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Seeding Resilience: An Examination of the Impacts of a Seed Saving Network in Western Montana

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SEEDING RESILIENCE:

AN EXAMINATION OF THE IMPACTS OF A SEED SAVING NETWORK

IN WESTERN MONTANA

By

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ABSTRACT

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Seeding Resilience: An Examination of the Impacts of a Seed Saving Network in Western Montana

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Seed saving, a worldwide practice as old as agriculture, continues even in the context of an increasingly industrialized and globalized agricultural system. While some scholarship has focused on informal seed saving practices that continue to thrive in the global South, few studies have examined the dynamics of these practices in the global North, particularly in the American West. Informal seed saving systems have implications for the resilience of agroecosystems. The concept of resilience has become an important framework for conceptualizing agroecosystems as social-ecological systems, both in scholarship and in policy. However, operationalizing the concept of resilience, particularly in agroecology research, has been limited. This thesis utilizes a resilience framework to assess a seed saving network and its impacts in western Montana, specifically the Bitterroot and Missoula Valleys. Two questions guide the inquiry: 1) How do significant actors connect within the seed saving network of the Missoula and Bitterroot Valleys, and 2) How does the seed saving network contribute to the social-ecological resilience of the local agroecosystem? The thesis begins with an introduction to the conceptual framework, which considers different ways of evaluating resilience. To overcome some analytical shortcomings of resilience thinking, other theories such as actor network theory, political ecology, and non-human agency are integrated into the conceptual approach. The primary methods used to collect data were semi-structured interviews and participant observation, resulting in qualitative data that were coded to develop themes. The results of the data analysis are presented in two parts. Chapter 4 addresses the first question by describing the rich and varied actor connections and their local effects. The primary actors identified are seed, people, and the environment, which all connect and interact to develop a complex rooted network. Chapter 5 addresses the second question, first by exploring “resilience effects,” or the effects of actor interactions that may result in added resilience to the agroecosystem. Then, a pre-established indicator framework of resilience in an agroecosystem is applied to determine how the seed saving network contributes resilience. While the first strategy is useful in understanding situated resilience effects, the second strategy proves to be more practical for evaluating this particular agroecosystem in an efficient way. The discussion explores the impacts this research may have on studying resilience and agroecosystems in the global North, highlighting the role of resilience as a process, the importance of situated knowledge, and the agency of seed. The thesis concludes by suggesting that seed and seed saving networks could play vital roles in fostering resilience of local agroecosystems.

Keywords: seed saving, resilience, network theory, agroecology, political ecology, non-human agency, Montana

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CHAPTER 1. INTRODUCTION AND BACKGROUND

Introduction

It was a brisk fall day as we walked through a field of dry plant stalks, some growing to our knees, some towering overhead- vegetables going to seed. We exchanged joy and excitement in discovering the ways each plant shared its seed with us, some through fluffy flowers, others firmly secured in pods. The farmer leading the tour of her seed garden imparted us with this knowledge: *"Seeds are the past and the future, the current moment is your stewardship."* This thesis, in a sense, has been a year-long journey into better understanding what her provocative comment means. What power is imbued in the seed? And what is our role in maintaining this power?

Thesis Overview

This thesis examines how an informal seed saving network in western Montana, specifically encompassing the Bitterroot and Missoula Valleys, may contribute to the resilience of the local agroecosystem. It first considers agro-food and seed scholarship in the social sciences. It then reflects on the various meanings and implications of social-ecological resilience, considering the challenges and potential for evaluating resilience in the context of social-ecological systems. Two helpful frameworks emerge for evaluating resilience. One explores emerging "resilience effects" that become apparent after identifying significant actors and their connections with one another. The other framework employs a pre-established set of indicators of resilience that has been adopted in the field of agroecology. In addition to this resilience framework, the contributions of actor network studies and aspects of social theory, which here include political ecology and non-human agency, are incorporated.

The results of the study are presented in two chapters. Chapter 4 aims to describe various actor connections and their effects within the seed saving network. The primary actors identified are seed, people, and the environment, which connect to develop a complex rooted network. Chapter 5 utilizes the two frameworks for evaluating resilience, one emergent and one indicator-based, to see how the seed network may impact the agroecosystem.

This thesis contributes to understanding the dynamics that underlie informal seed saving networks, and their impacts, especially in the global North where seed saving networks have been under-studied. This thesis also considers the effectiveness of the concept of resilience when applied to an agroecological system, thereby exploring the potential to develop a framework for analyzing resilience within a complex and multi-faceted system.

Three significant takeaways from the application of a resilience framework to the study of a seed network include (i) the importance of seeing resilience as a process, (ii) the importance of situated knowledge, and (iii) the agency of seeds in agroecosystems. Understanding resilience and its real-world applications is important not just for scholarship in the field of social-ecological systems, but is also important for public policy that faces dramatic environmental and social change and uncertainty associated with climate change, demographic shifts, and a global pandemic.

Background

At its essence, the seed saving process is the manifestation of the human-plant relationship (Doolittle 2004). The agricultural seeds that gardeners and farmers save come from plants that have been connected to humans for millennia. Agricultural seeds would not exist in their current form if not for human selection of particular traits (Nabhan 1987).

Saving seeds is not just a singular action but part of a cyclical process that unfolds over many years and potentially generations (Shiva 2022). The act of saving seed occurs only at a brief moment in time within the context of an entire process. In its entirety, saving seed involves acquiring, germinating, planting, tending, selecting, and for a period of time, saving those seeds for another year; each step requires knowledge and deliberate decision-making to continue the process. As long as humans have performed agriculture, they have performed this cyclical process of selection, growing, and saving for the intention of a future crop (Doolittle 2004; Shiva 2022).

In North America, corn (*Zea mays* ssp. *mays*) is an example of the intertwined relationship between human and plant (Nabhan 1987). Corn is thought to be derived from a past relative of the current teosinte plant (*Zea mays* ssp. *parviglumis)* (Yang et al. 2019). Teosinte's small and wispy stature only suggests the tassels of modern-day corn. Yet, over millennia people indigenous to the American continents selected this plant for larger seed sizes. Their selections did not simply leave us with one corn variety; rather, thousands of varieties were selected for different features (color, taste, harvest time) and environmental conditions (soils, altitude, precipitation levels) (Nabhan 1987). Such a process happened throughout the world with countless other plants and has resulted in the many plants for food, fiber, and medicine that we are familiar with today (Brush 2000).

Despite the universal practice of seed saving, rapid industrialization and globalization of our markets in the past century have radically changed people's relationship to agricultural plants and their source of generation: seeds. For one, fewer people are directly connected to the growth of food. For those who do continue to grow food, their relationship to plants and seed have been dramatically altered due to the rise of a seed market. This seed market has made purchasing,

instead of saving one's own seed, an option. As part of an industrial food system, these seeds and their plants have been developed for different traits than in the past. Plants have been selected to be higher yielding, more durable in transport, and resistant to chemical inputs such as herbicides and pesticides. Often bred as hybrids, these seeds cannot be re-planted to come "true to type" as in the open pollinated seeds of the past. The selling of hybridized seeds, especially corn, became a key feature of the "Green Revolution" of the mid twentieth century (Altieri 2001; Shiva 2000). The rising use of seeds from genetically modified organisms (GMOs), and increasingly genetically engineered seed, has also had drastic implications for people's ownership over seed. Because of the amount of investment gone into genetic manipulation, large companies that sell seeds often hold patents on the intellectual property of these seeds, further limiting access (Kloppenburg 2004).

Hybrids and GMO seeds have contributed much to absolute food production across the world. However, seeds are now increasingly developed in sanitary labs far from the environments where they will be eventually grown for crop. The result is that a process that has been common since the origin of agriculture – that is, saving seeds and selecting for traits that may enhance the resilience of those seeds in place – is suppressed. The potential benefits of communities saving their own seed, such as biodiversity, adaptation to localized climates, and cultural connections, are increasingly lost (Howard 2015; Hubbard 2019; Ray 2012; Shiva 2000). Despite these dramatic system-wide changes, seed saving practices have persisted throughout the world, though increasingly on the margins (Montenegro de Wit 2015; Nazarea 2005). Understanding the impacts of an existing seed saving network within a community is the primary focus of this research investigation.

With a realization of the negative impacts industrialization and globalization have had on ecosystems and society overall, there has been growing discussion in academia and the public toward finding sustainable solutions in re-conceptualizing and re-building our world, including our food systems. Resilience is a concept rising in popularity in this century that speaks to individual and collective capacities to respond to these challenges, especially with rising concerns over adaptation toward climate change (Cabell and Oelofse 2012).

Prior to conducting this research, I had heard a lot about resilience, including in the alternative agriculture realm. But I was not sure what resilience actually meant, or even if people and institutions concerned with resilience had the same definitions or goals for resilience. I knew resilience was being applied to both ecological and social systems as disparate as development, wildfire management, community empowerment, and agricultural systems, which I found interesting but challenging. This research then, in addition to examining seed saving networks, is an attempt to consider how effective the concept of resilience is at evaluating a complex social-ecological system like an agroecosystem.

Research Objectives

Seeds remain the foundation of our agricultural systems, though they are often overlooked in research and public discourse (Hicks 2019). Seed saving, as well, is often considered a practice remaining in less developed parts of the world, but no longer part of industrialized food economies (Coomes et al. 2014). Seed saving in fact persists, even in the industrialized global North, with potential implications for the health of society and environment. This research attempts to uncover the processes that underlie seed saving through a case study of

a seed saving network in western Montana, as well as evaluate the seed saving network's impacts on the regional agroecosystem through a resilience framework.

My research aims to understand the dynamics and impacts of a seed saving network in western Montana, focusing on the Missoula and Bitterroot Valleys. It is is guided by the following two questions:

1) How do significant actors connect within the seed saving network of the Missoula and Bitterroot Valleys?
2) How does the seed saving network contribute to social-ecological resilience of the local agroecosystem?

Overview of Agriculture, Food, and Seed Scholarship

Introduction

Agriculture and food have always been important topics in academic research, being the foundation of human livelihoods. Agriculture-related topics, particularly agronomy, overwhelmingly fall into the material sciences for utilitarian purposes, with land grant institutions the main providers of research in the United States (Gliessman 2012). The social sciences have also long been concerned with how and why people produce and disseminate food. Much social science agro-food scholarship has focused on the economic components of the topic, considering the commodification and consumption of food products. Agro-food scholarship has also tended to fall in the realm of rural or agrarian issues (Del Casino Jr 2015).

Agriculture and Food Scholarship

Agro-food scholarship, particularly in the social sciences, has demonstrated how agriculture and our relationship to food has been transformed world-wide through industrialization and globalization (Shiva 1993; Weis 2017). The increasing use of petrochemicals, globalization of the market, and proliferation of specialized technology (including hybrid and genetically modification seeds) have contributed to an increasingly globalized and centralized food system. The rise of industrial agriculture is often linked to the Green Revolution of the 1950s, which was a movement to impose industrialized economies and agricultural technologies word-wide. The Green Revolution was ostensibly an attempt by the global North to encourage developing nations to the produce more food. However, this now dominant system has come to be criticized in both academic and public circles as environmentally and socially unsustainable, producing more food commodities in the short term but in ways that degrade agricultural landscapes and do not increase access to that food (Aistara 2011; Hubbard, Zystro and Wood 2022; Nazarea et al. 2013; Phillips 2008; Phillips 2013; Shiva 2000; Shiva 2022.; Mascarenhas and Busch 2006; Yapa 1993).

Alternative Food Networks (AFNs) have arisen, particularly in the global North, as an intended response to the industrialized food system. AFNs include organics, locally grown, heritage bred, and most recently regenerative agriculture. Scholars of AFNs have demonstrated both the potential as well as downfalls of these systems. Most notably, they highlight the often lack of consideration for social equality in AFNs, as well as their eventual (re)incorporation into the capitalist food systems they proport to resist (Forssel and Lankoski 2015; Raynolds 2004; Bryant and Goodman 2004). More recent scholarship has also considered a reflexive approach to

better understanding the existing impact and potential of AFNs (Carlisle 2016). Notably absent in research on AFNs in the global North, however, is that of localized seed saving networks.

A collective effort within scholarship to understand agricultural systems as jointly social and ecological has only recently gained prominence, relative to other natural resource issues. The field of agroecology, developed by social and ecological scientists across various fields, has been at the forefront of promoting the social-ecological aspects of agro-food research. According to leading agroecology scholar Gliessman (2018, 1), "With its ecosystem foundation, the science of agroecology has become a powerful tool for food system change when coupled with an understanding of how change occurs in society." Gliessman highlights the historical lack of integrating agronomy and ecology studies, along with a recognition of social factors influencing the food system. Thus, he and other prominent scholars in the field have defined agroecology as the "ecology of the food system" (Francis et al. 2003; Gliessman 2018). Agroecology has also arisen as a social movement aimed at countering the negative impacts of industrialized agriculture. Specifically, the technologies of the Green Revolution such as company-owned seed, equipment, and chemicals (Altieri and Nicholls 2012; Gliessman 2013; Hoy 2015; Kloppenburg 2004; Shiva 2022). Understanding agriculture as part of a larger social-ecological system is essential to framing my study of seed saving in terms of resilience.

Place of Seed in the Food System

Seeds, the genetic origin for food crops, are the essence of agricultural systems everywhere. The gardeners or farmers who have possession of a seed can provide food for themselves and their community. However, due to the rise of industrialized agricultural systems, individual and community access to seeds have become compromised (Aistara 2011;

Kloppenburg 2004; Shiva 2000). Development of hybrid and genetically modified seeds by politically influential government intuitions and companies has led to the loss of locally-based seed saving and exchange practices. More and more gardeners and farmers around the world rely on seeds that have been produced by large companies, far from the place the seed will actually be grown. Four companies – Bayer, Syngeta, BASF, and Dow-DuPont – produce 60% of the seed used in the world (Hubbard 2019), and it is estimated that over 90% of the world's diverse vegetable and fruit crop varieties have been lost to the industrialization and commercialization of seeds (Lappé 2014). This loss has led to public concern over the environmental and social implications of the loss of access to a variety of seed varieties and sources (Howard 2015; Veteto 2008).

Despite these pressures, seed saving continues within increasingly marginalized social circles. In the global South, where food systems may not yet be completely incorporated into the global food system, seed saving remains in many communities a necessity for subsistence practices. However, seed saving also persists within the more industrialized global North, where subsistence practices are not often necessary for survival (Nazarea 2005). A better understanding how and why seed saving and exchange continues, especially within the context of a highly industrialized society, can shed light on the potential for a more sustainable food system in an increasingly industrialized world (Montenegro de Wit 2015).

Agrobiodiversity Conservation

In the mid-1900s, seed saving arose as a research topic, as changes in the seed production market became apparent (Kloppenburg 2004). Concurrently, conservation agendas began to focus on the topic of biodiversity in environmental systems. The concept of biodiversity

influenced the realm of agriculture, as both public and academic circles became interested in the topic of *agro*biodiversity (Fenzi and Bonneuil 2016). With plant growers deciding to save less seed given the option to purchase purportedly "improved" seed instead, there was a realization that the potential diversity of plant varieties (both intra and inter species) was at threat. Overall, diversity of the seed stock is of concern, as well as the diversity of actual on-farm cropping dynamics (Montenegro de Wit 2015). Within the public, concern for sustainable agriculture arose, which included and an aversion toward what are considered homogenized or "monoculture" systems, or those that use one or very few plant varieties. In contrast, "polyculture" systems are seen as more dynamic and resilient (Nazarea 2005; Shiva 1993).

This concern for the loss of polycultural systems has led to an interest in preserving a diversity of seed varieties (Montenegro de Wit 2015). The initial attempt to preserve diversity, in an act reminiscent of "fortress conservation," was to save seeds in seed banks. Frozen, labeled and stored, seeds in seed banks remain in safety deposits for potential future use, both to grow or to improve the genetics of other crop varieties (Graddy 2013). Two of the largest seed banks in the world are the Svalbard Global Seed Vault in Norway and the National Center for Genetic Resources Preservation in Fort Collins, Colorado, though many smaller-scale ones exist often as national repositories.

Seed banks are part of a process known as *ex situ*, or out of context, seed saving. While these seeds may remain in use for future generations, proponents argue that these seeds are not allowed to continue dynamic processes of adapting to their climates or remain a part of cultural systems. Seed banks are an interesting, and probably essential, method of preserving agrobiodiversity for future generations, but they do not allow for the continuation of agrobiodiversity out in the world (Montenegro de Wit 2015; Graddy 2013). Graddy (2013, 590)

notes that, “though useful—and indeed critical—in many regards, merely ex situ conservation, such as gene banks, cannot keep alive agricultural biodiversity, which is inherently dynamic, interactive, place-adapted, living, thriving, co-evolving, and transforming with changing soils, animals, insects, weather patterns, and general global climate.”

Many social scientists, especially environmental anthropologists and cultural geographers, have identified the significance of *in situ,* or in context, seed saving as a complementary or alternative approach to seed banking. Indeed, before the use of modern technology, this place-based approach is how agricultural plants have been maintained for all human history. Understanding how and why communities continue to save seeds is important for the preservation of agrobiodiversity (Aistara 2019). These seeds are able to continually adapt to local climatic circumstances, while perpetuating heterogeneity in farming systems (Nabhan 1987; Pautasso et al. 2013). Other scholars have further noted that focusing research on the dynamics that perpetuate seed saving networks themselves, instead of numerical diversity, will better strengthen adaptive and biodiverse agroecosystems into the future (Aistara 2019; Montenegro de Wit 2015).

Scholars have also shown how saving seeds in situ also has significant implications for the production of knowledge and the perpetuation of culture (Nazarea 2006a; Shiva 2000). If people stop saving seeds, they lose part of a physical and emotional connections to the food-crop being saved, and the knowledge needed to sustain it. Indeed, people save seeds not just for sustenance, but for less tangible reasons such as enjoyment, color, flavor, and tradition (Nabhan 1987; Nazarea 2006a; Veteto 2014).

There have been many compelling studies on how and why people continue to preserve seeds, though most of these studies focus on the context of the global South, where global food

(and seed) markets have not been as complete as in the global North (Veteto 2014). A significant outcome of critical research in agrobiodiversity conservation in the context of the global South, is a recognition that the cultural practices that enable in situ conservation go hand-in-hand with resisting colonizing powers that would otherwise seek to homogenize locally-based agricultural practices, including seed saving, through Green Revolution technologies and markets (Grady 2013; Nazarea, Rhoades, and Andrew-Swan 2013; Shiva 2022).

Seed Scholarship in the Global North

While understanding seed saving dynamics in the global South is certainly compelling work, people continue to practice seed saving in the global North as well, with relatively few researchers shedding light on these dynamics (Hicks 2019). Compared to research in the global South, the existence of informal seed saving networks are often overlooked in the context of western, developed countries. Topics that are focused on instead include improving the effectiveness (including resiliency) of seeds within the formal seed production market, and maintaining public access to seed intellectual property (Lammerts van Bureren et al. 2018; Phillips 2013).

At the beginning of the 21st century, realizations of the damages of industrialized agriculture on seed became part of public conversation. Farmers had increasingly stopped saving their own seed with the option of purchasing from companies. As the seed industry became increasingly conglomerated and centralized, farmers have relied more and more on these companies. Genetic diversity and performance of seeds was now in the hands of institutional seed breeders. The financial input required to develop newer, "better" varieties has incentivized these companies to prevent growers from saving these seeds themselves, and in the most extreme

cases, push for the patenting of certain genetic traits. Thus, a biological resource that has been a common agricultural inheritance of all people has become increasingly privatized. This issue of seed privatization has become of greater concern with the increasing use of genetically modified organisms and now genetically engineered crops (Altieri 2001; Lammerts van Bureren et al. 2018; Phillips 2013). This is also a topic of great concern in the global South of course, with vocal proponents such as Vandana Shiva (1993, 2000) of India and others leading the movement to protect the intellectual property rights of small-scale farmers worldwide.

As communities began to realize that the very source of their foods was in the hands of a few, powerful organizations, initiatives to ensure access to this source arose (Phillips 2013). Seed libraries have become a common form of localized seed saving in the US. Regional organizations have also arisen to support seed saving activities, including the Organic Seed Alliance based in Port Townsend, Washington, which targets localized organic seed production systems (Hubbard, Zystro and Wood 2022). The Open Source Seed Initiative (OSSI 2022) is a national platform for the free exchange of seed and seed saving education. Many seed companies that specialize in open-source and heritage seed varieties have gained prominence, including Baker Creek Heirlooms, Seed Savers Exchange, and Fedco. A movement for the preservation of Indigenous seed saving traditions has also grown, with the leadership of organizations such as Native Seed SEARCH in Tucson, Arizona and the national Indigenous Seed Keepers Network (Nabhan 2016). Research on the protection of intellectual property rights for localized seed savers has also arisen, including through the University of Montana (Jenney 2022).

In contrast, another large focus of seed research in the global North considers seed breeding. These studies appear to assume through erasure that local or regional seed saving networks no longer contribute significantly to the overall food system (Coomes et al. 2015).

They consider how seed, as a commodity controlled by institutions such as companies and land grant institutions, can better serve the industrial food market. Obviously, the natural sciences such as agronomy and genetics play a large role in this field. But many social scientists also study the seed as an industrial commodity, overlooking informal seed markets. This is not to say that improving industrial seed systems, especially with an eye for social and ecological resilience, is not important (Lammerts van Bueren et al. 2018). But knowing that seed systems still function informally, it is also important to study their contributions to the food system (Coomes et al. 2015).

The small but growing body of research on informal seed saving networks in the global North is contributing to knowledge that "prepares for climate change, increases biodiversity and resilience within local food networks, and resists corporate interests" (Hicks 2019, 4). These researchers, focusing on Western and developed nations, include Aistara (2011), Bocci and Chable (2009), Bonicatto et al. (2015), Calvert-Mir et al. 2012, Da Via (2012), Phillips (2008), and Purdue (2000). This scholarship is complemented by similarly interesting research being conducted in developed countries in East Asia, including Hong (Author 2021), South Korea (Author date), and Tomiyoshi, Uchiyama and Kohsaka (2020) in Japan.

A significant field of inquiry in seed research in the global North emanates from the Seed Legacy Project founded by anthropologists Virginia Nazarea and Robert Rhoades at the University of Georgia. This work is continued by their former student, James Veteto. Their research focuses on international contexts (primarily the Philippines and Peru) and in the American Southeast, especially the Appalachian region. Their seminal edited anthology, *Seeds of Resistance, Seeds of Hope* (2013) provides compelling qualitative case studies of different efforts to save seed both in situ and ex situ across the world. Rhoades's chapter, "When Seeds are

Scarce," sheds light on how localized seed systems thrive in the cultural margins, including marginal communities of the U.S. such as immigrant communities and other less globally-connected communities of the American south.

An important theory purported by Nazarea is the concept of the "countermemory" which emerges between human-seed relations. The countermemory stands in contrast and resistance to industrialized systems, including the industrial food system. Countermemories that are developed by people who save, propagate, and share seeds and seed saving knowledge contribute to a more sustainable and place-based food system. She writes:

> *Memory embedded in food and place enables small-scale farmers and gardeners to resist the vortex of agricultural commercialization and monoculture by continuing to nurture a wide variety of species and varieties in their home gardens and their fields, sustained by sensory recollections regarding the plants' aesthetic appeal, culinary qualities, ritual significance, and connection to the past* (Nazarea 2006b, 325).

Molly Hicks (2019) builds upon Nazarea's work in her dissertation, *Following the Seed*, , where she focuses on a seed network in southeast Ohio, also part of the Appalachian region, to better understand how saved seeds influence social-ecological systems. A significant finding of her research pertains to what she describes as "resilience knowledge," which can serve as a kind of "countermemory" within the local food system. The implications of countermemory and knowledge for resilience thinking will be explored further in Chapter 2.

In my understanding, a few limitations are paramount in seed saving literature to date. One limitation that persists despite those discussed above, is a continued lack of literature focusing on the global North, particularly in the context of the western United States (Hicks 2019). Another limitation is that there is still a need for more research on the social dynamics influencing informal seed saving networks, which is an area that has often been overlooked in the field of agrobiodiversity (Aistara 2019; Montenegro de Wit 2015). And finally, effectively

bridging the social-environmental dichotomy within seed saving research has been lacking (Pautasso et al. 2012). This study seeks to address these gaps in knowledge and provide nuance through a locally-grounded place-centered study.

Conclusion

Agro-food studies have a long scholarly tradition. The rise of the importance of agroecology, which understands food systems as jointly social and ecological could have large implications for how we can better conceptualize this complex system. However, seeds, informal seed saving networks, and the role of seed in the food system has often been overlooked. Understanding that dominant industrial food systems, including seed systems, are inherently unsustainable, this study aims to shed light on the role informal seed saving networks may play in contributing resilience to a particular agroecosystem. The next chapter will elaborate the conceptual framework for this study and explores definitions and implications of theoretical work on social-ecological resilience.

CHAPTER 2. CONCEPTUAL FRAMEWORK FOR UNDERSTANDING SOCIAL-ECOLOGICAL SYSTEMS

Introduction

This chapter presents the conceptual framework for examining seed saving within the context of the food system as an "agroecosystem," with joint social and ecological system components. Building upon work in recent agro-food studies, the approach centers on the concept of social-ecological resilience which has become a popular way to consider the sustainability of social-ecological systems (SES) in both academia and policy. Social-ecological resilience serves as my guiding framework for evaluating the informal seed saving network of western Montana. Incorporating the concept of network theory, particularly actor network theory, enhances this analysis, especially in the approach to conceptualizing the seed saving *network.* Finally, I also incorporate ideas from social theory, drawing from political ecology and non-human agency, to provide nuance to the understandings of resilience and networks.

Social-Ecological Resilience

Background on the Concept

The concept of resilience arose in the field of ecology in the 1950s. Previous theories of ecology described ecosystems attempting to achieve a single state of stability, operating in linear form (Holling 1973). In contrast, the idea of resilience posits that many states are possible due to the ever-changing nature of climate, suggesting a systems approach to understanding nature. In simple terms, resilience is a system's ability to maintain its function, despite outside shocks or changes imposed on it (Gunderson 2003; Holling 1973).

In the 1980s, the idea of resilience began to move beyond the field of ecology and resource management, as researchers explored its potential to apply to human systems (Folke 2006). Fikret Berkes and Carl Folke are considered foundational in this theoretical paradigm of social-ecological systems resilience (Berkes and Folke 1998; Berkes, Folke and Colding 2000; Berkes, Folke and Colding 2008). Social-ecological resilience revolutionized cross-disciplinary thinking as, "a holistic, system-level approach [integrating] science, management, and policy to embrace uncertainty, manage risk, and adapt in a rapidly changing and unpredictable world" (Curtin and Parker 2014, 922).

Probably the most innovative contribution of SES resilience is its attempt to analyze human and natural systems holistically, instead of separating them in the traditional western human-nature dichotomy. This holistic approach is described as a "human-in-nature" model, where humans are considered part of the ecosystem (Davidson-Hunt and Berkes 2003). While theorizing and operationalizing this in practice has been a challenge, it remains a compelling way to view modern-day challenges.

The concept of resilience has become more important in the public sphere as well. Previously, *sustainability* was seen as a goal for the health of our social and natural systems, but over the decades has proven too simplistic. Particularly in agriculture, sustainability often only addressed ecological components of the system without regard to social dynamics, and provided static solutions - such as growing organic, or eating local - that have been reincorporated into capitalist food systems (Lamine 2015). Considerations for adaptation and transformation of social-ecological systems in the face of what is seen as more dramatic and inevitable shocks, such as climate change and a global pandemic, have risen to public attention, in discussion among various professional fields such as agriculture, public health, planning, government, and

development. While academics may grapple with operationalizing the term, it has become a barometer for the public's attempts to address various social-ecological challenges in the modern age (Brown 2014). Thus, understanding factors that may contribute to or inhibit resilience is in the best interest for scholarship and society. As Carlisle (2014, 45) writes, the ultimate goal of resilience scholarship and policy should be to understand the dynamics behind "healthy livelihoods and landscapes amidst challenging social and ecological conditions."

The concept of social-ecological resilience is especially relevant when considering food and agricultural systems (Hoy 2015; Nelson et al. 2016). The concept of agroecology in fact often includes "resilience" as part of a healthy agroecosystem. (Gliessman 2014). A resilient agroecosystem is generally thought of as one that continues to provide healthy and abundant food to people, even in times of ecological or social stress. As Hedberg (2021, 16) notes, "the focus of resilience thinking on persistence and adaptation amidst change and its complex systems approach that draws together social and ecological factors offers a promising combination for addressing the myriad challenges faced by food systems."

Evaluating Resilience

Resilience has been embraced in theory, and increasingly in the public realm. Effectively operationalizing the concept, though, is challenging (Brown 2014; Hedberg 2021). This challenge is due to the relative nature of resilience, as resilience "of what" and "from what" are constantly shifting parameters (Cote and Nightingale 2012). Additionally, definitions of resilience have branched and changed across disciplines. Furthermore, effectively combining social and ecological theory into one operational concept has fallen short.

Attempts at identifying indicators of resilience in agroecosystems have been manifold, ranging from quantitative indicators to emergent properties. However, many scholars acknowledge that the complexity of food systems and agroecosystems does not lend them to easily consolidated measurements (Cabell and Oelofse 2012; Darnhofer et al. 2016).

An Indicator Approach to Resilience

A useful approach to evaluating the fluid nature of resilience is offered by Cabell and Oelofse (2012) in their article entitled, "Ecology and Society: An Indicator Framework for Assessing Agroecosystem Resilience." These authors recognize the particular challenges of evaluating the resilience of an agroecological system because of the complexity of actors and scale. Despite this, they have developed, through aggregating research done across the discipline, some helpful indicators to consider while evaluating the resilience of a particular system. These thirteen indicators include the following: socially self-organized, ecologically self-regulated, appropriately connected, possess functional and response diversity, have spatial and temporal heterogeneity, are exposed to disturbance, coupled with local natural capital, promote reflective and shared learning, globally autonomous and locally interdependent, honors legacy, builds human capital, and reasonably profitable. The indicators are further described in the chart below:

Table 1: Resilience Indicators (Adapted from Cabell and Oelofse's (2012, 1)

INDICATOR	DEFINITION	IMPLICATIONS
1) Socially self-organized	The social components of the agroecosystem are able to form their own configuration based on their needs and desires	Systems that exhibit greater level of self-organization need fewer feedbacks introduce by managers and have greater intrinsic adaptive capacity
2) Ecologically self-regulated	Ecological components self-regulate via stabilizing feedback mechanisms that send information back to the controlling elements	A greater degree of ecological self-regulation can reduce the amount of external inputs required to maintain a system, such as nutrients, water, and energy
3) Appropriately connected	Connectedness describes the quantity and quality of relationship between system elements	High and weak connectedness imparts diversity and flexibility to the system; low and strong impart dependency and rigidity
4) Functional and response diversity	Functional diversity is the variety of ecosystem services that components provide to the system; response diversity is the range of responses of these components to environmental change	Diversity buffers against perturbations (insurance and provides seeds of renewal following disturbance
5) Optimally Redundant	Critical components and relationships within the system are duplicated in case of failure	Gives the system multiple back-ups, increases buffering capacity, and provides seeds of renewal following disturbance
6) Spatial and temporal heterogeneity	Patchiness across the landscape and changes through time	Through time, it allows patches to recover and restore nutrients
7) Exposed to disturbance	The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond a critical threshold	Increase system resilience and adaptability in the longer term by promoting natural selection and novel configurations during the phase of renewal

INDICATOR	DEFINITION	IMPLICATIONS
8) Coupled with local natural capital	The system functions as much as possible within the means of bioregionally available natural resource base and ecosystem services	Responsible use of local resources encourages a system to live within its means, creating an agroecosystem that recycles waste, relies on healthy soil, and conserves water
9) Reflective and shared learning	Individuals and institutions learn from past experiences and present experimentation to anticipate change and create desirable futures	The more people and institutions can learn from the past and from each other, and share that knowledge, the more capable the system is of adaption and transformation
10) Globally autonomous and locally interdependent	The system has relative autonomy from exogenous (global) control and influences and exhibits a high level of cooperation between individuals and institutions at the more local level	A system cannot be entirely autonomous, but it can strive to be less vulnerable to forces that are outside its control; local interdependence can facilitate this by encouraging collaboration and cooperation rather than competition
11) Honors legacy	The current configuration and future trajectories of systems are influenced and informed by past conditions and experiences	This relates to the biological and cultural memory embodied in a system and its components
12) Builds human capital	The system takes advantage of and builds resources that can be mobilized through social relationships and membership in social networks	Enhanced human capital including constructed (economic activity, technology, infrastructure), cultural (skills and abilities), social (organizations, norms, networks)
13) Reasonably profitable	The segments of society involved in agriculture are able to make a livelihood from the work they do	Allows participants in the system to invest in the future, which builds buffering capacity, flexibility, and wealth

I employ these thirteen indicators in my evaluation of the potential resilience contributions of the seed saving network. They also help me to consolidate my own understanding of social-ecological resilience in a sea of definitions and applications. The application of these indicators in this study will help to identify if and how much the local seed saving network is contributing to resilience of the local agro food system. Further, this study presents an opportunity for testing the utility and applicability of this indicator-based approach.

Resilience Effects

In contrast to a deductive approach to evaluation, some researchers have advocated for a more emergent approach to understanding SES resilience, in the form of resilience "effects" or "outcomes" (Carlisle 2014; Hedberg 2021). Liz Carlisle (2014, 47) has made a case for an emergent understanding of resilience in her work in agroecological systems. In her ethnographic research of Great Plains farmers in eastern Montana, she identifies individuals' "working knowledge" of resilience that is "hinged on continual, everyday processes of learning, adjustment, cooperation, and long-term planning."

In another example, a study supported by the Organic Seed Alliance entitled "Assessing the Resilience of the Organic Seed System: A Network Perspective" (Wood 2022) interestingly uses research participants' own definitions of resilience to evaluate the resilience of the seed system. These studies show that that resilience is not a factor "out there" to be measured but can be defined and evaluated in relation to the values and priorities of individuals and groups.

Furthermore, the contribution of knowledge, especially situated and traditional ecological knowledge, to SES resilience has begun to be acknowledged, by potentially contributing information and practices that improve societies' adaptive capacity to cope with environmental

or social disturbances (Folke 2004; Gómez-Baggethun et al. 2012; McIntosh et al. 2000). As Reyes-Garcia et al. (2014, 223) recently noted, "Resilience of a social–ecological system largely depends on the capacity of the corpus of knowledge to learn by absorbing new information." However, little research has been done on the specific contributions of seed saving knowledge in particular to resilience.

Further Limitations of the Resilience Framework

The rise of social-ecological systems thinking demands that we understand human and nature in relationship. It also asks that we strive as researchers to break down this dichotomy of understanding the human and natural work as separate. And while many social scientists increasingly embrace this in theory, in practice it has proven difficult to execute. For this reason, I would like to employ some additional social theory in order to supplement the resilience framework I plan to use to evaluate the seed saving network (Watts and Scale 2015).

With these understandings of resilience, my thesis attempts to consider how seed saving networks in western Montana may contribute to the resilience of the local agroecosystem. The additional concepts - network theory, political ecology, and non-human agency - will contribute to enhancing this resilience analysis.

Network Theory

One attempt at breaking down the human-nature binary has been to focus on networked relationships. Network studies exist in many forms and arose in science-technology scholarship. They have been increasingly used to better understand complex social-ecological systems (Rocheleau 2011).

Critical food systems scholars have also called for an understanding of food systems through networks. This is due to a tendency in the past decades within both scholarship and policy to conflate "local" with better, healthier food systems, though this has proven to not necessarily be the case. In reality, food systems often rely on a variety of scales connected through networks to bring food to people. Better understanding the dynamics of these networks is essential to understanding and ultimately improving our food and agroecosystems (Aistara 2011; Born and Purcell 2006).

An emerging field of network studies is Actor Network Theory (ANT). ANT considers the role of *actors* and the effects of their associations to better understand complex, multi-scalar issues. Most significantly, an actor is anything, living or nonliving, that may influence other actors within a network. ANT's explicit goal is to break through the social-ecological binary, that so often favors the human within social systems (Michael 2017)**.** In this way, the social is not merely something that determines human behavior but is actually created by interactions between all actors, human or otherwise. An important outcome of ANT analysis is discovering "effects" of different actor interactions (Latour 2005).

ANT has already been applied to a number of food and agricultural systems studies (Martinez-Flores, Ruivenkamp, and Jongerden 2017; Roep and Wiskerke 2012; Tanaka and Busch 2003), although relatively few studies focus on seeds. Hicks' (2019) study is an example of an Actor Network analysis conducted on a seed saving network. She "follows the seed" in southeastern Ohio to determine what effects are produced from networked interactions. Through her ANT analysis of various forms of agricultural systems, Hicks (2019, 89-92) determines that the "degradation in agroecosystems, which indicates a decrease in resilience and overall sustainability, will continue to be an effect of actor associations with industrial hybrid seed."

Conversely, she finds that networks within localized seed saving systems support resilience of the agroecosystem by preserving and increasing seed genetic diversity (89-92).

In short, approaching an analysis of a *network* instead of, say, a strictly bounded case study, may help to reveal effects that are not bound by scale. It also more effectively does what SES resilience analysis attempts to do without much guidance: linking social and ecological interactions. As Hicks (2019, 87) writes, "The scholarly conversation shifts from a traditional journey into human influences upon 'natural' things, to emergent outcomes of actor relations."

The primary criticisms of ANT are similar to some of those in SES resilience. Critics point out that ANT has an apparent blindness to power relations and lacks a normative approach to potential outcomes. Given these limitations, concepts from social theory might help to inform our understanding of resilience and networks.

Social Theory

In order to round out a resilience and actor-network approach to this research, I consider what certain social theories, particularly political ecology and non-human agency may contribute to an analysis of seed saving. The analyses I focus on are primarily inspired by critical geographers, though many disciplines have contributed to these fields including sociology and anthropology.

Political Ecology

Political ecology is, as Robbins (2012, 3) puts it, a "community of knowledge" in which scholars from many disciplines, including geography, participate. Though multi-disciplinary, it is dedicated to how social and ecological functioning are interconnected. It takes a normative

approach to natural resource management issues, considering the interaction between situated dynamics and global politics (Robbins 2012).

Political ecology has found compelling synergy with the ideas of agroecology, especially in the ideas of adaptation and transformation in the face of crisis, as noted by Galt (2013, 648):

> *Political ecology's key insight is that transformations, first and foremost, require rethinking and recreating social relations and structures. As we face peak oil, the more ecological-oriented food systems replacing industrial food systems will be diversified, reliant on fewer fossil-fuel-based inputs, more efficient in nutrient cycling, and more labor intensive. An important question is how they will be embedded in plural and just agrifood economies that meet food needs through various combinations of subsistence production, entitlement programs, gift and other alternative/ community economies, and market-oriented activities. Social movements must forge these new conditions, as they will not occur under self-regulating markets.*

This quotation highlights how both agroecology and political ecology recognize how global processes have contributed to the very "shocks" that our social-ecological systems now face, and true resilience means transformations of these systems (O'Brien 2012).

Despite these synergies, scholars have noted how little political ecology has been applied to studies of agro-food systems, especially in the context of developed countries (Galt 2013). Galt (2013, 648-49) describes how "by possessing knowledge of biophysical and social sciences, political ecologists can facilitate boundary crossing a divided academy, thereby helping to join agroecology, food studies, and political economy to produce new insights and actions," creating a *political agroecology*."

Critical geographers, especially those in the tradition of political ecology, have critiqued the resilience concept. Some find the two theories incompatible, especially in the international development field where resilience has become a kind of "buzz-word," justifying the imposition of neo-liberal policies (Mikulewicz 2019). However, some appreciate resilience making more mainstream the interlinking of social and ecological challenges and systems thinking (Turner

2014). Some strive for more cohesion between resilience theories. Many of the critiques toward resilience are similar to that towards network theories. Thus, employing some of the analytical tools of political ecology could help round out these frameworks.

The primary synergies between resilience, network theory, and political ecology include 1) an interest in breaking down the social-ecological barrier, and 2) an acknowledgement of multiple scales of interaction (Galt 2013). Cote and Nightingale (2012, 477) claim:

> *The emphasis on feedback dynamics between social and ecological systems encourages the view that these cannot be conceived in isolation, as human systems are a component of, and in turn shape, ecological ones. One promising aspect of this work is the genuine commitment to a holistic approach that integrates a diversity of scholarly disciplines and embraces complexity.*

Political ecology also supports ANT-thinking, as both aim to eliminate the nature-society binary, viewing the world as a web of complex interactions in which both "nature" and "society" are undivided actors (Hicks 2019).

Normative Approach

A primary criticism of resilience thinking is its overlaying of ecological or technological processes onto social ones (Brown 2013). Most significantly, this results in a lack of a normative understanding of social dynamics. In other words, just because a system may prove resilient does not mean it is beneficial or equitable to all social members of that system (Cote and Nightingale 2012).

In both resilience and ANT, there is also a lack of consideration of power dynamics in these systems. Watts and Scales (2015, 230) write, "The reliance on ecological principles to analyze social dynamics has led to a kind of social analysis that hides the possibility to ask important questions about the role of power and culture in adaptive capacity, or to unpack

normative question such as ‘resilience of what?’ and ‘for whom?’ when applied to the social realm”

Political ecology’s strength is in considering the dynamics of power relations within systems and across scales. It presents both theories with a way to resolve some their ethical and political limitations (Tschakert and Tuana 2013). The task for research can be to not simply to track connections, but to evaluate the ethical and political implications of these connections.

Political ecology offers a compelling theoretical framing for the re-examination of agroecosystems. There is “a challenge of reorienting agrifood systems from domination and exploitation to values of respect and recognition of radical interdependence. Thus, justice and fairness toward all humans and non-humans involved in the agrifood system remain a necessary component of sustainability” (Galt 2014, 639). Political ecology has proven adept at providing this viewpoint.

Situated Processes

Studies of resilience and networks are often so focused on the bigger picture, that their analyses are rarely “tied to place” (Watts and Scale 2015). Political ecology’s strength is in empirical analysis, bringing to light contextual, situated experiences. In this viewpoint, resilience looks different depending on the social, historical, political, and environmental context of the place resilience is being examined.

Political ecology can thus help bring both resilience and ANT’s models “back down to Earth” by tying agricultural networks to a sense of place (Watts and Scale 2015). Ultimately, political ecology may contribute to resilience thinking and ANT the idea of situated resilience

and networks. The cross-disciplinary strengths of resilience and ANT are utilized along with a critical social analysis provided by political ecology.

Especially compelling is political ecology's focus on the margins, better described as interstices, or "an intervening space, especially a very small one" (Blaikie and Brookfield 1987, 649). These interstices "are necessary for resilience as they tend to harbor resources important for transformation."

The situated experiences of people and non-humans given the historical and cultural context of place give rise to situated knowledge (Cote and Nightingale 2012). Situated knowledge considers knowledge as a process, not merely an absolute fact. Carlisle (2016) provides a similar understanding of knowledge-as-process in her analysis of the Black Beluga Lentil, considering the formation of heritage as process. In this way we might consider resilience as produced, not merely mechanistic or apolitical (DeVerteuil and Golubchikov 2016).

One compelling study employing political ecology in the context of seed saving is Graddy's (2013) analysis of biodiversity conservation in the Peruvian Andes. His article shows how seed saving, agrobiodiversity conservation, and the situated knowledge that produces it are not merely ecological but part of complex social, cultural, and economic processes. He also incorporates compelling use of non-human agency, synthesizing it with Indigenous Peruvian views about the agency of nature. Graddy (2013, 590) concludes, "In many regards, merely ex situ conservation… cannot keep alive agricultural biodiversity, which is inherently dynamic, interactive, place-adapted, living, thriving, co-evolving, and transforming with changing soils, animals, insects, weather patterns, and general global climate."

Non-Human Agency

Both political ecology and ANT compel the researcher to question the agency of non-human actors such as seeds. A burgeoning area of research, especially in geography, is that of non-human agency, also known as more-than-human geography. This field to date has mostly focused on animals in its conceptions of non-human agency, but there has been a call to bring plants forward in this conversation (Head and Atchison 2009; Hitchings and Jones 2004).

An explicit focus on the theory and methodology used to consider non-human agency may overcome tendencies of both political ecology to, in practice, prioritize human interests over non-human ones. It also provides a methodological framework in order to "take seriously" ANT's claims to elevate the non-human actor on the level of the human (Watts and Scales 2015). As Watts and Scales (2015, 229) put it, "Agricultural systems are the product of interactions between land managers and a wide range of non-human actants (e.g. seeds, soils, tools and animals) … While there is no doubting the major role humans have played in shaping agricultural systems, for example by selecting, breeding and genetically modifying plants and animals to suit their needs, it is important to recognize that these relationships are not just one way."

In her study of the politics of seed saving, Phillips (2013, 7) explains the importance of non-human agency in the context of seed:

> *The idea that agency is more distributed and relational than concentrated in people brings together otherwise disparate studies through an interest in 'relational materialities.' An underlying shared interest exists in understanding how different things and beings interact, and how their relations shape themselves, others, and the worlds in which they exist. People, documents, technologies, birds, whatever else, each has the potential to create change in the world through their relations with others.*

Non-human agency does not mean all actants behave like humans. Instead, "acknowledging that actants (both human and non-human) have the capacity to influence the configuration of an SES awakens our awareness to the fact that the ability of humans to perform agency and build resilience is dependent upon the specific relationalities between them and the nonhuman components" (Dwiartama and Rosin 2014, 27).

Successful attempts at combining ANT and political ecology with non-human agency have led to a concept called "rooted networks," originally developed by Rocheleau in her analysis of an agroforestry project in the Dominican Republic. The rooted network is a "complex assemblages of plants, animals, people, physical landscape features, and technologies—created through the habit-forming practices of connection in everyday life" (Rocheleau 2009). Carlisle (2019) also adopted this paradigm when considering the role of the Black Beluga lentil in the food system. The significance of these studies is in showing how social-ecological systems are composed of deep relationships between various actors, both human and non-human.

Conclusion

The purpose of this chapter was to describe the conceptual framework adopted in this study. Building upon these conceptual understandings of resilience within complex social-ecological systems, I explore how the seed saving network in western Montana, specifically the Bitterroot and Missoula Valleys, may contribute to the resilience of the local agroecosystem. In the following chapters I describe the context of the study and identify actors and their connections within the seed saving network, similar to the approach adopted by Hicks (2019). In addition, I use two strategies to evaluate resilience. One is aimed at determining emergent resilience effects that result from the seed saving network. The other strategy is to compare the

seed saving network to Cabel and Oelofse's indicator framework to see if it proves a useful tool for evaluating resilience, and if their resilient features are present in the seed saving network.

CHAPTER 3. SETTING AND METHODS

Introduction

This chapter provides an overview of the geographic context of the research and the methodological approach to the study. I describe the research setting of the Missoula and Bitterroot Valleys, including relevant historical and environmental details. The methods I employ, both participant observation and semi-structured interviews, are described as well as process of source identification. I provide a statement of positionality to better provide a reflexive context for my role in this study and conclude by addressing how this information may help inform my research questions.

The Missoula and Bitterroot Valleys

The geographic focus of my study is within the Bitterroot and Missoula Valleys, including the city of Missoula, Montana. These valleys lie close to the western border of Montana. The Bitterroot Valley is a wide, glacially carved valley surrounded by the Bitterroot Mountains to the West and the Sapphire Mountains to the East. Missoula, the second largest city in Montana, lies at its northern end. The socioecological development of the Bitterroot Valley is linked closely to the development of Missoula due to proximity. Furthermore, agro-food studies recognized that cities and surrounding rural regions often display enmeshed food systems, with greater access to land for growing space outside of the urban area (Forster et al. 2015; Swanson 2006).

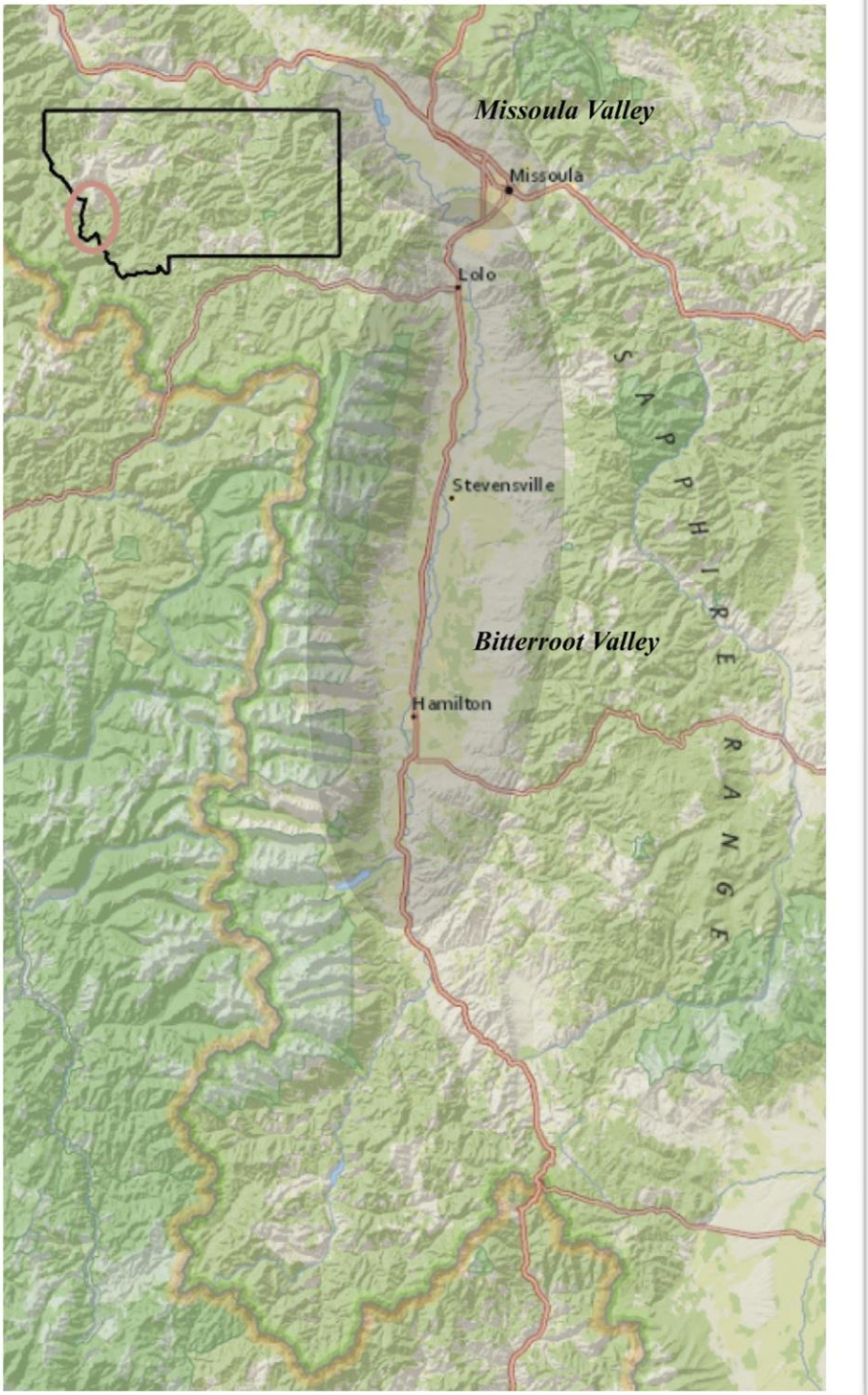

Figure 1: Locator Map of the Missoula and Bitterroot Valleys, created by author.

Prior to colonization, these valleys were primarily inhabited by the Indigenous Salish people (also known as the Bitterroot Salish or Flathead people). They have practiced a semi-nomadic, hunting-fishing-gathering relationship with the land (Bear Don't Walk 2019). The Bitterroot Valley was the first place in Montana with permanent European settlement, at current-day Stevensville in 1855. Missoula was established as a small trading post in 1860 but boomed in the 1880s as a railroad hub supporting the logging industry in the region. The Salish were forcefully removed in 1891 to live on the Flathead Reservation which is located north of Missoula in the Jocko and Flathead Valleys (Salish-Pend d'Oreille Culture Committee 2019).

European colonization drastically impacted the Salish peoples' way of life, including dramatically altering and eventually diminishing the sustainability of their own food systems (Bear Don't Walk 2019). As such, the study of agricultural traditions in this region is the study of a colonizing culture and food system. Due to a variety of ethical and pragmatic reasons, I do not expect my work to touch directly on Indigenous food ways, though my intention is not to perpetuate their erasure. Instead, in studying a form of land stewardship, one that currently dominates the valley, we can better understand its past, current, and potential future ways that this land has and can provide sustenance to its inhabitants, and how people conceptualize that relationship. My hope will be to not overlook such narratives, but to consider how they fit into the larger history of the region, one that began long before European settlement. Many participants expressed acknowledgement that they were on Indigenous land and wanted to consider how seed saving could contribute to building a strong relationship with our food ways and environment, while not taking away from Indigenous people's own connection.

The Bitterroot and Missoula Valleys have thus maintained rich agricultural traditions that continue to this day. Having previously been settled by homesteaders, the residents of the

Bitterroot Valley particularly maintain a pride of self-sufficiency. Notably, Missoula became known as the "Garden City," since its microclimate proved relatively fruitful for the production of food crops to support the regional logging and mining industry, especially during the boom days of Butte to the east (Matthews 1948).

The Bitterroot Valley and Missoula maintain a variety of public and private gardening and small-scale farming operations. Notable institutions of the region include a number of seed libraries, including the Five Valley and Mansfield seed libraries in Missoula and the O'Hara Commons in Hamilton, which provides infrastructure for seed saving and exchange in the region. Additionally, the Triple Divide Seed Cooperative (Co-op) is a collection of small-scale farmers developing and distributing open-pollinated seed varieties throughout western Montana. Garden City Harvest is an organization that runs a handful of small-scale urban farms and community gardens in Missoula and provides infrastructure for education and seed saving and exchange. Important to the seed history of the region, Hamilton and later Missoula was the site of Garden City Seed, a prominent organic seed producing and selling industry, the largest to have existed Montana. It went out of business in 2000, but its influence continues to this day, as many participants mentioned to me. The significance of actors within these organizations will be examined further in this study.

Resilience and building a strong local food system are both publicly supported initiatives within the region. Missoula County (2016, 8) recognizes the potential threats of climate change and in their 2016 Growth Policy state: "Missoula County seeks to reduce its contribution to climate change while promoting resiliency and adapting to its impact on the natural environment and communities.". The County established Climate Smart Missoula as an initiative to identify improvements that could be made to better address and adapt to climate change. Climate Smart

Missoula considers agriculture to be a significant variable in their climate adaptation strategies, with twelve total objectives concerned expressly with agriculture. Ravalli County, encompassing the Bitterroot Valley, is also concerned with climate change impacts. The Bitterroot Climate Action Group prepared a report on "Climate Resiliency in the Bitterroot Valley" for the Hamilton City Council identifying many ways climate is projected to change and impact the community, including access to food (Tilly 2020 et al.). Given concerns in Missoula Valley and the Bitterroot Valley for building greater resilience in their communities, this study could have direct implications for these initiatives.

The research setting of western Montana serves as a compelling case study in seed saving literature. Of regions that have been studied in the global North, most reflect relatively temperate environments such as the Iberian Peninsula or the Southern Appalachians (Calvet-Mir 2012; Nazarea and Rhodes 2005). Montana proves a relatively challenging place to grow food, experiencing a short growing season (approximately 120 days), with frequent unpredictable late and early frosts. In climate change models, the region is expected to have increasingly dryer and hotter summers, adding extra strain to food system networks, and suggesting the significance of having a resilient and adaptable seed system (Adams et al. 2021; Environmental Protection Agency 2016). While various projected climate scenarios exist, it is probable that western Montana will have wetter springs, drier and hotter summers, and more wildfire impacts. Climate Smart Missoula has identified various ways climate change may impact agriculture in Missoula, including increased soil compaction, lack of water, and impaired plant growth due to wildfire smoke (Schenk et al. 2015).

Additionally, this region demonstrates a compelling case study due to the social changes currently taking place. Both Missoula and Ravalli Counties have more than doubled in

population since 1980 (US Census 2020). It will be interesting to explore how the seed saving network responds to or potentially influences these social and environmental changes as a result of altered populations.

As this process focused on a seed saving network, it was difficult at times to completely bound my work by physical geography. In the spirit of a multi-scalar understanding of a network, the strict boundaries of the Bitterroot and Missoula Valleys did not always serve me in fully understanding the seed network of that place (Carlisle 2014). For this reason, some interviews were conducted with seed savers outside of these strict boundaries, but I felt justified in talking with and incorporating these participants' perspectives into my analysis because they did impact the region's agroecosystem in a meaningful way. There may also be reference to individuals and organizations who are not physically located within these valleys, but nonetheless were identified as important actors within the seed network.

Research Methods

This research is designed as a qualitative study in the tradition of qualitative social sciences, especially utilizing methods and theories of human geography Specifically, this research involves a case study of a practice (seed saving) in a particular region (the Bitterroot and Missoula Valleys of western Montana). Since the data in this research is developed through interpretation, not merely observation of phenomenon, its results are subjective (Hay and Cope 2021).

The primary methods used in this study are semi-structured interviews and participant observation. After considering theories in social-ecological resilience, I developed an interview guide that focused on eliciting the potential social and ecological impacts of seed saving (Agee

2009; please see Appendix A). The guide and recruitment process were approved by the University of Montana's Institutional Review Board (please see Appendix B). I initially selected participants who I knew through my preliminary involvement in seed saving practices, such as attending seed packaging events. Then, recruitment became opportunistic as I sought out additional participants through previously interviewed people as well as continued research on local seed saving efforts. My criteria for "seed saver" included anyone who participates in the growing and subsequent saving and/or sharing of seeds. Participants comprised two broad and sometimes overlapping categories: people who participated in the management of seed libraries, and people who grew and saved their own seed for either fun or profit. The distinction between "farmer" and "gardener" proved to be a blurry one. Some people were true hobby gardeners, others farm owners who saved seed on the side, and some still who saved seeds as their primary form of income but also participated in more informal seed exchange.

From April 2022 to September 2022, I conducted 19 interviews. Ten took place with people living in the Bitterroot Valley and nine in Missoula Valley, though there was some overlap with where people had previous experience. The interviews took a variety of formats including formal, in-person with audio recording, over the phone, or on Zoom. Some interviews were conducted "in the field" where I asked questions while working alongside the participant, and recorded important ideas right after the interview. Each format had its own advantages and challenges; formats were chosen based on the preference of the participants. The interviews were semi-structured in that, while I followed the general outline of my interview guide, I often tried to focus on topics that the interviewee seemed most interested in and followed the natural flow of conversation. All interviews were transcribed by utilizing Microsoft 365 audio transcription services and then hand edited.

Another significant method of data collection was participant observation. Participant observation came in many forms, including participating in seed library seed packaging meetups, attending seed swapping events, and helping seed savers in their fields during the growing and saving process. I also worked at the University of Montana's Program in Ecological Agriculture and Sustainability (PEAS) Program farm located in the Rattlesnake Valley which is associated with Garden City Harvest and a place where many seeds are saved and used in seasonal growing. I served as both a summer volunteer and fall semester student intern at the PEAS Farm. Participant observation was important for this study to develop an understanding of the social dynamics of seed savers, the spatial contexts in which these activities take place, and to better understand the roles of seeds and plants in the seed saving network (Hesse-Biber, Nangy, and Leavy 2010). Since I cannot interview the seeds, working with them was the best way to better understand them and their relationship to seed savers (Pit 2014). Field notes for these events were recorded shortly after my involvement and interactions in these activities. As a fall PEAS Farm intern, I was also able to create a weekly reflective journal of my insights with the plants and seeds, which assisted in my analytical process.

Analysis of interview transcriptions and field notes was conducted through coding. Coding was an iterative process, conducted multiple times with each document as new insights occurred. I began the coding process by exploring descriptive codes, inspired by Cope's (Hay and Cope 2021) CRAFT process, standing for Conditions, Relationships, Actions, Feelings, and Themes. I eventually moved into more analytical codes that reflected the concepts of resilience and network relationships that I was exploring in my research.

Positionality

In an interest in being reflexive, I would like to disclose my positionality within this research. Qualitative researchers generally understand that scholars come to research not with completely objective viewpoints, but are shaped by their own upbringing, race, gender, social status, and other products of society. Researchers are not mere bystanders but also influence the research of which they are a part, whether that is with the responses of a participant or through their interpretation of data (Hay and Cope 2021).

I am an American woman of European-descent in my late-twenties. I moved to Montana from Colorado for graduate school, so in many ways can be considered an "outsider" (although having lived previously in the Rocky Mountain region, I have experienced some geographical "insider" status). I did not grow up in a gardening or farming household but worked on various organic farms during my undergraduate career and after graduation, where I gained a profound appreciation of growing food and became interested in food systems research. I therefore approach this research with a normative view of supporting sustainable agricultural initiatives. I find that my background has aligned me well with my interview participants who were often well-educated, white, and actually mostly not originally from Montana. I also believe my background in farming also gave interviewees a sense that I know a little about what I am talking about in regards to the dynamics of growing food.

My positionality especially shaped my research in the communities I did *not* research. My focus for this topic was a relatively affluent group of mostly well-educated, white gardeners and farmers who chose seed saving as a hobby or profession. However, food issues are inherently political, and tied up in survival, health, and identity. In the context of the region where I conducted research, agricultural practices of gardening and farming domestic crops was

in fact a colonizing force that was used to justify the removal of the Bitterroot Salish people. If taken out of this context, my study could suggest that growing purely domesticated crops such as the tomato or cucumber is done without replacing a former, and arguably more resilient food production practice of hunting-gathering-and-fishing (Aveling 2013).

My hope is not to erase the voices of Indigenous people who have fought and continue to pursue food sovereignty for themselves and in their own ways. I hope this study can serve as a part of a collective conversation for how all people, Indigenous, of white settler decent, and other marginalized groups, can understand and collaborate in a more reciprocal relationship with land, food, and each other.

Applications to Research Questions

In review, my research aims to understand the dynamics and impacts of a seed saving network in western Montana, focusing on the Missoula and Bitterroot Valleys. The previously described frameworks, theories, and methods inform the approach taken to address the guiding research questions:

Question 1: How do significant actors connect within the seed saving network of the Missoula and Bitterroot Valleys?

In Chapter 4, I draw on the results of my interviews and participant observation to address this question. Through interviews and participation, I identify who and what significant actors are within this seed saving network, and how these actors interact. This process is inspired by actor network theory, in particular the analysis done by Hicks (2019) of another seed-saving network.

In her analysis, she identifies a myriad of actors, including soil, buckets, and shovels. At the same time, she focused her analysis on three primary actors: people, seed, and environment. While smaller actors will be mentioned in my analysis, I decided to focus on these three significant actors in order to more deeply analyze their relationship with each other. The results of this part of the analysis are descriptive, but they serve to describe who and what constitutes this seed saving network, and help to contextualize the approach to the second question posed in this study.

Question 2: How does the seed saving network contribute to social-ecological resilience of the local agroecosystem?

In Chapter 5, this question is first considered through the concept of emergent resilience. Emergent resilience refers to how actors' interactions may impact local agroecological resilience, especially in light of particular themes that arise from the qualitative data. Second, this guiding question is addressed through an indicator-based approach, where I assess how the seed network may lead to or support resilience based on a range of selected indicators that emerge from the literature. In utilizing these two strategies, one "top-down" and one "bottom-up," I am able to triangulate data and ensure the rigor of my analysis of this agroecosystem.

Ultimately, these two questions aim to address my primary research objective of understanding the dynamics and impacts of this seed-saving network in Western Montana.

CHAPTER 4. RESULTS: ACTOR CONNECTIONS

Introduction

The initial stage of my research is concerned with identifying significant actors within the seed saving network and how they interact in ways that might foster or support resilience. Like the ANT analysis it is inspired by, the results of this analysis tend to be descriptive (Hicks 2019). The primary actors identified were: seeds, people, and environment. These data address my first research question: How do significant actors connect within the seed saving network of the Missoula and Bitterroot Valleys?

People and Seed

The most obvious and primary connection within the seed saving network is that between the seed saver and the seed. Most obviously, the seed relies on the saver – whether a gardener, farmer, or seed librarian - in order to preserve its genetic potential and be planted and tended to into the future. The seed growers and savers rely on the seed for either sustenance or profit.

Seed growers often express that seed saving has given them a deeper or fuller relationship with plants than they previously had, even if they had previously grown plants for food. Seed savers develop a greater understanding of the needs of the plants, both in the habitat that they require, as well as the genetic and botanical knowledge needed to reproduce seed. When working with a plant during its entire lifecycle, and into its next generation of growth, one develops a greater appreciation and knowledge of the seed-plant's needs. It is a satisfying, fulfilling process.

One participant described to me how seed saving made her more attuned with the plants she grew:

> *Once you start seed saving you pay a lot more attention to how a plant is growing. You pay attention to certain characteristics, because you're not just picking the plants you're saving seed from randomly. And also you're paying attention to the status of development and, like oh what's going on with it now, is it about to set seed, does it look like its been pollinated well this year? And I feel like it just deepens my relationship with the different plants that grow, so it makes me pay more attention to them* (Participant J).

The more skilled a seed saver becomes, or the more networks or resources they have access to, the more types of seed they are able to save. There was often discussion of "easier" and "harder" seeds to save. Self-pollinated seeds like lettuce and beans are seen as simple, which was the focus for many savers. Biennial plants like beets and carrots are considered harder because they require multiple years to save seed from, and require adequate overwintering conditions. Additionally, cross-pollinating seeds are often a challenge because one has to consider those plants in relation to similar species. As a seed saver learns about the diversity of ways to work with seeds, the greater potential biodiversity of the overall seed stock.

Seed growers often explain that seed saving was a lot of fun for them, compared even to just growing vegetables. One seed saver explains, "It is a very enjoyable experience. It fills the gap in the plant cycle. It closes the loop, and is fulfilling" (Participant D). This observation suggests a relationship with the seed that is not merely utilitarian but emotional. Another explained,

> *It's super fun for one thing, like if nothing else, it's super cool. You use a different part of Farmer Brain because you have to understand in farming like spacing or timing or whatever and with seeds it's a whole other layer on top of that, of needing to understand timing and spacing and all that, so it's exciting. It's mentally challenging for being a farmer, like it's something new and just another layer. It's cool, the nerd part* (Participant A).

One saver puts it quite eloquently: "I also enjoy the whole sport, it's like sailing, like hooking onto the wind, this free wild energy. I think gardening is much more slow motion in that

you're riding on all these various currents of sun and soil and water, and just the seeds are the epitome of all of that" (Participant L).

An interesting perception held by many of the seed saves concerned the seeds' generosity. Many savers discuss the phenomenon of one seed producing an abundance of food and exponentially more seeds. There is a sense that the care that the seed saver gives the seed is reciprocated in sustenance and future harvest.

Some interviewees even mention a kind of spiritual relationship they have with the seed. It is clear that for many, seeds represent more than food. They are a tangible reminder of our role in nature that can literally be held and admired. One participant explains, "If you consider the environment as everything, I think it's spiritually healthy for people to save their seed, to be more connected to the Earth in that way" (Participant H).

Another participant explains: "Being in the presence of the plant spirit, hopefully I'm better able to do what the plant spirit needs to be able to grow. That's definitely not how all seed savers or farmers approach things, but that's just one part for us. Like, there's the spiritual side of farming as well, which is connection with the plant spirits themselves" (Participant A).

Eventually, people who are not even active seed savers, but bystanders to the process can develop a greater knowledge and appreciation for seeds due to the efforts of seed savers. Many expressed the excitement of involving children in seed saving activities, to better teach them about food systems. As a seed librarian explained, even when library visitors see the seed bank, they are compelled to consider seeds as part of a collective knowledge and resource base. Many other seed savers discussed sharing seed saving with young people in order to teach them about the food system:

> *One of the wonderful things about gardening is getting your kids involved. If you have time to talk to him, hang out, do something productive, teach him something about plants.*

> *You know, show him where their food comes from. Teaching them about the whole cycle of food from harvest and preserving and storing and cooking. A lot of people think their food comes from the grocery store. I don't think that's healthy. Because, you know, give farmers their due. You know they don't know that the farmers are working that hard* (Participant C).

In summary, when people and seed come together in the seed saving process, the interactions result in a sense of fulfillment, generosity, and knowledge about agrobiodiversity and the food cycle.

People and People

Seed saving helps bring people together on both individual and organizational levels. These connections result in further knowledge exchange and building community around seed. People-to-people connections were evident in a number of ways and context, including seed libraries, seed-focused seed swaps and educational events, and simply being in the seed garden or farm.

It was communicated how seed libraries "filled a gap" in the local food systems work. While organizations like Garden City Harvest and the Community Food and Agriculture Coalition provide land, resources, training, and food distribution infrastructures, the seed library can both store and distribute seeds produced through these organizations (Participants A, N).

Primarily, people are also brought together in the exchange of seed saving knowledge. This exchange happens in both formal ways, as some of the seed savers I interviewed provide or organize formal trainings to new seed savers. Many seed savers also attend regionally or nationally organized conferences and educational events on seed, such as those held by the Organic Seed Alliance or the Open Source Seed Initiative. Seed savers must collaborate in

knowledge production and exchange because information on seed saving is not as prolific as, say, producing vegetables for market gardens.

Those who grew seed for an outside company even expressed a sense of connection with the companies, and the individuals that make them up. Participant P claims that there is an interest of the seed company to ensure that the most appropriate seeds were selected for in the right conditions. Another discusses the importance of having a personal relationship with the people at the seed company he grows for (Participant B). They explain that having these personal connections with the seed companies for which they grow seed is an important form of support in their work:

> *I tried to grow out some seeds with Fedco just to see what it was like… And it was different, you don't have as much connection with the company. When I grow for the people in Idaho, it's like I know who I'm talking to personally, I know their faces. I know what they want to see. But with Fedco you have a contract that says you cannot use this seed, it's our property. They're giving you a seed for them to sell. It's just the feeling of doing it* (Participant B).

At the outset of my research, I was expecting more explicit connections among seed savers, such as people deliberately exchanging seed with one another. When asked about this connection directly, however, seed-savers tended to focus on the more solitary aspect of their seed saving activities. At the same time, they would often mention connections they have to other seed savers or seed organizations, for example, getting seed from the PEAS Farm or Triple Divide Co-op.

The physical act of seed saving often brings people together, from seed packaging with the Five Valley Seed Library based in Missoula, or group collection of seed on an afternoon at someone's garden or farm when the weather conditions are just right. One participant mentions how fun weekly seed packaging events were. As a participant, I was able to witness how these

bring community members together. In the presence of seeds, people often discussed local environmental or social challenges.

A participant eloquently describes how a love for seeds can bring people in place together: “We all share this connection with seeds, but it's the particulars that vary. It's something we can come back to, like we all love seeds. You might love fava bean seed… and I might especially love, like flowering broccoli seed, because that's what's really great for me right now. But we both love seeds and so there's a connection for everyone” (Participant A).

This human connection extends past current time as well. People feel that seeds connect them to both the past and future generations. Participants often reflect on how seed saving has been such an important part of the human experience in the past, in order for people to survive and thrive in their local environments. One participant, who has Native American heritage, shared with me the significance of corns and beans that had been shared with him from other Indigenous tribes. He was also able to show me seeds he had acquired that had been previously developed in the Andes Mountains of Peru. Though continents and generations apart, he was able to connect to these people through seed (Participant O).

Another participant describes how seed saving connects her to her immigrant relatives: “I'm a first generation American. I like the ideas of people taking this part of their tradition and their past and carrying it with them in the seeds. The fact that they're transportable and something to connect you to the past, but also like grow into the future. You know, so they bring out all these different stories in people, depending on their perspective and their history” (Participant J).

For many, the seed represents the present moment, while also honoring the past and providing hope for the future:

> *It's like a super genuine connection to the past into the future. So really, when you're holding the seed in your hand, that's like the present moment. That is everything that exists because it's all the past grandmothers and great grandmothers that saved the seeds and its all the future of everyone in our children and their children. Children will be eating or using those seeds. But none of that matters if we don't take care of this moment now* (Participant A).

Seed saving brings people, both individuals and organizations, closer together in the exchange of physical seed and of knowledge about seed, creating greater community relationships and greater community and institutional knowledge about seed saving.

People and Environment

Seed saving also provides savers with a deeper connection and understanding of the local environment. This was expressed both in a better sense of connection to place as well as a deeper understanding of the environment.

One participant explained how her garden has become like a microcosm of her greater surroundings:

> *[The seeds] are sort of like a little sampling of my neighborhood because when I go on walks, I'm like I want some of those, I want to try to grow those in my yard. You know I'll stash them in my pocket and hopefully remember to dig them out before my clothes get washed. So, I feel like whatever I have growing, it's always kind of representative of where I live, because it's you know the seeds that I gather, just like randomly are it's like where I walk where I ride my bike you know it's like a little sampling from like what my neighbors have grown in their yards, a lot of the time* (Participant J).

The above quotation demonstrates how plants are imposing agency upon people as the person moves through the environment. Through participant observation, I also discovered how plants throughout the locality can impose themselves *through* others. Someone would mention their interest in a particular plant, and another person could explain a park where it grew or knew someone who had that variety. Thus, plants that are memorable in their usefulness to humans, can pass their genetic inheritance on through the locality.

Seed savers develop a greater agroecological knowledge base through the process of seed saving. For one, they are selecting for seed-traits that may withstand the local ecological conditions. They have to recognize how a seed-plant has performed throughout the season, with considerations given to the weather conditions of that season and predictions about the variability of the next season. In Montana, growing food can be especially challenging given the dramatic variability in weather patterns.

This knowledge is often produced through experimentation. As one multi-decade saver of seeds says, he is "always learning" (Participant O). Visiting another seed saver's farm, I was struck by all the small experiments he was running at the time, in order to better understand the best time to harvest, water, space plants, and the likes (Participant B). In some cases, the information on how to best save certain seeds is essentially inaccessible through formal networks. As one seed saver who grew flowers explained, there is practically no publicly available information on flower seed saving, that it is all "in the industry," so local gardeners and farmers have to figure it out for themselves through trial and error.

Many seed savers expressed how they were not growing the seeds, but the seeds grow themselves. The gardener merely provided the habitat for the seed to flourish. One seed saver says, "I'm not growing them. They do the growing. I'm just providing them a good home to grow in" (Participant M). Thus, seed saving became less about tending seed but tending to a greater agroecological environment that the seed would be comfortable thriving in.

Thus, other actors in the agroecosystem factored into the relationship with the seed, and how the seed saver had to consider them as well as the seed. Study participants express concern for the health of pollinators, the soil, and birds. Many participants are interested in saving flower seeds in order to support local pollinating species. Others discuss the importance of maintaining

wild habitats near where their seed was grown for the health of birds. They emphasize that the health of these other ecological actors contributed to the health of the seeds such as assistance in pollination or reducing pests. Therefore, seed is not just saved and selected for in the interest of just the seed or the people, but for these additional actors in the agroecosystem.

Seed savers share their knowledge with one another. This knowledge sharing is especially important in the seed saving world because, unlike in conventional farming-for-crop networks, there is not that much formal information on the most appropriate ways to produce plants-for-seed. Seed-savers cite only a handful of seed saving "bibles," or key reference books, upon which people could rely on information. However, these guidebooks and technical materials are nationally focused and are not written to be particular to the characteristics of place. Information exchange happens locally, as well as across scales at gatherings such as the Organic Seed Alliance conference, through online forums, or word-of-mouth.

Seed saving thus connects local people with their local environments, compelling seed savers to develop more knowledge about the climate, weather, and other agroecological actors within the environment. It also compels them to steward habitats and seeds that are compatible with one another.

Seed and Environment

Seed, as an agent in the agroecosystem, also responds to and adapts to the particular environment in which it is located. Over time, this tie to locale results in seeds that are better suited to the agroecosystem's particular weather, climate, soils, and pests.

Interviewees who have been saving seed in place for a number of years discuss how their plants have become better suited to the local environment and its variables. Seed-plants grown in

place adapt to their environments in the most ecological sense of the world. One participant explains how in the Bitterroot Valley, strong winds are a challenge to growing plants. Through seed saving, she believes her plants have grown stockier and more resistant to these particular weather events. Cold resistance is another trait that has been mentioned, as many plants are now adapting to be overwintered. They have also shown adaptation to the particular social circumstances they are grown in. Diversity and novelty of color were discussed as ways that local plants have changed over the years:

> *We make a lot of decisions to harvest things based off of regionally adapted seeds. We need cold hardy seeds. We are definitely restricted because our weather is very unpredictable. We have really extreme shoulder seasons in the spring, and then the fall, and they can be kind of all over the place. A lot of places can be that way, but I feel like it's even more extreme here because you can have like a 50 to 60 degree temperature change and that takes special seeds, you know that takes special plants to be able to survive that, and so I do think that we are very interested in focusing and trying to gain more knowledge and what's going to do best here. There are things that even I grew in Colorado that don't do well here and so it's always a learning experience. You're kind of at the mercy of your climate and region, and I think that learning to go with it and go with the flow instead of fighting against it and trying to grow everything that you want to grow, it just doesn't work that way. Sometimes you know, we need to be selective, and we need to pick things that are going to survive and do well here* (Participant E).

Another explains, "I think definitely things are getting locally adapted every year that we grow them. Its different traits are able to come out based on weather changes. And from like an energetic level, they're adapting to us being their steward, and so then we're able to co-create together better if they're open to us and we're open to them" (Participant A).

These quotations demonstrate just how challenging but crucial it is to have locally adapted seeds in this region. And they, the seeds, are succeeding. Many multi-decade seed savers express how much better their seeds seemed to do in the local conditions, especially if saved over a number of years.

Seed librarians are especially mindful of the localness of their seeds. A seed library opened up this past year in Stevensville, despite other libraries existing in Hamilton and Missoula. The librarian's reasoning was that, even here, the climate and needs of the people were different:

> *We're really trying to keep it where the seeds that we're giving away are coming from the Bitterroot Valley, so that the seeds that are grown are ones that do well in the valley, since you know down here in the Bitterroot we've got lots of tiny little micro climates and things just don't grow the same, here as elsewhere in Montana, or you know where a lot of seeds are typically grown and harvested are in warm moist climates*
> (Participant G).

In seed saving, especially on the non-commercial level, there was even a consideration for the seed's connection to wild places. Through this connection, we see how agrological systems, including seed systems, are intimately tied to ecological ones. An interesting anecdote came from touring the garden of one seed saver who was especially concerned with fusing the wild-domestic interface. He grows many "wild" plants, often which had medicinal properties, growing among his domesticated plants. These plants he often collects in the forest near his home. Because he does not have fences, many of his seed-plants become sustenance for wild animals. But their presence, like those of birds, bring benefits to the seed in the form of eating problematic insects. Other participants collect seeds from wild places, especially flowers and herbs, to bring back to the garden and mingle with their own seed stock.

As an example, the amaranth (*Amaranthus)* is an interesting seed-plant that came up in a number of contexts during my research. Amaranth is native to the Americas and was domesticated in Mesoamerica for its nutritious grains and leaves. It grows across North America, including in Montana, but amaranth is often considered a weed, known as pig weed because of its abundance. However, its persistence viewed in another light may speak to the particular resilience of the plant. The above seed saver was excited to plant domesticated amaranth because

he felt it would do well in his cultivated habitat because of the abundance of pig weed already present. This year an amaranth plant appeared unexpectedly. It could have been part of the seed stock he was already planting or carried by some bird or other animal. Either way, it appeared in his garden, a testament to the power of "creating a habitat" for the seeds to thrive in, and seeds responding to that stewardship.

This story brings the idea of the wild-domestic interface to the forefront. How separated is the corn from the teosinte, the amaranth from the pig weed, the tomato from the nightshade? These miniscule degrees of separation remind the seed saver of the seed's, and indirectly our own, connection to the "wild." Gardens and farms can be an active part of a greater agroecosystem.

One participant expressly compared wild places to seed: "I am an advocate for protecting wilderness, because these managed areas aren't doing that well. The wilderness landscape is like a seed" (Participant L). There is a lot that could be taken from this statement. One interpretation is that seeds, like wild places, are better off when they are part of intact, ecological systems. It also is a reminder that wild places contain the genetic inheritance of our domesticated seeds. Our seed-plants wouldn't exist without the human-environment-seed connection over generations. Maintaining "wildness" is just as important for our domestic species as keeping them in the field.

Seed saving thus allows for seed to interact with their environment in a more dynamic way than would a hybrid or GMO seed. The seed must adapt to the climatic variations it finds itself in, in addition to other plants from the wild. This adaptation results in seeds that are more "of place."

Seed and Other Seed

How seed-plants interact with each other is another consideration. The existence of other plants, especially like-plants, influences how a seed-plant will grow, and eventually the type of new seed it produces in the next generation. For example, Participant B does not grow squash for seed because the property he grows seed on produces many other cucurbits, and there could be potential cross pollination with those species. This is an issue of seeds being true to type, which is not always a concern for growers, especially if they are not growing seed to be sold. Cross pollination can introduce new genetics and potentially strengthen the line of the seed.

The implications of seed-cross pollination can be potentially dangerous for a farmer, though. For example, Participant P does not grow brassicas for seed because a neighboring farm grows a GMO variety of canola (which is part of the same genetic family). Lawsuits between GMO seed developing companies and small farmers have occurred in other states, and farmers are held accountable on a state-by-state basis for such crossings. While this participant believes Montana would side with the small farmer, he does not want to experiment with the possibility of legal consequences and also wants true-to-type seed to resell.

Because of these interactions, there is greater diversity in the varieties of plants being grown. Especially by larger growers, there is consideration of the diversity within a species in order to produce healthy and robust plants. The greater the diversity of a plant being grown for seed, the less bottlenecked a variety becomes in terms of genetics. There seemed to be a tension between selecting plants that were true to type and those that possessed enough diversity to stay healthy (Participant N).

Different types of seed can also interact with each other. As seed growers grow seed with an understanding of agroecological processes, as discussed above, there is a greater tendency

toward polycultural systems. The power of this diversity was demonstrated to me while taking part in a seed harvesting activity at the PEAS Farm. There, a student has worked with the Mandan, Hidatsa, and Arikara Nations to create a "four sisters" garden, using seed saved from the tribes. In this garden, the plants were grown together, since each plant provides different necessary structural components to the garden. We saw how the squash leaves shade the ground, the beans provide nutrients to the soil, the corn provide structure for the beans to grow on, and the sunflowers attract birds and pollinators. Thus, plants impose their own needs upon each other, eventually influencing natural selection and the next generation's seed. Saved seed is not produced in isolation, but often in the company of other seed-plants. In the end, where, and how the seed is grown is influenced by proximity to other seeds.

Conclusion

This chapter attempts to address my first research question: How do significant actors connect within the seed saving network of the Missoula and Bitterroot Valleys? It is primarily descriptive in its examination of actors and the effects of their interactions. Many rich descriptions provided by interviewees reveal various connections between people, seed, and the environment that result in relationships, revealing a "rooted network."

I detail the significant actors found within this seed saving network and describe their connections. I specifically describe this unit of analysis as a network instead of a system while considering the potential for multi-scalar and cross boundary interactions that may occur. Through this analysis, I show how informal seed saving within this network, in contrast to purchased seed, results in a variety of rich connections.

We also see the seed's agency come through in these relations. The seed wants to survive and propagate as much as the people growing from seed want to benefit from them. Study participants observe seed adapt not only to the environment, but to the people who would want to grow them, or as one participant described as "co-evolve" (Participant A).

We also see how the seeding relationship exists on a spectrum of social-natural. The more a seed is saved, the more both the seed, and the person, become better attuned to the place they are in. Similarly, we see other actors enlisted into this complex network as well, whether they be pollinators, birds, or the soil. Seed saving supports complexity of the agroecosystem, creating what Rocheleau (2011) would call a "rooted network."

As Dwiartama and Rosin (2014, 27) state, "Actants (both human and nonhuman) have the capacity to influence the configuration of an SES, awakening our awareness to the fact that the ability of humans to perform agency and build resilience is dependent upon the specific relationalities between them and the nonhuman components." In this seed saving network we see how both people and seed impose their needs and shape and are shaped by the network of which they are a part.

This seed saving study moves past humans as sole agents and shows how the seed plants move through the world and impose agency on the network. The materiality of the plant is an important part of the interaction and the relationship. What they need, how they respond, and what they can provide to the grower in terms of taste, storage, beauty, medicine all influence the network's makeup.

Thus, in examining how actors connect within this seed saving network, we find a complex rooted network of interactions. Seed that is purchased year to year likely does not have this same ability to create such a rooted network because it does not have the opportunity to

become “of place.” Instead of part of a process of interaction, like the saved seed, the commercial seed is merely an input. This rooted network’s impact on resilience is explored in the next chapter.

CHAPTER 5. RESULTS: IMPACTS ON RESILIENCE

Introduction

As outlined in Chapter 2, social-ecological resilience has not been fully operationalized, especially in such a complex system as an agroecosystem. However, because the idea of resilience has grown even in the public as a goal for our ecosystems and communities, identifying resilient features of a network proves pertinent. For this reason, I consider how the seed saving network within my area of study may contribute resilience to the local agroecosystem. This examination is done in two parts, first exploring emerging resilience effects, and then utilizing a pre-established indicator framework (adapted from Cabell and Oelofse 2012). The following sections aim to answer my second research question: How does this seed saving network contribute to social-ecological resilience of the local agroecosystem?

I explored emerging resilience effects that became apparent through my interviews and participant observation of seed-focused events. An effect is understood as the result of actor-interactions within a network (Hicks 2019). "Resilience effects" is a term I derive from the work of Liz Carlisle (2014) in her exploration of emergent properties of a particular agricultural network. In the following section, I demonstrate how various connections within the seed system result in resilience effects, demonstrated through participant quotations and observations.

Resilience is primarily concerned with adaptation or transformation of a system in order to maintain its function, especially in the face of change or "shocks" (Folke et al. 2010). In this case, the agroecosystem is of concern and its ability to provide healthy food to all community members. Thus, a resilience effect would be a resulting effect of actor connections that contributes to the continuation of this function within the local agroecosystem. Especially when considering emergent effects, these would be effects that participants felt contributed to their

own sense of resilience within the agroecosystem. The resilience effects identified through this study are: multi-scalar connections that are decentralized yet interconnected, connections across time, effective response to a shock, abundance and redundancy, ecological resiliency, systems adaptations and transformations, and resilience knowledge.

Resilience Effects

Multi-Scalar Connections: Decentralized but Interconnected

Seed saving in Western Montana results in an agroecosystem that is less centralized and managed by global networks, but also interconnected across and between scales. Study participants felt that growing seed provided a sense of self-reliance from global forces on both the individual and community scale. Seed savers were concerned about ensuring their own access to seed and food. Even if they are not too concerned with the practicality of seeds coming from outside the region, many also experience a sense of satisfaction from saving seeds from their own plants. Some even cited that this sense of self-reliance was a particularly Montanan attitude to have and fulfilled some situated interests in being independent from large government or institutions:

> *I know for me, one of the reasons I like to save seed is that it's definitely linked to ideas of self-sufficiency, and being able to provide and having useful and important skills. So it's tied up with all these ideas of not relying on big government, not relying on big industry. But I do think there's always some element of people wanting independence and always a sense of like seeds being something that is our collective inheritance, that we deserve access to. … Something about it feels empowering I guess. I like to look at the plants that I'm growing down in my little house garden and to know that, like they came from the seeds that I saved, and I will be able to keep them for myself later this year* (Participant F).

At the same time, seed savers relied on complex interactions with other seed savers and organizations, both locally and nationally, for both physical seeds and knowledge. Thus, the seed

network also proves to be multi-scalar. In contrast, both seeds and seed information lose their centralized place in the unsituated, globalized, industrial space and moves through everyone.

At the individual and local level, seed savers are compelled to discuss with one another the best methods for growing and saving seed. Because information on seeds is not widely available, local knowledge exchange is practically essential. Additionally, the abundance of seed as mentioned above compels seed savers to share their surplus harvest with others. This sharing could be directly to friends or in the form of one of the seed libraries that exist in the valleys. More formal events, such as seed swaps that often occur in the spring, bring together many people who may be interested in collecting seeds.

Seed saving knowledge is no longer obscured by specialized knowledge producers, but operates horizontally, or even from the ground up. I learned that seed-related knowledge developed in Montana has had implications for nation-wide seed networks. Many people cited two prominent seed breeders who spent a significant amount of time in the region, associated with Garden City Seed. Since the end of Garden City Seed, they have left Montana, but a great wealth of knowledge on seed saving was developed here. One works for what is considered the most influential open-pollinated seed company in the US, Seed Savers Exchange in Iowa. Another provides education on seed saving through the Rocky Mountain Seed Center in Colorado. The knowledge on seed production that these individuals developed while seed saving in Montana have helped benefit national networks of seed exchange.

Actual seeds that have been developed here in Montana have also had influence on the national collection of seeds. Painted Mountain Corn was originally developed by Montanan Daniel Christensen, who was inspired to develop a corn that would grow quickly in the harsh Montanan environment. This seed is now sold by Baker Creek Heirlooms (a popular national

source of open-pollinated seeds) and is a useful crop for those growing in northern latitudes. A variety of watermelon was also developed by Triple Divide Co-op, is now sold by Fedco as a fast ripening melon, a feature quite rare in the cucurbit world. Thus, the uniquely challenging climate of Montana has inspired the development of seeds especially hardy to challenging mountain climates, contributing to the resiliency of the national seed stock.

Seed savers also discussed building connections with individuals across the nation. One interviewee participates in a national seed exchange where she receives seed from individuals across the country. Others gain information for seed savers in potentially similar climates, such as across the Rocky Mountains. These larger connections are facilitated by gatherings of one of the prominent seed organizations. Many cited the Organic Seed Alliance's biannual conference as a place of community-building among seed savers in the West.

> *The OSA conference is actually a good time to talk to people. It all happens in like four days and it's kind of madness. It's not like vegetable farming where I know tons of people and everyone who you know is doing something similar. It's like there's far fewer seed growers you know, so it's a much more like a smaller national community and it's harder to find people to really bounce ideas off with. Yeah, a lot of it is figuring it out myself. Hopefully learning from other people's mistakes when I talk to them, bit by bit* (Participant B).

The seed saving network in western Montana has developed from the ground up, in a decentralized fashion, but connects with other seed saving networks across the country. It is both decentralized, interconnected, and multi-scalar. The knowledge about seed saving that has developed here has had tangible impacts on the agroecosystem not just in Montana but potentially across the country. Having the source of our food developed and shared in this way allows for a more resilient agroecosystem since it is not bound to a top-down, centralized system.

Connections Across Time

Another unique feature I identified within this seed network was how it connected seed savers across time. Seed saving supports an agroecosystem that does not just consider one season's crops, but learns and takes inspiration from the past, and considers the health of the future.

Many seed savers expressed how seed represented a moment in time, the potential to connect the past, present, and future. Seed saving allowed people to relate to an ancestral sense of tending to the land. But it also provided hope for a future where people are living closer to the environment:

> *It's our good fortune to get to be in a relationship with seeds and it's our obligation. We owe it to our grandmothers and our grandchildren, because we're in this moment and if we don't take care of it, it's all for not, which would be sad. So if nothing else, it's like do your best as a human, and for me part of that is I can save seeds. If you can save seeds, whoever you are, then you should. But we all get to, which is cool. I think it's a compelling thing, to consider the possibilities. There's so much about what's crappy right now, but seed saving is in the category of possibility, and I think we need things that are possible right now* (Participant A).

One seed saver was gifted heirloom seeds of corn, squash, and quinoa from Peru, the place where these plants were originally domesticated. He notes that the Andes may have a similar climate to the Rocky Mountains in Montana and was excited to literally bring these varieties back to life. Of course, planting and saving these seeds in western Montana would result in new adaptations, and eventually new plants. Even though these seeds are continents from their original home, they can become a part of this landscape. The same farmer had many corn varieties gifting from a Pueblo Native American tribe. His growing their seed directly connects him to their ancestral farming traditions, while also ensuring they survive into another generation. He described his role in this way:

> *There's a long tradition of people growing their food and vegetables and having a relationship with the landscape. To me, saving seeds is like preserving an inheritance, that we have that has been gifted to us from hundreds of generations of people who came before us. So to me, preserving that history and that story and those relationships with the land, like they're all encapsulated in a seed.* (Participant F)

There is a sense of shrinking of time and place with the seed, because of its mobility and its longevity. A seed, especially one that has been grown for generations, has a particular connection to the past. The current seed saver becomes part of the selection, and transformation of that plant. It also highlights a sense of responsibility to future generations. We want genetic diversity to exist for them as well.

Multi-scalar connections are an important feature of resilience, including across time. For this seed saving network, these connections to past and future were an important emergent effect of their seed interactions. Through the seed, the agroecosystem remembers the past, while imaging a more resilient future.

Effective Response to Shock

Perhaps the most foundational feature of resilience is a system's ability to respond to a shock. Defining a shock and analyzing its impacts within a complex agroecosystem, though, can be difficult. This study was conducted in 2022, while the COVID-19 pandemic was still impacting the world. The shocks imposed by COVID on the entire world, including food systems, were hard to ignore. The global pandemic was often a topic of discussion in interviews when participants were asked to consider the impacts seed saving had on their community, particularly in how important the seed network was to helping them buffer the shocks of COVID.

The seed network was able to provide seed to people at a time when it was not available, because supply chains broke down, and people had less access to regular food sources like the

grocery store. The knowledge that people had built, and the variety of seeds developed, and infrastructure put in place, was able to be mobilized during a very real shock to the system. This experience shows very tangibly how the seed saving network contributed to the resilience of the local food system.

Study participants feel that the beginning of the pandemic, in 2020, was a good example of the significance of having a local seed source. Seed became almost impossible to buy from regular seed companies in March and April due to shocks to the transportation and supply chains. But because places like the O'Hara Commons and the Five Valley Seed Library had seeds, people were able to continue growing their own food. Seed savers felt that those previously less attuned to seed saving were exposed to the significance of seed saving at this time. However, many fear this lesson has faded in the following years.

One seed librarian recalls, "We emptied our seed library during COVID during the shift that people were making growing at home" (Participant C). Another librarian discusses how much growers in the Bitterroot appreciated the seed library's presence even more than usual during the pandemic:

> *During COVID a lot of seed companies were selling out of their seeds. And so that's something I think really in Ravalli county, being self-sufficient within the county is a big theme down here. So people having self-sufficiency, with their food is really important to a lot of the patrons that come in and. I get lots of positive comments on the seed library* (Participant G).

Participants see a very real possibility of similar shocks occurring in the future. The pandemic was a reminder that their access to food was not guaranteed when seed was in the hand of global markets and ensuring that access into the future was essential. As inflation has been on the rise, many see this as another potential, though more chronic, shock to the system: "And now, especially with the rising cost of food prices, and more people gardening, it's more

important that we are saving or seeds, so that we have seeds available for the future" (Participant G).

Some participants are worried though that the lessons of the pandemic were already fading. "It's unfortunate that it took a pandemic for people to care about their food system. But that is slipping away again. The best way to get engagement is to empower people. Make a process that is more fun than fearful. Ownership is an important part of it" (Participant C). Thus, while the pandemic was a reminder of the importance of seed saving, savers saw that continued maintenance of the seed network should come about through other means, such as engagement and empowerment. In this way, the seed network of the Missoula and Bitterroot Valleys was able to provide agroecological resilience in the most classic sense, continuing to provide food to community members during a shock to the system.

Abundance and Redundancy

Abundance and redundancy are also common features of a resilient system. The local seed network returns a sense of abundance and redundancy to the agroecosystem in the form of physical seeds, and knowledge.

One idea expressed often was that of the "generosity" of the seed. This implies that people feel taken care of by the abundance that the seeds provide. Indeed, just one tomato plant can create hundreds of seeds, and thus new plants. "What an investment, you put one in the ground and get a whole bunch back" (Participant L).

This framework of abundance reconsiders the seed as a commodity object, translating it into an actor of caring and relation. "We can give them as plants or as seeds to gardeners and small growers in Montana and everyone will be successful. And then we can all grow more food.

Just trying to grow seeds to the things that grow the best and easiest and nicest for most people" (Participant A).

This idea of abundance connects well to the resilience concept of "redundancy." Redundancy in a system allows for there to be multiple elements to fall back on in times of stress. With the abundance of amount and variety of seed, this means there will be many sources of seed and thus food in case some sources fail.

Some seed savers also spoke of the importance of abundance and redundancy in the seed saving community. The more people save seeds, even just in their backyard, the more likely that a diversity of seed varieties will adapt and exist into the future. One seed saver explained, "The most secure thing would be to promote seed saving and trading and everyone have their stash at home. And if something does happen there is something" (Participant L).

Seed saving creates an abundance of seeds as well as seed saving knowledge, that can be shared with others. The more seed saved, and the more different people save seeds, the more food may be available, especially during a shock to the system.

Ecological Resiliency

The seed saving network can be seen to support resiliency in an ecological sense, especially on the seed and field scale. For seeds, diversity becomes the primary resilience effect, both within a variety, and among a diversity of species.

As seed interacts with each other, with seeds brought from other places, and with the wild, the genetics of the seed are able to diversify and become stronger. Adaptation of the seed to the local environment becomes significant, especially in a region subject to change dramatically and variably, even more so with climate change. This means the region's ability to grow food

will be secured and enhanced into the future. The importance of adapted seed was mentioned consistently as a reason for saving seed by participants. “I think that we find it important, not only because of the cost, but because we like to find adapted varieties for our region, and I think that knowing that something does well or survives in our area it only enhances the quality of the seed. Every year, that you harvest the seeds, and so I feel like we really like regionally adapted seeds” (Participant E).

In the industrialized system, the seed is a mere input, along with chemical fertilizers and pesticides. The seed is selected to conform to these other inputs in the name of efficiency. And the plant that is selected is for features like transportation ability and longevity. Diversity becomes the enemy of efficiency. A seed that is locally saved, however often is selected for different purposes. At the home garden scale these are likely flavor, color, success in the local environment, or in the case of medicinal plants, their healing properties. Even at the more commercial scale, the above factors are taken into account, as they are often growing for a home market as well. They are also growing for plants that respond well to organic methods of growing. The seed thus is grown as part of a complex agroecological system, not merely as an input or commodity.

Through the saved seed, the agroecosystem becomes more interconnected, and thus resilient. Its various elements are no longer working against each other. Instead of relying on seeds that are less adapted to the region, relying on even further outside inputs such as chemical fertilizers and pesticides, locally adapted seed is able to grow with and support the local environment.

Many seed savers who have grown for multiple generations have in fact noticed the adaptive qualities of their seeds:

> *I noticed after three generations of saving corn seed, it really seemed to improve, it evolved to the really local conditions. It did seem to have adapt itself after the first few years. And the soil was getting better. But I do think saving local seed and selecting for what works best can have an exponential effect on the resilience or vitality of the seed. The guy who developed the Pale Mountain Indian corn developed it to be short and stocky and wind resistant. So when the weather gets erratic, it could be a real curve ball. When there's a sudden storm it could really impact your ability to grow seed* (Participant L).

One participant highlights how saving open pollinated seeds so that they could adapt to their environments was more important than preserving a particular characteristic, like in an heirloom. "An heirloom is something in a museum. They are interesting and novel, but they become like orchids, something beautiful, precious. But it's not practical for the purposes of transforming agriculture for sustainably" (Participant I).

In this case, we are able to consider the original application of resilience to an ecological system. Concerns like diversity and biological adaptation are apparent in the saved seed in this network, and contribute to greater resilience of the agroecosystem of which they are a part.

Systems Adaptation and Transformation

Seed saving provides skills and knowledge to be able to both adapt and transform the agroecological system in the face of challenges. In the face of perceived shocks, many seed savers were compelled to take up seed saving as an adaptive strategy. At the same time, they see seed saving as a way to transform the globalized, industrial system that has led to these same challenges.

Many participants expressed their initial interest in seed saving stemmed from fears about food security or climate change. They sought a tangible way to ensure access to their food in the

face of outside shocks through seed saving. Thus, seed saving in western Montana represents an attempt to adapt to existing industrial, global food systems to an alternative, de-centralized form.

In addition to a form of adaptation, seed saving can also be considered a transformation of our agroecosystems. Saving seed actually transforms the seed's role in the food system. The seed production industry has succeeded in making seed a commodity, making it necessary to purchase every year in order to provide a profit to the grower. However, the saving of open pollinated seeds means seeds no longer need to be bought or sold. Indeed, when considering the "generosity" or abundance of seeds mentioned above, in many cases seed not shared simply go to waste. Saving seeds thus encourages a sharing economy, where singular ownership over one seed type makes less sense than sharing its abundance.

One participant explains how, "Hybrid cabbages are amazing, they're cool stuff. But that's not what is driving access, and that's what we're interested in with seed saving. Because then it's also having an outside dependency on the hybrid. Like then I have to get the hybrid again from wherever whoever is making it. That's why open pollinated seed is really important because we can do that ourselves, right now" (Participant A).

The money earning and saving aspect of saving seed should also not be overlooked, especially when considering potential economic transformations. On the more commercial scale, where seed is grown for profit, saved seed provides a livelihood to many seed savers. For those who may not sell seed but save their own for their farm or garden use, they are certainly saving a lot of money in yearly input. One farmer I spoke with saves nearly all of her seed and no longer has this significant yearly cost (Participant J). In both cases, the practice of saving and producing seed is returned to the farmer, instead of global seed producers. Saved seed also allows for access to seed by those who could otherwise not afford it. Someone who would have to buy seed may

not take the risk to grow a garden. But a free seed from a seed library means there is a lower point of entry and greater access to more community members.

Many study participants see seed saving as a way to not only adapt to climate change or involatile markets, but participate in a transformation of those destructive processes. Indeed, unsustainable agricultural practices have contributed to carbon emissions, which have resulted in climate change, which is the driving force behind a significant anticipated shock to the agroecosystem. The consolidation of the seed market is part of the industrialized market economy.

Garden City Seed started as, according to one informed participant, “a counterpoint to the consolidation to the seed industry and the production of widely adapted varieties through methods that would be marketed nation-wide. The idea that was to have varieties that were broadly adapted” (Participant I). Participant M described clearly, “The least resilient food system is the one that is dictated by Big Ag and patented seeds that you are not allowed to save. And then GMO seeds that you can’t save. The biggest part of seed saving is awareness and education about the food system.”

By transforming the role of the seed at the small scale, seed savers believe they are allowing for transformations of destructive systems at greater scales. In this way, seed saving is both an adaptation to perceived shocks, especially climate change, but also an attempt to dismantle the capitalist system that allowed for it to happen.

Resilience Knowledge

A final effect of the seed saving network is that of resilience knowledge. As people and seeds become more adaptable, and open to transformations in the face of social and environmental challenges, resilience knowledge becomes evident.

The seed saving process encourages learning and leads to the development of agroecological knowledge that is situated in place. It consists of a constant learning feedback between human and seed in order for both to transform and adapt to their local environments. One participant explained how seed saving provides greater knowledge of her environment: "If it didn't get pollinated well, I have to ask why is that, what's going on with the pollinators? I mean like it's like a window into understanding the environmental conditions in our area" (Participant J).

The Triple Divide Seed Co-op developed less as a way to make profit and more for combining knowledge and resources to provide farmers access to a more robust seed growing operation in Montana. Some participants spoke of a "Seed School" that the Co-op held a number of years back in order to bring together educators and seed savers to better learn about the importance of and methods for seed saving. Even though it was a one-time event, those who attended often reflected on how it brought the community together to harness their collective seed knowledge.

One seed librarian shares with me their insights on the idea of seeds *as* knowledge. Local seed, like the production of local knowledge, is often overlooked in the industrialized world over specialized seed (i.e. hybrids or GMOs) and knowledge. However, local seeds are the product of situated understandings of the environment. Almost all of the seed savers to whom I spoke claimed to not "be experts" on seed saving, even if they had done seed saving for decades. This

perspective means that they somehow did not equate their situated, experiential knowledge of seed saving with "expert" knowledge. However, this is a type of knowledge that humans have had and depended on for millennia (Shiva 2000). It has only been with the relatively recent rise of expert control, and eventual commodification, over seed has this kind of knowledge been taken away. Now this knowledge is being reclaimed.

The presence of seed libraries has spurred greater conversation and resultant knowledge about resilience:

> *I know that the gardeners in the area have really gotten on board, because they want to see varieties that do well, so they're super jazzed. And I've had lots of positive comments like, I'm glad to see this, what other things do you need, what kind of seeds should I be saving, to I haven't harvested seeds before, but now I want to start. yeah it's people even just thinking and communicating* (Participant G).

Seed savers expressed the significance of not only acquiring this knowledge for themselves, but for other community members to learn about it as well. One participant explained, "People forget about seeds. It's always farm to table, but not seed to farm to table. That food has to come from somewhere. So that's why we have to talk about it. Or else people will forget, where their food comes from, how to do it. In the past we lived in tribes, and we passed seeds down and among friends. That doesn't happen anymore" (Participant M).

The greater the connection to the seed, the greater communities and agroecosystems will understand how to adapt and transform in the face of challenges:

> *Slowly people have become more interested over the years, slowly, more people have become aware of various aspects of food security, healthy lifestyle, healthy food, support your local farmer. For various reasons people are paying more attention. The more an individual pays attention, pretty soon you filter down to seeds and the critical importance of seed. It's kind of the major link of the whole thing.* (Participant L)

Knowledge on how to adapt and transform in the face of change, or resilience knowledge, is a major outcome of the seed saving network on the agroecosystem. Seed savers acquire and share knowledge about seeds and the agroecosystem through the process of seed saving.

Resilience Effects Summary

The discussion above supports the chapter aim answer the question: How does the seed saving network contribute to social-ecological resilience of the local agroecosystem? It does so by identifying "resilience effects," or effects of actor interactions that may contribute to resilience. A wide variety of effects that are associated with resilience emerged through conversations with various seed saving participants. Through this qualitative data, we see that resilience is a relevant and powerful outcome of this particular seed saving network. The following section further elaborates this outcome using an indicator-based framework of analysis.

Resilience Indicators

Similar to the previous section, this section also attempts to answer the question: How does the seed saving network contribute to social-ecological resilience of the local agroecosystem? This section will consider how the seed saving network in western Montana contributes to resilience using a thirteen-indicator framework as described by Cabell and Oelofse (2012) (See pages 21 and 22 for an overview of these indicators). Compared to the "bottom-up" approach of identifying emerging resilience effects in the previous section, this process compares pre-established resilience indicators in an agroecosystem to the seed saving network's own impacts to the local agroecosystem of the Missoula and Bitterroot Valleys. By approaching an

assessment of resilience in both directions, I am able to triangulate the presence of resilience. I present each indicator, followed by evidence of the indicator that I found present in the seed saving network.

1) Socially Self-Organized

The seed saving network of western Montana is inherently self-organized. It arose out of an interest to reduce food-source dependence on larger companies. Seed produced are for specific cultural or environmental needs. These informal networks are formed from the grassroot level and help to support other social organizations within the community, such as community gardens and seed co-ops. This self-organization spans the local, to the regional and national (such as OSA and Open-Source Seed Initiative).

2) Ecologically Self-Regulated

Seed saving contributes to these self-regulating capacities. As demonstrated, when saving seed there are greater considerations for agroecological systems and how the seed-plants will interact with other actors within the system. This what results in plants that require fewer outside inputs, such as fertilizers or pesticides, since they are already better adapted to local conditions. Plants are also better adapted to climate extremes, like wind or extreme temperatures. It also leads to a more diverse agroecosystem, with a greater amount of inter-variety species. Incorporation of wild and/or perennial plants also promotes this genetic diversity and the "maximum amount of soil surface covered by a diverse mix of plants" (Cabell and Oelofse 2012, 5).

3) Appropriately Connected

This study has shown the high amount of loose connections that exist across both space and time. Local seed savers are connected to one another as well as regional and national seed saving organizations. There is an interest in connecting to past cultivators as well as to save for future generations. The seed saving network enhances greater relationships between people and plants, as described "closing loops" in the lifecycle of various plant growing institutions. Particularly, seeds are not just a commodity, but in relation with people. Seed saving encourages polycultures, which "encourage symbiosis and mutualism" (Cabell and Oelofse 2012, 4).

4) High Degree of Functional and Response Diversity

The seed network imparts greater diversity in the area as plants are developed in situ, allowing for greater response diversity to varying climate changes. There is also functional diversity in that the amount of types of plants grown in the region is more diverse. Seed saving can provide an additional income stream and provides heterogeneity to a farming market dominated by vegetable production. As Cabell and Oelofse (2012, 6) note, "Because of genetic variability, greater crop diversity may buffer against shifting rainfall and temperature patterns and possibly reverse downward trends in yields over the long term as they respond differently to such shocks."

5) Optimally Redundant

There exists redundancy in both seeds grown and people growing and saving seed. There is a lot of overlap, but in the instance of a "shock" such as COVID, or someone stealing the seeds from the library, there are likely enough seeds saved elsewhere to bring the stock back.

Additionally, redundancy in the knowledge bank of seed saving is important, as much of the information is word-of-mouth. Respondents discussed the abundance provided by seeds often. Furthermore, seeds come from multiple sources, instead of a few seed companies.

6) High Degree of Spatial and Temporal Heterogeneity

Participants, especially those involved in seed libraries, expressed the need for hyper-localized seed networks. Across western Montana, the ecosystem and microclimates vary drastically. What seeds may thrive in Hamilton might not in Stevensville or Missoula. Therefore, there was great concern for spatial heterogeneity of seed saving. On a broader scale, there was concern for saving seed particular to the climate of Montana, which is different than other places in the US, particularly where seed is often grown. Additionally, participants did not seem as concerned with preserving particular varieties of seed, like a novelty heirloom. They were most attuned to seeds changing and adapting over time.

7) Carefully Exposed to Disturbance

Seed savers' ability to select crops is an example of carefully exposed disturbance that, "push the processes of evolution and adaptation in ecosystems and build ecosystems' capacity to recover from future disturbance" (Cabell and Oelofse 2012, 8). In tending for their seeds, they are able to observe which crops might, say, do slightly better when exposed to an early frost. Seed thus are not left completely to the elements but are able to incrementally adapt to shocks with the help of the seed saver. As climate gradually changes, the seeds can change incrementally with it.

And though likely not considered a "low-level event," the pandemic and ensuing economic disruptions could prove to be a shock that did not push the system beyond a threshold. Instead, the seed network provided people a means to grow their own food at a time of increased food insecurity, making people even more aware of the importance of preserving seed locally.

8) Responsibly Coupled with Local Natural Capital

Seed saving by its definition is turning seed from an outside input into "local capital." The seed now becomes of place, instead of as an external input. Additionally, as we have seen, the seed grown in place relies less on additional outside inputs such as pesticides and fertilizers as it becomes better adapted to the local environment and works with instead of against the local agroecosystem.

9) Reflected and Shared Learning

The seed saving network relies on the sharing of seed saving and agroecological knowledge for it to be successful. This is both horizontal, across the locality, and vertical as with interactions with larger seed saving organizations. These venues for sharing are both formal, in the case of a seed swap, or informally between friends. The knowledge in the form of seed is also passed across time, as exemplified by the ancient seed shared with one participant. This collective knowledge, "allows actors in the system and, by extension, the system itself, to anticipate the future based on experience rather than simply react to present conditions" (Cabell and Oelofse 2012, 9)

10) Globally Autonomous and Locally Interdependent

Many, if not all participant seed savers were motivated by an interest to be more autonomous from the globalized seed and food systems, as well as connect with one another locally through seed. The seed libraries seem deeply connected to other institutions within their communities, including public libraries and agricultural organizations. At the same time, there was still concern about global influences, such as GMO patenting challenges, as well as finding adequate support locally.

11) Honors Legacy While Investing in the Future

This excerpt poignantly summarizes the importance of legacy:

> *Legacies can come in the form of culture and traditions, Indigenous knowledge, and institutions, but they also come in the form of seed banks and other biophysical resources that we inherit from our predecessors. Heirloom varieties are an important legacy that our ancestors passed down. In addition to taste, they were often bred to tolerate a range of environmental conditions or resist a changing onslaught of pests. That genetic legacy can be invaluable in developing new varieties that tolerate rapidly changing conditions* (Cabell and Oelofse 2012, 10).

These authors also speak of legacies in terms of cultural memory. Many seed savers talked about seed saving as a way back to how agriculture used to be and should be done in the future. Montanans' concern for self-sufficiency can also be considered a legacy that inspires the independence of seed savers. Seeds are saved not just to save a variety and honor past traditions, but so they can be adapted into the future.

12) Builds Human Capital

Seed saving actively builds the agroecological knowledge capital of both seed savers and those external to the system. We saw how the mere establishment of a seed library could

instigate greater engagement with seeds, from long-time gardeners starting to save their own seed, to library visitors opening up dialogue about their food systems. The act of seed saving and sharing, from packaging to attending seed swaps brings people together to exchange seed and knowledge. “It is like a bank account, but rather than being filled with money, it is filled with collective knowledge about how the world works” (Cabell and Oelofse 2012, 10). This agroecological knowledge would not be as strong if all seeds were merely purchased.

13) Reasonably Profitable

Unlike in industrialized farming systems, where wealth accumulation is the primary goal, within this small seed network profit is considered secondary. Many study participants explained how that, while money saving or profit was a resulting effect of seed saving, it was not the primary goal. Thus, seed saving provides profit or money saving while not making it the essential goal of the system. Admittedly, though, most participants saved seed for the passion of doing so, not necessarily because it was the most lucrative use of their time, particularly for those running seed libraries. “If agroecosystems are to continue to meet human needs, those who manage them must have their needs met as well” (Cabell and Oelofse 2012, 10).

Indicators Summary

In summary, Cabell and Oelofse’s resilience framework proves effective in demonstrating how this seed saving network has contributed to agroecological resilience. I am satisfied with how well all of the indicators identified were applicable to this system. This framework may be used to evaluate seed systems in other locations, or other food networks in western Montana.

Conclusion

This chapter presents data to address the second question in my research objective: How does the seed saving network contribute to social-ecological resilience of the local agroecosystem? It is an attempt to utilize a resilience framework to better understand the impacts of the complex network previously described. I do this in two parts, first by determining "resilience effects." This strategy is more ground-up in its approach to understanding resilience, taking into account participant concerns and understandings as they are related to resilience. The goal is to determine effects from the previously described network interactions that result in resilience. Coding was used to determine the most important effects that connect to resilience. This strategy of an emergent resilience concept allowed for more situated understandings of resilience to shine through. I was attuned to what participants were most concerned about, where they felt vulnerable, why seed saving was important to them and how they felt it contributed to the agroecosystem they were a part of.

In the second part to answering this question, I utilize a pre-established indicator framework to determine how the seed saving network could contribute resilience to the agroecosystem. I found many instances where the network supported resilience to the agroecosystem through the indicator framework. Honestly, it applied even better than I expected it to. This leads me to believe it could be a useful tool for institutions attempting to evaluate resilience in an applied sense within a given agroecosystem. At the same time, this strategy did not allow for a more situated understanding of resilience to shine through in the analysis, as it did in the previous strategy. Locality was not taken into account, with a more universalized approach to understanding resilience. The second strategy, while allowing less for nuance, was simpler in

its application of a pre-established indicator framework that could, in theory be applied to other locations or other parts of an agroecosystem in a more objective way.

CHAPTER 6. DISCUSSION, RECOMMENDATIONS, AND CONCLUSION

If we consider many previous scholars' analysis of the industrial food systems, the modern, dominant seed industry could be characterized as non-resilient. It operates in a top-down model, with knowledge production kept internal. It depends on ecologically unsustainable inputs such as chemical fertilizers and pesticides. It drives us toward monocropping and lack of diversity within and among plant species. It operates under the assumption of scarcity. Most significantly, it turns seed into a commodity to be purchased, instead of the commons it has been throughout most of the human-agricultural relationship (Aistara 2011; Hubbard, Zystro and Wood 2022; Nazarea et al. 2013; Phillips 2008; Phillips 2013; Shiva 2000; Shiva 2022.; Mascarenhas and Busch 2006; Yapa 1993).

I analyze an informal seed saving network in western Montana to see how it may contribute resilience to the agroecosystem, considering what the dominant seed and food systems lack. Through this study, we can see how a local seed saving network combats many of these challenges within the seed and greater agricultural institutions. In describing the seed saving interactions as a network, I demonstrate how seed saving results in deeper connections as a rooted network between seed, people, and the environment. The act of seed saving builds community, both among people and across other actors such as the soil, pollinators, birds, and trees.

When looking explicitly for ways that this network may contribute to social-ecological resilience of the agroecosystem, I found a number of emergent properties that the seed network generates. It creates more interdependent connections across scale and time. It allows for the agroecosystem to respond to system shocks. It provides for redundancy, abundance, and diversity. It provides the means for systems transformations. It creates greater agroecological

knowledge. I also apply a pre-established indicator framework of resilience in agroecosystems to the seed network, finding many ways the seed network may directly impact the local agroecosystem.

This was a qualitative, empirical study and results were interpreted subjectively. Additionally, this study aimed to describe a particular network, and its effects related to situated understandings of resilience. For this reason, the results and interpretations should not be considered universal. However, the framework for understanding seed networks and agroecology resilience could be applied to other cases.

Theoretical Implications

Resilience as Process

This study took seriously the interdependence of social and ecological systems. I attempt to combine a four historically related but disparate concepts: resilience, network theory, political ecology, and non-human agency in order to come to a nuanced but instrumental approach to understanding how people and seeds respond to challenges they may face in the agroecosystem. It considers a primary limitation of resilience thinking in overcoming the human-nature dichotomy.

Social-ecological resilience theory tends to merely apply environmental concepts onto social ones, overlooking normative issues. To avoid this, I incorporated ideas from actor network theory and certain social science traditions to better understand and analyze them as inner-connected. While a human-in-nature approach appreciates that humans are part of ecological systems, it also does not mean that complex social challenges of power and agency of people are lost.

At the same time, by centering seeds in the narrative and analysis, and also incorporating other actors (both natural and social), as inspired by ANT and non-human agency, I attempt to overcome this shortcoming. The materiality of the seed and their resultant plants is considered an important agent in the network and resulting effects.

This framework highlights the significance of resilience as a concept to situated responses in the face of social and environmental challenges. I was struck by how many people took up seed saving as a response to a perceived threat, whether it be climate change, the pandemic, a more industrialized economy, lack of biodiversity, or merely economic strain. Seed saving *is* the adaptive measure and simultaneously, as demonstrated in this study, may help contribute to changing the very threat. I think this elicits an idea that resilience does always not fully capture. Resilience is usually defined in terms of adaptation to an *outside* shock to the system. But all of these shocks are actually part of and may in fact be what is causing the stress within the system. In this seed saving network, the idea is not merely to respond, but actually to change the system itself, so that it may better provide for the social-ecological community.

Many people in western Montana, including seed savers, care about and think about resilience in their daily actions. At least in the realm of seed saving, it has moved beyond a mere academic concept. But when we consider livelihoods and political motivations of the actors as they attempt to achieve resilience, we see agency to actually transform the social-ecological system in question, including who has power over material (seeds) and knowledge. Seed saving is an attempt to not accept the status quo, but change our very relationship with seed, food, and nature. It challenges the dominant economy and assumptions about natural resources.

When it comes to seed, this study also highlights how the particular features of a seed-plant can factor into its resilience in place. This is a challenge to discuss in my study since I look

at a variety of types of plants that all have various features. We could consider, though, how particular plants provide for resilience of a particular agroecosystem more than others. For example, brassicas (such as kale and chard) have the potential to adapt to survive over winter, and are less susceptible to unpredictable shoulder season frosts. The resilience of a kale plant then contributes to the resilience of agroecosystem overall due to its material nature and agency to survive. As plants become more situated, or "of place" they display greater resilience features, as in the example of the early ripening watermelon. Some plants that displayed less resilient characteristics were mentioned, particularly nightshade plants such as eggplant and pepper. These plants' cultural (and relatedly economic) significance to their growers, however, inspires a desire to create better adapted varieties.

This situated understanding is more aligned with social scientists' conceptions of resilience, as a transformative process, instead of a terminal goal (Dwiatarma and Rosin 2014). Seed saving really shows this because it is a process. Instead of storing seeds in a bank to preserve biodiversity, or producing the same hybrid year to year, there is a continual process of saving, storing, growing, all parts of which require knowledge to maintain. The plants are always "becoming", "never individuals" (Carlisle 2016, 144). They are always responding to soil conditions, weather, other plants, other features in the environment, or how their stewards treat them. It is not about preserving one heritage variety, because each one turns out different based on the forces of selection and its genetic environment. In short, a seed grown in place is always becoming more and more situated. It is a constant process of contesting the industrial agroecosystem.

Overall, this study shows that resilience continues to be an important framework for which to consider various social-ecological systems, including the agroecosystem, but maybe

more as a process than a static state of being. As long as communities are concerned with adapting (and potentially transforming) their lives to the various challenges of the world, it will remain important to think about resilience, despite the challenges of the concept.

Knowledge on the Margins

I found many more seed savers than I was expecting to find at the onset of this study. While not that many people grow seed, rely on plants from locally produced seed, or even know about the significance of seed saving in western Montana. In other words, it is a marginal process.

Resilience, though, is fundamentally a response to shocks in the system. As we may see more shocks to our environment and society, the local seed is the one that will be there for us. Due to its generosity, within one seed-generation it will be abundant, and the vast amount of knowledge that the few seed-savers do possess can be shared quickly and easily. Therefore, I think of our local seed saving network as a repository of resilience. It is there, like a pilot light, or a saved seed if you will, that will inevitably prove useful when the time is right. Nazarea (2005, 137) writes:

> *What makes seed savers – and by this term I mean the independent gardeners and smallscale farmers who save and pass along folk or "old-timey" varieties without any formal organization or design – special is the place they hold for diversity in their hearts and in their fields. What makes a seed saver is a kind of marginality characterized by engagement rather than remoteness, by joyful irreverence rather than outright resistance, by celebration rather than protest, and by creative openings rather than dead-end walls. In the face of spreading global monocultures, seed savers find their place or make one (ix).*

This study contributes to the body of knowledge on the intersection of resilience and situated knowledge in recognizing the presence and application of situated knowledge in an

informal seed saving network in the global North. Most seed savers relied on their own informal knowledge exchange and development through on-farm experiments. Specialized knowledge, particularly in the form of botany, was also an important scientific framing. While many of these seed savers claimed to not "be experts" on seed saving, they were actively developing and sharing situated knowledge through the seed saving process.

Through the saved seed, I find a tangible representation of Nazarea's "countermemory" or Hicks' "resilience knowledge." These forms of memory/knowledge exist on the margins, standing in contrast and resistance to industrialized systems. Though small, their presence is important for maintaining this knowledge within a community, to act when the time is right. We saw this in the example of the seed saving network's ability to respond to the initial pandemic shocks imposed on the agroecosystem. This idea of countermemory also aligns with Blaikie and Brookfield's (1987) conception of interstices. This marginal knowledge is the seed bed in a sense for resources that can allow for the transformation of a system.

As Nazarea (2006b, 4) writes, this resilience knowledge is in "direct opposition to industrial agriculture's dominant belief in monocropping, homogenization, and laboratory seed hybridization." To allow for full transformation, of course, this knowledge must spread and strengthen so it is no longer "counter", but "mainstream," making it not a countermemory but a more all-encompassing cultural memory. This is different than the process of re-incorporating alternative technologies into the mainstream, as has so often been the case for Alternative Food Movements in the past. Instead, a dedication to resilience in the form of transformation may actually alter the globalized, industrial forces that have caused social and environmental challenges.

Agroecology and Seed in Agro-Food Studies

This thesis contributes to understandings of agro-food and seed studies as well. It tries to incorporate agroecology into the field of social-ecological systems thinking, which has more often been applied to the field of natural resource management issues. Additionally, political ecology, while often concerned with various livelihood issues such as agriculture, has largely focused on the global South. Widely, agriculture and food systems are often seen as issues of economy, commodity, or culture. This study sees the materiality and ecology inherent in agricultural systems, framing it as a wholistic *agroecosystem.* Considering the social systems, it may venture to be a *political agro-ecology*.

As for seed scholarship, it also takes a different perspective on this small line of research. This research centers the seed, an often over-looked but essential part of agro-food system. Seed research that does exit often focuses on agrobiodiversity, considering diversity – understood as a greater quantity of different plant units - an inherently necessary thing to achieve. While this study neither refutes nor denies the importance of agrobiodiversity, it also does not use it as the goal to measure the seed saving network on. Instead, it is resilience. This takes us away from quantifying the impacts of seed saving networks, but asks us to look closer at the dynamics at play both among people and between people and seeds (Aistara 2019; Montenegro de Wit 2016). When we center the role of the seed, its portability and longevity make it a powerful actor within the food system.

Indeed, while biodiversity has been a helpful measurement in the greater world of conservation, the seed savers with whom I spoke in western Montana were not very concerned with this. Focusing on diversity may thus overshadow other important situated considerations and priorities. Agrobiodiversity *may* be a by-product of utilizing multiple microclimates and

species within a landscape. However, maybe agrobiodiversity should not be the primary goal or barometer, especially in a place like western Montana where aridity and marginality dominate. How people are adapting with a small number and types of plants may be the focus. Instead, this study explores resilience, including emergent, place-based concepts of resilience, as a measurement for the sustainability of the agroecosystem.

While this study emphasizes a resilience framework, we should not lose sight of what is truly important for the agroecosystems we may imagine for our future. This what is where constantly reminding ourselves of the resilience *of what*, or the outcome we are trying to achieve, instead of mere indicators or effects, is important. In this normative approach, we consider the function of an agroecosystem to be one that provides healthy food to all communities. But what is considered healthy? How do we know there is equality in access? These are questions that are challenging to probe with a resilience framework, leaving us with the conclusion that, while a helpful framework, perhaps others better serve this function, such as those in the realm of food security and food sovereignty. Exploring the seed's role in these other frameworks could be an interesting turn of future research.

Empirical Implications

This study was originally conceived of as a case study of a local condition. However, it became clear in identifying participants and trying to get the "entire picture" of seed saving in the Missoula and Bitterroot Valleys that bounding my research location would not be easy. This is because many participants were linked across multiple scales in both their sources of seeds and information. Seed savers in the Bitterroot and Missoula Valleys also closely collaborated with those in the Mission and Flathead Valleys (to the north of Missoula). While many physical seeds

originated in the east of the country (such as Fedco and Baker Creek), a lot of information exchange and seed-community building happened across the Pacific Northwest. While complicating my own conceptions of a "local" seed saving network, this phenomenon is actually in keeping with a more complex understanding of food systems. Indeed, a great critique of food systems research is a preoccupation with the "local," also known as the "local trap," where locally produced food has been conflated with sustainability and resilience (Born and Purcell 2006). However, a better understanding of how the food system is in fact networked across geographic and organizational scales is more reflective of how these systems function and may be analyzed and improved.

This pushes us to consider the implications of a situated understanding of resilience. As discussed previously, the majority of research on informal seed network in the United States focuses on the Appalachian region of the country. Historical, cultural, and environmental conditions in western Montana are much different than in this place. To this end, I found differing motivations of people here than seemed to be found in studies by Hicks (2019) and Nazarea (2005). In Montana, a great concern was for self-sufficiency as well as adaptation of local plants to local environmental conditions. In Hicks' (2019) study, primary motivations, on the other hand, were for cultural preservation and community building. Adaptation of plants was considered a mere byproduct of seed saving. Understanding how and why seed savers may be motivated differently in different places would be significant to upholding seed saving initiatives in these areas, and to understanding how objectives for resilience may change in location and scale.

Furthermore, when we think in terms of networks, we can see the potential for multiple networks existing in one locality. Much like the idea of the community is non-homogeneous, I

imagine the existence of multiple agroecological systems and seed or other food networks within this locality. This especially could be considered in the context of more marginalized community members, including communities indigenous to the region. How might their food ways inner lap, contribute, or potentially inhibit one another?

Limitations and Further Research

I recognize that this research centers on a dominant white settler social community, primarily more affluent European-Americans. Though some diversity exists withing my research participants, no one identifies as a first-generation immigrant or a person indigenous to the region I studied. The food ways, including cultivation and seed saving practices, of marginalized community members (including Indigenous and immigrant), have been studied in a number of contexts including in western Montana (Bear Don't Walk 2019; Cramer 2017), though none explicitly focus on seed saving.

For this reason, I understand that these results are not generalizable to all communities in Western Montana. Most significantly, I struggled with representing Indigenous understanding of agriculture in this place. The Salish and Kootenai who have inhabited this landscape, indeed, did not practice a formal form of domesticated agriculture before the arrival of Europeans. Agriculture, including gardening, was imposed on their way of life in order to better immobilize on reservations. However, participants, some of whom were Indigenous themselves (though none of the local tribes), discussed how seed saving provide a way of (re)connecting to the landscape, including with wild plant "relatives." Additionally, it should be noted that at the University of Montana PEAS Farm, where I interned over the summer and spring during this research project, the Hidatsa tribe began an effort to rematirate their agricultural practices through centuries-old

saved seed. While the Hidatsa are not of these valleys specifically, they do represent a native agricultural society, whose own land and practices were taken from them by the forces of colonization. In this way, I saw the positive impacts that seed saving could have on Indigenous food security and cultural empowerment.

I regret that my research did not touch more explicitly on these topics. At the same time, as a European-American, who was new to this region at the onset of my research, and who did not have much familiarity with Indigenous issues, I also do not know that I would be the best to tell this story. Perhaps this is an opportunity for further research for an Indigenous scholar, or with someone more connected to the Indigenous communities of this place. Studying seed saving specifically within Native American communities could have benefits in both further securing these community's food sovereignty, as well as bring forward Indigenous understandings of social-ecological systems.

Another interesting area of study that could be better articulated through the conception of the seed saving network is that of "place-making." While I was able to demonstrate how situated networks produce unique results based on their location, I did not explore in a systematic way the concept of place-making. There is certainly a deep literature in this topic, with implication for resilience (Folke et al. 2010).

This thesis looked at a particular category of seed, primarily the culinary vegetable (including some fruits). Further seed research could expand into other types of seed saving practices. Heritage grains come to mind as an interesting focus. Additionally, the culinary vegetable seed is admittedly a diverse community. Focusing on one type of plant, say the tomato or corn, could be of particular utility to more deeply describe deep relations.

Reflections and Recommendations

Through this thesis, I hoped to operationalize some complex topics, such as resilience, network theory, and social theory, so that the significance of seed saving could be better understood. Organizations based in the region, such as local government, the Community Food and Agriculture Coalition, and Garden City Harvest, may be able to utilize the indicators of resilience framework in better assessing the strength and sustainability of their food systems.

Furthermore, the role of seed in these food systems could be considered in more tangible ways. While I was exploring the contributions of seed saving to the greater agroecosystem, the resilience of the seed system itself was also a big part of conversations I had with participants. Many participants, especially those running seed libraries, discussed the organizational and financial challenges to running a seed library. While some decent quality seed was better than none, they often reflected on the potential for better organizational systems, more resources, and more individuals to assist with the process. If seed libraries could be considered as integral as, say *book* libraries, to the public good, and supported materially through local funding sources, the seed system could prove to be more resilient itself, and provide even more benefits as described previously. Furthermore, the seed network may not necessarily be considered egalitarian (Aistara 2019). If we are to consider the resilience of a local seed network, future research on the resilience of local seed networks could consider how benefits and participation are shaped by social factors.

This thesis does not claim that commercially produced seed does not have a place in future agroecosystems. I do believe though that saved seed is uniquely capable of contributing to the resilience of agroecosystems in a way that these industrial seeds, as commodities of

industrialized, capitalist systems, cannot. Thus, the call is to consider more thoroughly the role of informal seed networks in our existing seed and agroecosystems, and how they may be bolstered.

Conclusion

The tiny seed can have a large impact. This thesis was an attempt to demonstrate how and why, in a theoretical and empirical context where seed is often overlooked. I described the rich interactions saved seed creates among seed, people, and environment, through both interviewee reflections of their experience in seed saving as well as participant observation in seed-tangential events and activities. I then explore emergent resilience effects that this network may create. I also utilized pre-established indicators of resilience in an agroecosystem to determine this method's efficacy. Ultimately, I was able to explore the dynamics that underpin a particular informal seed saving network in the Missoula and Bitterroot Valleys of western Montana, as well as consider the impacts this network may have on the local agroecosystem's resilience.

This study shows how saved seed, an often-overlooked aspect of the agroecosystem, can have a powerful impact on resilience. If we are to take resilience of our various social-ecological systems seriously, including of our agroecosystems, more people should consider not just where their food comes from, but where that food's seed comes from as well. This may help shift the countermemory that the saved seed possess currently, into a collective appreciation, and call to action to transform our agroecosystems. As one study participant noted, "Seed and people are co-created" (Participant A). Appreciating and strengthening this connection may allow social and ecological communities not only to survive in the face of challenges but thrive.

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APPENDIX A: INTERVIW GUIDE

Introductory Questions on Seed Saving Activities

Why do you save seeds?

What kinds of seeds do you save?

How many different varieties of seeds do you save?

Why those seeds in particular?

How long have you been saving seeds?

What stories do you know (if any) to the origin of these seeds?

Where did/do you get your seeds?

Have your reasons for saving seed changed over time?

Social Context and Cultural Heritage

What are the benefits of saving seeds for you and your home?

What are the benefits of saving seeds to your community?

What other people influence your seed saving practices? In what way?

What other organizations influence your seed saving practices? In what way?

Do you exchange seeds/plants with others?

How do you think the particular culture and history of Missoula/the BRV influence seed saving practices?

How do you learn about seed saving?

Environmental and Agroecosystem Connection

How has saving seed impacted your understanding of the environment?

How do you think seed saving benefits the environment?

How does the local environment influence seed saving in this area?

Do you think your saved seeds are locally adapted? How so?

Have you noticed differences in your saved seeds compared to outside seeds in how they grow?

Final Thoughts

Can you think of any other benefits of seed saving?

Are there any disadvantages or inhibiting factors of seed saving?

Is there anything else about seed saving you would like to share with me?

APPENDIX B: SUBJECT INFORMATION AND INFORMED CONSENT

Scripts for Contacting Potential Participants

Research title: "Seed Saving Networks and Social-Ecological Resilience in Missoula and the Bitterroot Valley, Montana"

Primary researcher: Christina Leas
University of Montana
Department of Geography
christina.leas@umontana.edu
(571) 251-3925

Email script:

Hello [Potential Participant Name],

I received your contact information from [Referrer's Name – include his/her affiliation]. I am a graduate student at the University of Montana, and am conducting research for my master's degree in geography. My research is about seed saving networks within Missoula and the Bitterroot Valley, and their potential for creating or enhancing resilience within the local food system. I am reaching out to see if you are able to share your experiences in seed saving with me. Would you be willing to participate in an interview and mapping activity about your seed saving activities? The interview will address basic topics such as social and environmental dynamics of seed saving. The mapping activity involves drawing out how various things and people are involved in your seed saving network. I anticipate that the interview and mapping activity will take one to two hours. I am happy to work around your own schedule. Please let me know if you are interested! I am happy to discuss more and answer any questions you may have. You may respond to this email or call me at (571) 251-3925. I look forward to hearing from you.

Regards,

Christina

If they reply yes – Thank you so much for your willingness to take a part in my study. When would be a good time for you to meet in the upcoming weeks?

If they reply no – Thank you for getting back to me. Good luck with your growing season!

If no response, I will resend the first email one more time after one week.