the current state of a social-ecological system, and for whom the system is desirable.

I have identified several areas of future research on the Fairfield Bench. The farming decisions made by these malt barley producers are influenced by multiple factors, but the most critical one is money. Farming is their livelihood, and therefore their decisions need to be financially sound. Many of these farmers pointed out that because of the high costs of inputs, their farming decisions are often primarily based on finances. For years, the contracts offered by the brewing companies provided financial security and stability according to most farmers. With recent changes to these contracts and relationships with the brewing companies, however, these contracts do not provide the financial security they once did.

Multiple researchers and practitioners have acknowledged the importance of financial capital in social-ecological resilience (Kerner and Thomas 2014, Tango International 2018, Walker et al. N. d.). Without adequate financial capital, farmers on the Fairfield Bench will face significant hurdles to adaptation and system transformation. Experimentation and adaptation are financial risks, and access to financial capital is an important capacity for resilience. Financial incentives that allow farmers to take these risks and experiment with new and more diverse crops are needed. Additionally, structures outside of this system, such as land grant universities, can help encourage or create access to new knowledge about diversity in agroecosystems and assist in finding markets for new crops. With the growth of the craft brew industry (National Beer Wholesaler's Association 2018), perhaps a new potential market could be these small businesses, who might be interested in partnering with farmers to grow unique varieties of malt barley. Finally, creating stronger farmer-to-farmer networks on the Fairfield Bench may encourage knowledge sharing and production. The GID, with its local control and active participation from farmers, may help enable stronger farmer connections and provide farmers with the space to discuss crop experimentation and new potential markets.

In the social-ecological resilience literature, there are relatively few case studies that attempt to understand resilience in a particular place and context. One avenue for future resilience research is to build understanding of resilience from case studies using an inductive approach as I have used here (Carlisle 2014, Ungar 2018). By studying a wide variety of systems at different scales, researchers can create a more robust social-ecological resilience theory, as well as recognizing how outside social, economic, and political structures influence the data and its analysis.

At a Crossroads

The social-ecological system on the Fairfield Bench is currently experiencing significant tensions and challenges. Frustrations with the brewing companies, significant weed pressures, and changes to the community structure (e.g. larger farms, influx of commuters) have created a community at a crossroads. There may be enough tension in the system to tip the scales, which could result in two primary outcomes. The Fairfield Bench could transform into a diversified agricultural system where farmers are less limited in their choices and agency, retaining the identity of the system as a community of small, family farms. A diversified agricultural system would reduce the farmers' dependence on a few major companies and provide more market options for their crops, which could expand their choices and decision-making power. Alternatively, the Fairfield Bench could remain within the industrial agriculture system and continue to be impacted by the same challenges, eventually resulting in major ecological issues, loss of identity as farms grow increasingly bigger, and development pressures from outside of the system. For the longevity of the system and the continuation of its identity, transformation towards diversity is likely the best option.

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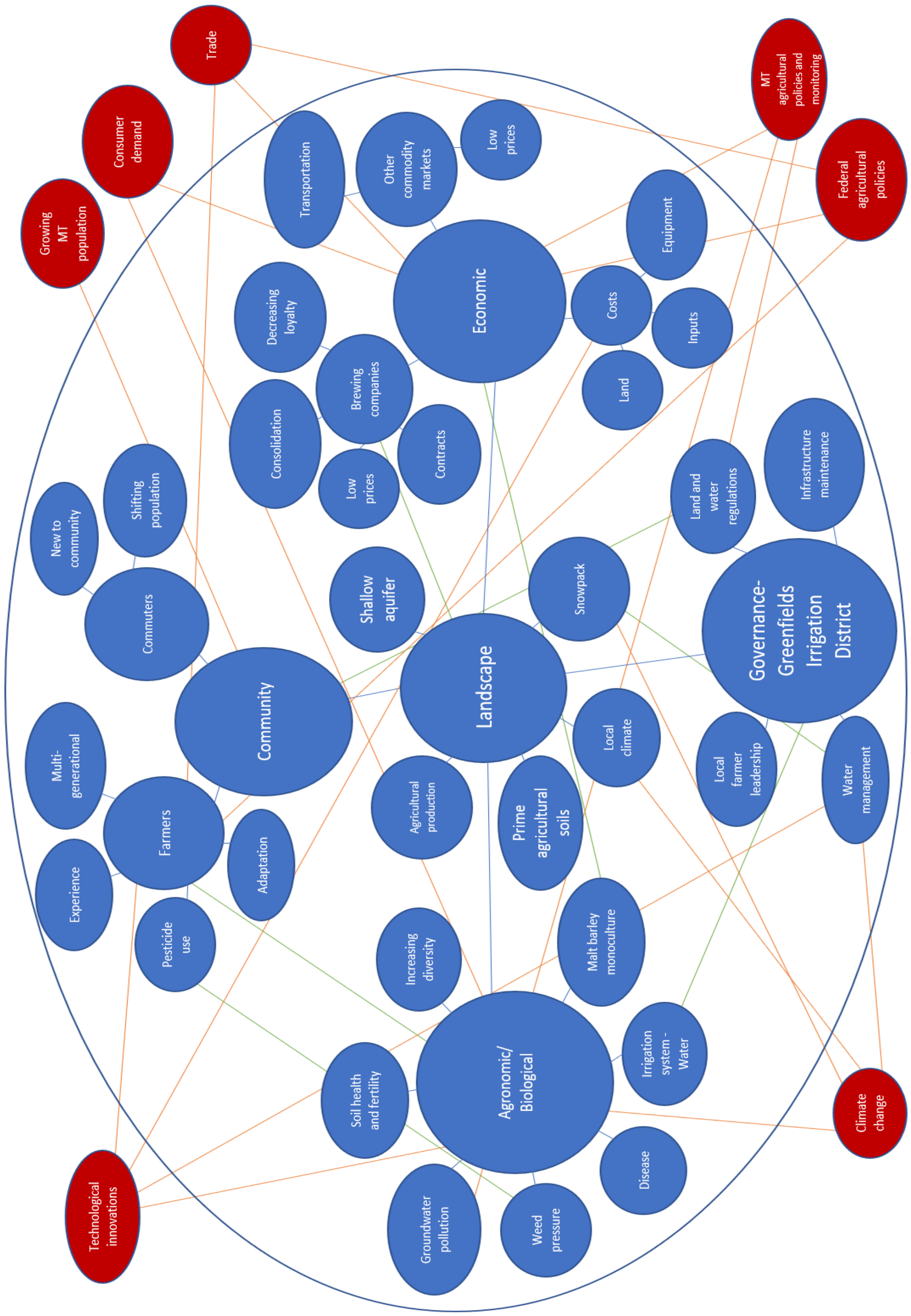
Appendix A

The diagram below is a conceptual map of the Fairfield Bench created from the major elements of the social-ecological system. The blue elements encased in the larger circle exist within the system boundaries (in this case, the Greenfield Irrigation District boundaries), and the red elements are outside forces that impact the system. This provides a visual example of the complexities that exist within this social-ecological system.



Appendix B

Interview Guide

Introduction:

Thank you so much for agreeing to participate in this interview. This is part of a project I am conducting through my graduate program looking at how our agricultural production systems and farmers like you respond to challenges. I really appreciate the opportunity to talk with you about your operation and to listen to your perspective on agricultural production on the Fairfield Bench.

In this interview, I will be asking you about the challenges and vulnerabilities of malt barley production on the Fairfield Bench, how you've responded to challenges in the past, and how you think you might respond in the future.

I wanted to let you know that I will be presenting this research publicly in the fall, and if you are interested in attending, I can let you know when that would be.

I want to reiterate that your identity as a participant will remain confidential. Your name will not be attached to this interview and will not be used in any written or oral reports of this project, unless you specifically request that I do.

You can choose not to answer any questions that you are not comfortable with. Additionally, if at any point during the interview, you decide that you do not want to continue, I will stop the interview and the data will not be used in the research.

If it's ok with you, I would like to record this interview so I can accurately capture your specific ideas and perspectives. It'll help me focus on listening. Is it ok if I record this?

Do you have any questions before we start?

Farming Background and Community Context

1. As you know, I'm not from around here. So, I'd like to start off with you giving me a brief description of the Fairfield Bench. Please tell me about what this place is like from your perspective.

2. Now, I'd like to hear a little bit about your personal history farming. How long have you been farming?
    a. How long have you been farming this particular land?

Current Operation

Thanks for the background information. Now, I'd like to talk a little bit more about your current operation.

3. Please tell me a little bit about your farm. What do you grow?
    a. What rotations do you use, if any?
    b. Do you raise any livestock?

4. How long have you grown malt barley?

5. Why did you decide to grow malt barley initially?

6. Do you grow malt barley on contract for one or more of the brewers in the area? If so, which one(s)?
    a. How much security do these contracts provide?

7. What percent of your farm will be in malt barley production this year?
    a. How does that percentage compare to previous years?

Challenges

8. Given your experience, please tell me about a recent time when you faced a challenging situation while **growing** malt barley. What happened?
    a. Why was this a problem for your operation?
    b. How did you respond?
    c. How did you determine what your response was going to be?
    d. Did this situation threaten your farm's viability in any way?

9. Given your experience, please tell me about a recent time when you faced a challenging situation while **marketing** malt barley. What happened?
    a. Why was this a problem for your operation?
    b. How did you respond?
    c. How did you determine what your response was going to be?
    d. Did this situation threaten your farm's viability in any way?

10. I've seen a few articles about the recent contract cuts from the major brewing companies. How have these cuts impacted your malt barley production, if at all?
    a. Looking forward, how secure are these contracts?
    b. If these contracts were to disappear, how would you respond?

Climate

11. In 2017, there was a so-called "flash drought" in Montana. How did that impact your barley crop?
    a. Did you change anything as a result of your experiences that summer?

12. A lot of folks have been talking about more erratic weather or hotter, drier summers. When you think about the future of your farm, do you anticipate making any major changes in response to those kinds of shifts?
    a. If so, what are they?

13. What role do you think technology will play in your response to agricultural challenges, like weather?
    a. What technologies are you considering, if any, to meet future challenges in your production? Why?

Natural Resources

14. What do you think are the most pressing natural resource challenges for your community?
    a. What do you think needs to be done to respond to these challenges?

15. As you may know, the state of Montana monitored the groundwater in this area from the early 1990s till 2015. They found nitrates in nearly all the wells tested. Does that concern you? Why or why not?
    a. Did you change any of your farming practices as a result of this data? If so, what were the changes?

Irrigation/Governance

16. The irrigation system seems to be a defining feature of the Fairfield Bench. Please tell me about the value of the irrigation system for your farm.
    a. How does the presence of irrigation impact how you think about or respond to production challenges you may face, if at all?

17. What role does the irrigation district play in the farming community?
    a. How does the district impact your decision making for your farm?
    b. Are there other governing bodies that impact the community? If so, what are they and how do they impact your decision making?

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18. I've mentioned overcoming challenges related to malt barley markets, weather, and irrigation. Are there any other major challenges that you are facing that I didn't mention?
    a. How do you think you'll respond to those challenges?

Community

19. When you think about the future of the malt barley industry on the Fairfield Bench, how secure do you think it is? Why?
    a. What might make the malt barley industry on the Fairfield Bench vulnerable or susceptible to change?

20. When you think about the community on the Fairfield Bench 50 years from now, what do you hope it will look like?
    a. Please tell me more about that.

Conclusion

21. Is there anything that I didn't cover that would be important for me to know?

Thanks so much for taking the time to talk with me today. I really appreciated learning about your experiences and perspectives.

If I have any clarifying questions or want to follow-up, is it ok if I call you?

Appendix C

This list was borrowed from Montana Department of Agriculture (N. d.).