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Socio-Ecological Resilience in a Southern California Dryland Agroecosystem: Contributions from General and Specified Resilience

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Abstract

In general, California agroecosystems are vulnerable to social and environmental change, threatening the provision of vital ecosystem services and human food security. Socio-ecological resilience, comprised of general resilience and specified resilience, could serve as a framework for improving the ability of agroecosystem managers in this region to support coping and adaptation to change. However, there are yet many examples of research into both general and specified resilience, particularly in this region. This research investigated the activities and methods employed in a Southern California dryland agroecosystem that contribute to these two resilience types. The researcher performed a case-study over five months in 2020 and used participatory observation and semi-structured interviews to identify activities and methods employed in the agroecosystem. The data were analyzed using two assessment frameworks, one for each resilience type. Through the data collection methods, 17 activities and 145 unique methods were identified. Through analysis, it was found that all 17 activities supported both resilience types and that 137 methods supported general resilience while 108 supported specified resilience. As these results suggest, it was discovered that many of the activities and methods support both resilience types. Some also supported multiple general resilience indicators and specified resilience main issues, indicating a high level of importance for overall resilience. However, difference between methods to support each of these resilience types were also discerned, upholding the need to consider both. The collection of these activities and methods support socio-ecological resilience through building overall resilience and facilitating adaptive capacity and agency, resulting in an example of a socio-ecologically resilient agroecosystem. Agroecosystem managers and policy makers can look to this example to build socio-ecological resilience in the California food system.

Key words: *socio-ecological resilience, agroecosystems, socio-ecological systems, California, drylands, general resilience, specified resilience, adaptive capacity, agency*

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Chapter 1: Introduction

With the rapid decline of ecosystem functions over the last century, experts believe that we have shifted into a historic era characterized by human impact at a global scale (Folke et al., 2006; Chapin et al., 2009). The emergence of this era, the Anthropocene, is coupled with monumental and potentially irreversible effects on global climate patterns and biodiversity levels (Chapin et al., 2009; Walker et al., 2010; Wilkinson, 2011; Gonzalez, 2011; Folke et al., 2016). In addition to shifts in climatic cycles and temperature extremes, the presence of global climate change is linked to increased climatic volatility and subsequent disasters at a range of spatial scales (Hodbod & Eakin, 2015). Furthermore, topsoil erosion and the loss of freshwater and other biophysical resources have contributed to a reduction in vital ecosystem services including hydrological and nutrient cycling (Cabell & Oelofse, 2012; Hodbod & Eakin 2015; Webb et al., 2017). This destruction of the biosphere has repercussions for human society as we are dependent upon it to supply essential materials and services (Folke et al., 2016). In addition to important social impacts such as reinforcing economic disparity (Cretney, 2014), this environmental degradation and climatic volatility threatens food security (Gonzalez, 2011; Cabell & Oelofse, 2012; Altieri et al., 2015) and fortifies barriers to achieving agricultural sustainability (Maleksaeidi & Karami, 2013). Conventional-industrial agriculture systems do not adequately address these issues and, in fact, often contribute to them through deteriorating resources and inadequately preparing for changing conditions.

As roughly 40% of the land surface in the world is used for agriculture, the management of these lands has a significant impact on local and global ecosystem dynamics (Darnhofer et al., 2010). Conventional-industrial agriculture is untenable as it degrades these crucial ecosystems and coupled services across scales. For instance, in the modern, globalized food production and distribution system, resources are often extracted from the production zone, transported to distant regions, and not returned, thereby depleting the production area's resource base (Cabell & Oelofse, 2012). This fragmented production system structure requires continual inputs from yet other distant resource bases, contributing to further ecosystem degradation at local and global scales (Kremen & Miles, 2012; Altieri et al., 2015). What is more, these production systems are often based on simplified monoculture schemes that significantly reduce biodiversity, a critical component of healthy ecosystem functioning in and around the production area (Gonzalez, 2011). This structure has led to widespread ecosystem degradation and the loss of vital ecosystem services, impacting local and global dynamics and climate regimes (Kremen & Miles, 2012). Moreover, conventional-industrial agriculture produces high greenhouse gas emissions due to land-use change, production, processing, and distribution, further contributing to climate change (Gonzalez, 2011). In addition to ecological degradation, the current conventional-industrial agriculture model also has social impacts.

Globalization and industrialization have led to increased resource concentration and other negative social impacts in the agricultural sector (Allen, 2010; Hodbod & Eakin, 2015). This is the case not only of biogeophysical resources, such as land and access to and control of fresh water, but also technology, research and development, markets and distribution channels (Hodbod & Eakin, 2015). This has exacerbated the concentration of wealth in the agricultural sector, particularly along racial, gender, and class lines, and furthered inequalities in health and agency (Allen, 2010; Gonzalez, 2011; Cretney, 2014). These impacts are upheld through policy at regional, national, and international levels. According to Cretney (2014), these policies are in the context of rising neoliberalism, which has "expertly normalized and rationalized the discourses of private property, individual responsibility and dominance of the market." This contributes to social breakdown in agricultural communities and the loss of associated benefits, including the ability to manage for sustainability and under changing conditions (Altieri et al., 2015).

Through eroding environmental functions and social institutions, the conventional-industrial agriculture structure, and encompassed management and production methods, increases vulnerability in agroecosystems (Aggarwal, 2006). Vulnerability is considered "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate variability and extremes and denotes a state of susceptibility to harm from exposure to stresses associated with environmental change and from the absence of capacity to adapt" (Folke, cited in Altieri et al., 2015). This definition can be expanded to encompass shocks and stresses of all kinds, including those of a social nature, such as economic shock or stress. Conventional farming management predominantly assumes stability and linearity, managing for efficiency and maximum output (Hodbod & Eakin, 2015). This creates vulnerability in agroecosystems by simplifying naturally complex systems (Darnhofer et al., 2010; Berardi et al., 2011,). As shocks and stresses are anticipated to increase under predicted climate change related scenarios, this emphasis on efficiency and specialization creates rigidity (Wilkinson, 2011; Berardi et al., 2011; Maleksaeidi & Karami, 2013). This locks up resources and reduces the ability of these systems to adapt to changing conditions (Walker et al., 2004; Darnhofer et al., 2010; Wilkinson, 2011; Hodbod & Eakin, 2015). However, while climate change and related effects can be considered "the defining challenge of the current era" (Hodbod & Eakin, 2015), Wilkinson (2011) asserts that it is "the interconnectivity… and non-linearity of causal relationships between [bio-physical boundaries']" that poses the greatest challenge to effective resource management. In line with this, it is the complexity of agroecosystems that creates difficulty in their management for sustainability and, at the same time, these systems need a "better understanding of how to manage, cope, and adapt to change," as instability becomes the norm (Walker et al., 2010). Therefore, we must investigate and apply alternative frameworks to production systems, particularly those that are centered around mitigation and adaptation to change and uphold resource conservation and regeneration, food security/ sovereignty, and social justice and agency (Chapin et al., 2009; Allen, 2010; Crane, 2010; Gonzalez, 2011; Cabell & Oelofse, 2012; Webb et al., 2017; Pathak et al., 2018; Córdoba et al., 2020). This thesis positions socio-ecological resilience as an alternative framework to address these concerns.

Rooted in ontological developments in ecology in the 1960s (Holling, 1973), which began to challenge the idea of system normality or equilibrium (Córdoba et al., 2020), resilience theory bolsters the understanding of the non-linearity of system dynamics in linked socio-ecological systems (Folke, cited in Wilkinson, 2011). The concept of socio-ecological resilience helps to clarify the interconnectedness of social and ecological dimensions of complex systems and holds this understanding when considering and preparing for disturbance, serving as a framework for disaster preparedness and response (Cretney, 2014). Socio-ecological resilience is defined as "the process of using a set of resources, abilities and adaptive capacities to absorb disturbance while conserving self-organization and enabling recovery" (Maleksaeidi & Karami, 2013). Socio-ecological resilience helps investigate and gain a holistic understanding of complex system dynamics and behavior (Anderies et al., cited in Plummer and Armitage, 2007) and uses this understanding to improve the capacity to adapt to disturbances and threats (Hodbod & Eakin, 2015).

Resilience thinking, socio-ecological resilience, and assessment frameworks can be used to build these abilities and capacities in agroecosystems (Berardi et al., 2011). In practice, factors that support resilience will differ greatly depending on the system in question (Cabell & Oelofse, 2012); therefore, a place-based approach is essential when applying assessment frameworks (Jackson et al., 2012; Pathak et al., 2018).

The application of socio-ecological resilience to agroecosystems in drylands holds significance as these areas make up a sizable portion of the earth's land surface and global populations, and are thus constituted as important sites for food security and resource conservation (Peters et al., 2006; Chen & Wang, 2016). Dryland areas have several unique characteristics and issues common to most (see Appendix A). One such example of a dryland area with significant impact for food security and resource conservation can be found in California, which produces much of its food under increasingly semi-arid to arid conditions (Bourque et al., 2019; Maurer et al., 2020). California is a critical agricultural production zone for the United States, producing nearly one-half of the nation's fruit, nut, and vegetable supply (Jackson et al., 2012; Pathak et al., 2018). According to Pathak et al. (2018), California is the "largest and most diverse agricultural state in the United States of America, with 77,500 farms comprising [14,085,000 acres-] 5.7 million ha of pasture and rangeland and [9,390,000 acres -] 3.8 million ha of irrigated cropland that generate an overall agricultural production value of $50.5 billion." Much of this production happens in the Central Valley and accounts for 20-40% of employment in the region (Bacon et al., 2012, Hodbod & Eakin, 2015). This regional food system is predominantly built upon economic earnings and profit, prioritizing specialization and efficiency (Bacon et al., 2012; Hodbod & Eakin, 2015). According to Hodbod and Eakin (2015), this focus, and the associated increase in industrialization, chemical input use, land consolidation, and monoculture production, "has come at the expense of food system functions such as ecological integrity, water resource sustainability, livelihood maintenance, nutritional viability, food security, and economic diversity." These effects have raised serious concerns over the viability of the current agricultural model in the state (Berardi et al., 2011; Hodbod & Eakin, 2015). This factors into moderate to high levels of vulnerability in the typical California agronomic model and the macro agroecosystem, with the potential to ripple outward to the national food system, threatening nationwide food security (Berardi et al., 2011; Jackson et al., 2012;

Hodbod & Eakin, 2015; Wilson et al., 2017; Pathak et al., 2018). It is therefore increasingly necessary to apply alternative frameworks to agroecosystems in this region, and socio-ecological resilience could prove to build sustainability and robustness to disturbances and threats.

In California, socio-ecological resilience frameworks could help to build robustness to identifiable threats as well as threats yet known. While there are a number of threats that commonly affect agroecosystems in this region(see Appendix B), a primary threat is water availability for crop production. As precipitation is low and variable, nearly 90% of crops in the state are produced through irrigation, predominantly sourced from groundwater (Pathak et al., 2018; Bourque et al., 2019). Predicted changes in water availability from aquifers, snowpack, and other vital sources, threaten the continuation of production in agroecosystems in the state (Wilson et al., 2017; Pathak et al., 2018; Bourque et al., 2019). Furthermore, studies have indicated the California food system to have an insufficient ability to cope with environmental disturbances such as drought, flooding, and fire, which are predicted to become even more frequent in the region, particularly in the southern portion of the state (Jackson et al., 2012; Hodbod & Eakin, 2015; Wilson et al., 2017). This decreased ability to adapt and change, as is ubiquitous in the conventional-industrial agriculture model, only increases susceptibility to collapse in the face of disturbance, such as those described (Berardi et al., 2011). This indicates that, on the whole, and especially in Southern California, agroecosystems are vulnerable to these disturbances (Jackson et al., 2012; Hodbod & Eakin 2015; Wilson et al., 2017).

What is more, there is an unlimited number of other unpredictable yet highly impactful disturbances that can affect these systems. We need not look further than the current (2020-2021) COVID-19 pandemic, which has drastically altered global social dynamics and economies (Barua, 2020). This reinforces the need for agroecosystems in this region to have the capabilities necessary to cope and adapt with predicted as well as unpredictable disturbances. Assessment frameworks can be used to provide insights into these two facets of socio-ecological resilience, known as specified and general resilience. Therefore, applying these two lenses for resilience to California agroecosystems is a critical component for building socio-ecological resilience in the California food system.

The argument for investigating socio-ecological resilience in California agroecosystems is strongly supported by relevant literature. For example, to curb the impacts of accelerating climate change on the California food production system, Pathak et al. (2018), alongside Berardi et al. (2011), call for applying socio-ecological resilience frameworks to California agroecosystems. Furthermore, Pathak et al. (2018) argue that this application should come in the form of localized agricultural adaptation research to address relevant issues in the California context. There are yet many examples of research of this kind in California, and, as a place-based approach is essential when investigating socio-ecological resilience (Jackson et al., 2012), this indicates a need for research into the real-life applications of socio-ecological resilience. Furthermore, in the literature on socio-ecological resilience, several authors argue for considering both general and specified resilience, calling for an integrated approach (Walker et al., 2010; Folke et al., 2010; Berkes & Ross, 2013; Folke et al. 2016). Apart from the work of Meuwissen et al. (2019), there is a gap in the literature on assessment frameworks that incorporate both of these criteria as well as their applications. Finally, it is argued that small-scale agriculture can contribute to "climate change mitigation and adaptation while conserving agrobiodiversity and promoting food security" (Gonzalez, 2011). Therefore, the application of socio-ecological resilience frameworks applies most aptly to small-scale agricultural production systems.

This research aims to fill those mentioned gaps in knowledge by providing a case study of the application of socio-ecological resilience via general and specified resilience assessment frameworks to a small-scale Southern California agroecosystem. The case study will be an example of these applications to a suspected socio-ecologically resilient system operating in exceptional dryland conditions, representing potential future conditions for the state. The study is framed around the projects and practices/strategies, here called activities and methods, employed in the agroecosystem that contribute to general and specified resilience. This is done to contextualize these activities and methods in terms of the two resilience types and socio-ecological resilience so that they may be taken up and adapted by interested agroecosystem managers to build socio-ecological resilience in their context; or, alternatively, to form a deeper understanding of existing practices' contributions in terms of general and specified resilience. Through this exploration, this research aims to answer the following research question: What activities and methods have the potential to contribute to general and specified resilience in a Southern California dryland agroecosystem?

Chapter 2: Conceptual Framework

Defining Socio-Ecological Systems

The concept of the socio-ecological system (SES) is essential to resilience thinking and socio-ecological resilience (Berkes et al., 2002; Walker et al., 2010). When it comes to the interaction between humans and nature, including natural resource management, issues are not simply social or ecological; they are complexly interlinked by social dimensions, such as cultural, political, and economic institutions, and ecological components and dynamics (Chapin et al., 2009; Walker et al., 2010; Folke et al., 2010; Wilkinson, 2011; Nightingale & Cote, 2011; Maleksaeidi & Karami, 2013; Folke et al., 2016; Córdoba et al., 2020). Folke et al. (2016) describe socio-ecological systems and dynamics as follows:

> In essence, the social-ecological systems approach emphasizes that people, communities, economies, societies, cultures are embedded parts of the biosphere and shape it, from local to global scales. At the same time people, communities, economies, societies, cultures are shaped by, dependent on, and evolving with the biosphere (Clark and Munn 1986, Folke et al. 2011, Leach et al. 2012). Hence, people are not just interacting with but are inhabitants of the biosphere together with all other life on Earth, shaping its resilience in diverse ways, from the local to the global, consciously or unconsciously.

This perspective emphasizes that humans are dependent upon the natural environment and cannot be removed or thought of as separate. Socio-ecological resilience reflects this perspective, situating ecosystems as foundational for and integrated with human society. This integration makes it imperative to take a systemic approach and consider entire socio-ecological systems when investigating potentials for socio-ecological resilience.

As agroecosystems are complex, comprising social and ecological dimensions including cultural, economic, biological, and physical elements and institutions, they are to be considered socio-ecological systems; therefore, socio-ecological resilience and assessment frameworks are applicable to agroecosystems (Darnhofer et al., 2010; Bacon et al., 2012; Cabell & Oelofse, 2012; Maleksaeidi & Karami, 2013; Palanco Echeverry et al., 2015; Córdoba et al., 2020).

Defining the Adaptive Cycle

Another integral concept for socio-ecological resilience is the adaptive cycle (Figure 1). The adaptive cycle stems from ecological resilience theory (Holling, 1973), considering "nature as an evolutionary process made distinguishable by adaptive cycles which are nested at scales increasing in size, [resulting] in uncertainty, non-linearity, and self-organization" (Plummer & Armitage, 2007). This concept has since been applied to socio-ecological systems and expounded as it relates to socio-ecological resilience (Wilkinson, 2011). The adaptive cycle consists of four successive phases: (1) exploitation, (2) conservation, (3) release, and (4) reorganization (Holling & Gunderson, 2002; Walker et al., 2004; Chapin et al., 2009; Walker et al., 2010; Darnhofer et al., 2010). These phases outline system dynamics over time; first moving through the forward loop, beginning with the exploitation phase, characterized by growth and exploitation of available resources, and eventually transitioning to the conservation phase, characterized by the conservation of resources and services when they are no longer in abundance. When disturbances occur that the system is unable to cope with, such as a sudden shock or significant constant stress, the system is pushed into the subsequent release phase. The release phase begins the back loop of the adaptive cycle and signifies the collapse of the existing system configuration, freeing up resources and making them available during the reorganization phase. Socio-ecological systems naturally flow through the adaptive cycle, and socio-ecological resilience has to do with the effective management of this flow across scales.

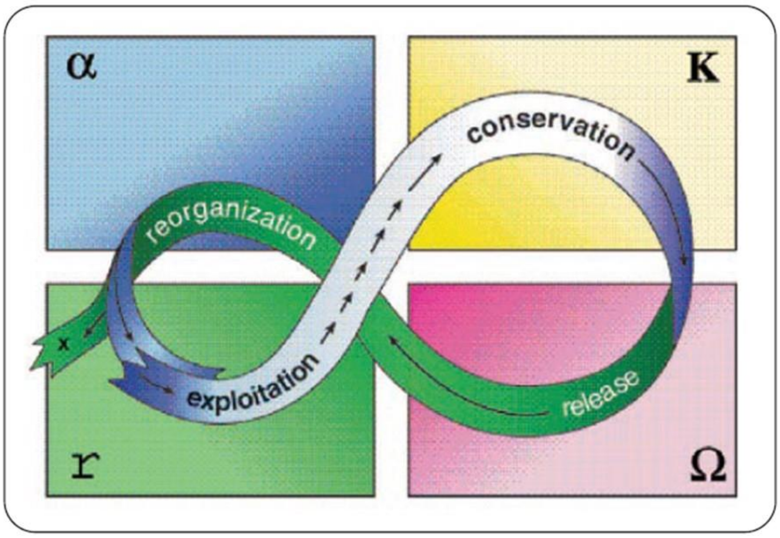

Figure 1. Adaptive Cycle Diagram - Diagram modeling four phases of adaptive cycle: exploitation (r), conservation (K), release (Ω), reorganization (α) (Holling & Gunderson, 2002; Walker et al., 2010).

Panarchy

Just as systems exist at different scales, adaptive cycles also operate at different scales, often nested in a hierarchy, referred to as ‘panarchy’ (Holling et al., 2002; Walker et al., 2004; Chapin et al., 2009; Walker et al., 2010) In panarchy, happenings and cycle states at one scale can affect other scales (Cabell & Oelofse, 2012). These cross-scale dynamics are consequential as they can alter the path of the adaptive cycle at the focal scale, with additional effects cascading throughout (Holling et al., 2002; Walker et al., 2004; Nightingale & Cote, 2011; Wilkinson, 2011). Therefore, awareness and understanding of social and ecological factors and feedback mechanisms at larger and smaller system scales are critical to understanding the system of interest and how it is impacted by these scales, as occurrences at larger or smaller scales can lead to a loss of resilience at the focal scale (Walker et al., 2010; Cabell & Oelofse, 2012). However, Walker et al. (2010) claim that these events "can also serve as windows of opportunity for change," that is, as long as they do not push the system past a certain threshold or 'tipping point.'

Thresholds and Disturbance Types

When a socio-ecological system is unable to maintain fundamental elements and feedback loops as the result of stress or shock, it passes a threshold and transitions into an entirely different system configuration (Chapin et al., 2009; Walker et al., 2010). According to Walker et al. (2010) and Hodbod and Eakin (2015), socio-ecological resilience is related to the distance a system and its elements maintain from a threshold. The distance from different thresholds fluctuates over time as the system, and its nested subsystems, pass through adaptive cycles. Walker et al. (2010) argue that "even if the exact location of a threshold is unknown, simply being aware of a threshold can help reduce the likelihood of crossing into a new state." Disturbances that push a system closer to or past a threshold can come as distinct events in time, also referred to as 'pulse' disturbances, or through constant pressure from a single or combination of stressors, called 'press' disturbances (Walker et al., 2010).

Characterizing Socio-Ecological Resilience

Socio-ecological resilience is considered an emergent property of complex, socio-ecological systems, allowing for buffering or coping, adaptation, and in some instances, transformation

(Cabell & Oelofse, 2012; Hodbod & Eakin, 2015). It is forged not only from the appropriateness of elements in a system but also the efficacy of relationships between elements within and outside the system across spatial and temporal scales (Cabell & Oelofse, 2012; Altieri et al., 2015). Therefore, a system is not definitively or perpetually resilient but continuously changing based on system dynamics across scales. On this point, Herreria et al. (2010) write that "the resilience approach attempts to understand human action within a specific context and explores the resources available to people to enact change processes." These processes are supported by capacities and features such as adaptive capacity and agency.

Applying socio-ecological resilience to agroecosystems has the potential to improve the ability to anticipate disturbance, better responses, improve adaptability, and increase learning after an event, which are facilitated by adaptive capacity and agency (Cutter et al., cited in Brown & Westaway, 2011).

Defining Adaptive Capacity, Agency, and Transformation

Socio-ecological resilience encompasses the capacity to adapt to disturbances, either through anticipation and planning before a disturbance, or after, as part of the reorganization phase, otherwise known as adaptive capacity (Chapin et al., 2009; Nightingale & Cote, 2011; Maleksaeidi & Karami, 2013; Cretney, 2014). This adaptive capacity and its application are shaped by a myriad of factors and features in SESs, including effective governance, accessibility, equity, agency, and more (Chapin et al., 2009; Brown & Westaway, 2011). Agency is highlighted in much of the literature as particularly important in supporting adaptive capacity in socio-ecological systems (Davidson, 2010; Brown & Westaway, 2011; Berkes & Ross, 2013; Córdoba et al., 2020). Davidson (2010) asserts that agency encompasses individual and collective level action, which are expressed through confidence in the ability to enact change as well as "the cultural, infrastructural, and communicative resources that enable collective action." These capacities and features allow for coping, adaptation, and, when necessary, transformation. Transformation of these systems is a deliberate and fundamental change of system configurations by system actors and stakeholders (Walker et al., 2004; Chapin et al., 2009; Cretney, 2014). This occurs when the existing system is perceived to be "untenable or undesirable" (Cretney, 2014) and is an important feature of socio-ecologically resilient systems (Wilkinson, 2011).

Discerning Resilience and Socio-Ecological Resilience

Definitions of socio-ecological resilience vary in the literature, with differing perspectives in defining resilience versus socio-ecological resilience. For Walker et al. (2004), resilience is defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks." While definitions of resilience appear to focus more on preventing the shifting to a new system state, or surpassing of a threshold, and to maintain the current configuration of an SES, socio-ecological resilience definitions are more focused on the process of enacting change and those elements and abilities that support adaptive capacity. In this way, resilience reflects an emphasis on structural configuration and the ability to maintain that structure, while socio-ecological resilience is more focused on the process by which change and adaptation are carried out. However, the ability to refrain from surpassing thresholds through absorbing disturbance, or coping, and reorganizing, or adapting, supports the continuation of an SES in its current configuration, and therefore helps to conserve self-organization and enable recovery. Therefore, in this thesis, resilience is considered a contributing factor to socio-ecological resilience, and resilience is made up of two resilience types (see Figure 2).

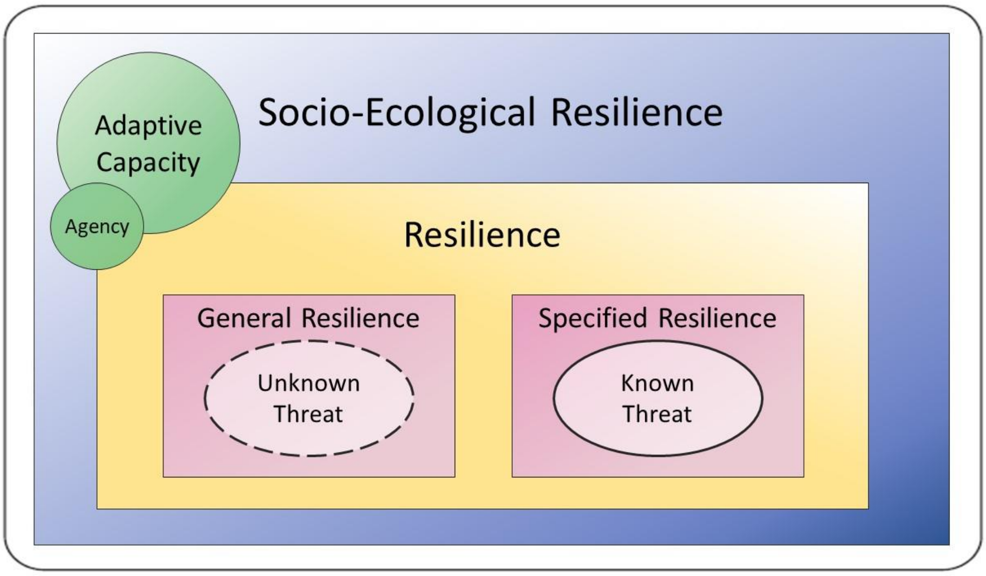

Figure 2. Socio-ecological Resilience Diagram - Diagram representing the different facets of socio-ecological resilience and how they layer upon one another. General and specified resilience allow the system to cope and adapt to known and unknown threats to the system (disturbances), together building system resilience. The combination of this resilience and adaptive capacity/ agency constitutes the foundation for socio-ecological resilience, or the process of conscious adaptation and/or transformation of system configurations (diagram by author).

Defining General and Specified Resilience

Within resilience discourse, two types of resilience are typically discussed: general and specified. General resilience does not prepare for any specific disturbance but builds capacities to mitigate effects and adapt to disturbance at a system-wide level (Walker et al., 2010; Folke et al., 2010; Berkes & Ross, 2013; Folke et al., 2016). Alternatively, specified resilience refers to resilience to a specific, identifiable threat, or 'of what, to what,' and aims to improve the coping and adaptation to these threats, or issues (Walker et al., 2010; Folke et al., 2010; Berkes & Ross, 2013). In their work, Walker et al. (2010) argue that a holistic resilience approach necessitates looking at both specified and general resilience. The authors clarify that distinction and consideration of both resilience types are important because focusing on one could create vulnerability to disturbance contained in the other. In agroecosystems, management strategies must be used that cover a broad range of potential and anticipated disturbances.

Critiques

Socio-ecological resilience and assessment frameworks are not without critique (see Plummer & Armitage, 2007; Davidson, 2010; Brown & Westaway, 2011; Bacon et al., 2012; Cretney, 2014 for in-depth critiques). Though socio-ecological systems are considered integrated in socio-ecological resilience theory and assessment frameworks, the social dimension is often lacking or limited (Crane, 2010; Berkes & Ross, 2013,). According to Crane (2010), "Despite having made great strides in theorizing the integrated nature of human and ecological systems, much of the literature… implicitly privileges the material, both in terms of ecosystem functions and human-livelihood outcomes." This notion also applies to agroecosystems. Some studies have been made on socio-ecological resilience in agroecosystems; however, as with its application to other resource management scenarios, the lack of development of the social dimension also applies (Herreria et al., 2010; Jackson et al., 2012). Often, focus is put on ecological production methods and less on the social realm and the encompassed mechanisms that enable anticipation, adaptation, and change (Darnhofer et al., 2010; Altieri et al., 2015). As Darnhofer et al. (2010) argue, "decision making on farms is under direct influence from humans... [therefore,] applying resilience thinking to farming systems requires careful attention to the social domain."

Chapter 3: Methods

Introduction to Case Study

Just south of the Central Valley, in the southeastern end of the California Coastal Mountain Range, is the Cuyama Valley (Cuyama Basin Groundwater, 2019). Located here is Quail Springs Permaculture, a non-profit organization teaching land-based skills and environmental stewardship. The organization operates on roughly 450 acres (182 ha) of pinyon-juniper-sagebrush woodland (*Pinus monophyla, Juniperus californica, Artemisia tridentata*). This system includes a community comprised of staff and non-staff community members, typically 8-12 people, who live on-site. Built on permaculture principles, Quail Springs aims to be a model of a sustainable human settlement, producing fruits, vegetables, and animal products for the community and prioritizing resource efficiency and regeneration in their production.

The Cuyama Valley region contains three climate classification types, Cold Semi-Arid, Hot-Summer Mediterranean, and Cool-Summer Mediterranean (California Department of Fish and Wildlife, 2003). Quail Springs fits most appropriately in the Hot-Summer Mediterranean climate classification. However, due to its geography and altitude, the site holds unique climate characteristics within this classification, with summer daytime temperatures consistently surpassing 100 degrees Fahrenheit (38° C) and winters frequently reaching below 32 degrees Fahrenheit (0° C). The Cuyama Valley, and its correlated watershed, is bounded on all sides, with the Caliente Mountain Range to the North and East, the Sierra Madre Mountain Range to the West, and the Western Transverse Mountain Ranges to the South (Cuyama Basin Groundwater, 2019). The Sierra Madre Range acts as a barrier to ocean climate dynamics, creating a rain shadow effect with little precipitation falling on the eastern side (Kelly, 2020). The area receives an average of 13.1 inches (333 mm) of precipitation annually, though even less than this often reaches the valley floor (Cuyama Basin Groundwater, 2019). Moreover, due to the Mediterranean influence, nearly all precipitation comes in the winter months, outside of the production calendar, and occasionally in the form of snow (Kauffman, 2003; Cuyama Basin Groundwater, 2019). What is more, precipitation can also vary drastically from year to year, with some years receiving much more precipitation, occasionally in the form of flash floods, and some years afflicted by drought (Cuyama Basin Groundwater, 2019). Due to these factors, agricultural production, the dominant land-use type and economic driver in this region, is nearly strictly performed under irrigation using groundwater resources. Just as with the Central Valley, the Cuyama Valley groundwater basin (Cuyama Basin) is critically over-drafted, with aquifer levels declining dramatically since the 1940s (Cuyama Basin Groundwater, 2019; Critically Overdrafted Basins, 2020).

Quail Springs is located in Burges Canyon, a secondary canyon off the Cuyama Valley, and has a higher altitude than the main valley floor — sitting between 3,400-3,600 feet in elevation. The geology in this area is categorized as alluvium, or unconsolidated sand, silt, clay, and gravel, with high horizontal transmissivity and low vertical transmissivity (Cuyama Basin Groundwater, 2019; Kelly, 2020). This area is characterized as badlands and generally considered unsuitable for agricultural developments, having soil with a fine-loamy texture with very little soil organic matter, making it prone to erosion (Cuyama Basin Groundwater, 2019; Kelly, 2020). Still, Quail Springs produces crops for community consumption in a production zone of roughly 1 acre (0.5 ha). Crops are irrigated with surface water from a perennial spring located just above the property line. The area around the spring is considered a Groundwater Dependent Ecosystem and, because of a perched water table, this water flows down gradient onto the property (Cuyama Basin Groundwater, 2019). Depth to groundwater under the production zone is 272 feet.

Methodology

To understand how socio-ecological resilience frameworks can be used, particularly in vulnerable California drylands, to improve the ability of agroecosystem managers to anticipate, mitigate, and adapt to disturbance, we must first observe how general and specified resilience assessment framework apply to an existing California agroecosystem. In this research, the researcher performed a case study to investigate the activities and methods of Quail Springs Permaculture for their potential to contribute to general and specified resilience. As socio-ecological systems are at the foundation of socio-ecological resilience frameworks, Quail Springs will henceforth be referred to as the socio-ecological system, or the SES. The SES was chosen based its high potential to be considered a socio-ecologically resilient agroecosystem. To answer the question stated in the introduction, an exploratory systems approach was taken. Qualitative methods, such as participatory observation, semi-structured interviews, and a focus group, were used to perform primary data collection. These data collection methods were chosen because, as Palanco Echeverry et al. (2015) point out, social science methods are important in research on agroecosystems as these systems are fundamentally built upon social constructs. This research was performed over a five-month period from April to September 2020.

To begin, participatory observation was conducted to gain an understanding of the SES, including system configurations, key elements, interactions, key actors, and stakeholders. To do this, the researcher lived and worked as part of the Quail Springs community while carrying out this research, performing daily farm and community tasks and noting observations and information gained from informal discussions. The information acquired from this method was then divided into subsystems to probe system dynamics, including resource and service flows. Once major subsystems notes were brought to light, key actors were identified to perform semi-structured interviews regarding these subsystems. The actors were all employees of the non-profit whose job duties were related to the area in focus, often being the coordinator or manager of the area. These interviews were used to shed light on activities and methods employed within subsystems, any issues that may affect the SES, and to understand connections across subsystems. Based on key elements that were highlighted in an interview about the community system, a focus group with the SES community was convened to gain a more comprehensive and holistic understanding of the values and ethics of the community. After the data were gathered from each subsystem it was synthesized into a series of categories in spreadsheets and presented to the key actor of each subsystem to review for accuracy and just representation.

From this stage, the data were analyzed based on two socio-ecological resilience assessment frameworks: *An Indicator Framework for Assessing Agroecosystem Resilience* by Cabell and Oelofse (2012) and *Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners. Version 2.0* by Walker et al. (2010). These two assessment frameworks focus on general and specified resilience, respectively. In their workbook, Walker et al. (2010) do discuss the importance of investigating general resilience and offer a list of criteria to assess this resilience type; however, the methodology laid out in Cabell and Oelofse's (2012) assessment framework provides a more in-depth look at this resilience type and was therefore chosen to investigate general resilience in the SES. Furthermore, these assessment frameworks were selected based on their holistic and non-normative perspectives, approaches, and assessment tools (see Córdoba et al., 2020 for critiques of assessment frameworks). Through them, the researcher was able to develop a descriptive framework of system configurations and dynamics as seen through a socio-ecological resilience lens in order to discern what activities and methods used in the SES support general and specified resilience. This information then served as the foundation for investigating the implications these activities and methods have for general and specified resilience.

Assessment Frameworks

In their general resilience assessment framework, Cabell and Oelofse (2012) argue that as agroecosystems are complex and change over time, indicators that can help to gauge the presence of specific qualities and characteristics in support of general resilience are more effective for helping socio-ecological system designers build this resilience type than other forms of metrics. This position and the offered assessment framework are based on a detailed literature review of resilience in different contexts and expanded to be applied to agroecosystems. The 13 Behavior-Based Indicators act as surrogates that can be measured in lieu of resilience within the context of the agroecosystem. On the application of the assessment framework, the authors write, "we present an index of behavior-based indicators that, when identified in an agroecosystem, suggest that it is resilient and endowed with the capacity for adaptation and transformation… [and] their absence or disappearance suggests vulnerability and movement away from a state of resilience"(Cabell & Oelofse, 2012). The authors offer descriptions of each of the indicators as well as the phase(s) of the adaptive cycle where they are considered most critical to occur, see Table 1.

Within the assessment framework, the first step is to define the boundaries of the focal system. The authors note that boundaries can be both spatial and temporal, encompassing those components related to the SES's social and ecological dimensions, including resources, infrastructure, institutions, and people. Once boundaries have been defined in terms of key elements and interactions, behavior that supports general resilience can begin to be identified based on descriptions of the indicators and the examples outlined in the

Table 1. General Resilience Behavior-Based Indicators (Cabell & Oelofse, 2012)		
Indicator	**Definition**	**Critical Phase(s)**
Ecologically Self-Regulated	Ecological components self-regulate via stabilizing feedback mechanisms that send information back to the controlling elements.	Exploitation to Conservation
Appropriately Connected	Connectedness describes the quantity and quality of relationships between system elements.	Exploitation to Conservation
High Degree of Spatial and Temporal Heterogeneity	Patchiness (variation) across the landscape and changes through time.	Exploitation to Conservation
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.	Exploitation to Conservation
Reasonably Profitable	The segments of society involved in agriculture are able to make a livelihood from the work they do without relying too heavily on subsidies or secondary employment.	Conservation
Optimally Redundant	Critical components and relationships within the system are duplicated in case of failure.	Conservation to Release
Carefully Exposed to Disturbance	The system is exposed to discrete, low-level events that cause disruptions without pushing the system beyond a critical threshold.	Release
Honors Legacy While Investing in the Future	The current configuration and future trajectories of systems are influenced and informed by past conditions and experiences.	Release to Reorganization
Socially Self-Organized	The social components of the agroecosystem are able to form their own configuration based on their needs and desires.	Reorganization
Reflective and Shared Learning	Individuals and institutions learn from past experiences and present experimentation to anticipate change and create desirable futures.	Reorganization
Responsibly Coupled with Local Natural Capital	The system functions as much as possible within the means of the bioregionally available natural resource base and ecosystem services.	Reorganization to Exploitation
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.	Throughout
Builds Human Capital	The system takes advantage of and builds “resources that can be mobilized through social relationships and membership in social networks” (Nahapiet and Ghoshal 1998).	Throughout

assessment framework. Larger and smaller scale elements and influences also need to be considered when identifying and characterizing system dynamics of the SES. As the authors stated, “The agroecosystem operates simultaneously at multiple scales and hierarchies, from the field to the globe” (Cabell & Oelofse, 2012). While performing the assessment, these scales and factors must be kept in mind and accounted for where necessary.

Use of Walker et al.’s (2010) assessment framework was coupled with the general resilience framework in order to outline system dynamic and investigate how activities and methods employed in the SES contribute to specified resilience. In this assessment framework, the authors argue that conventional methods for managing ecosystems that assume stability and linearity are inappropriate in these complex systems and can increase vulnerability to disturbance by overriding or masking issues. Such issues must be brought to light and systems must build their capacity to cope, adapt, or, if necessary, transform the system in order to reduce vulnerability to anticipated disturbance. This constitutes the foundational perspective on which the authors argue for investigating and building specified resilience. This contributes to the resilience and overall socio-ecological resilience of socio-ecological systems, preventing the surpassing of critical thresholds and supporting the provision of vital ecosystem services through adaptation. To aid in this process, the authors offer a workbook focusing on specified resilience in complex socio-ecological systems.

Mirroring the general resilience assessment framework, the first step in the specified resilience assessment framework is to define the boundaries of the SES. As Walker et al. (2010) note, “there is no perfect way to set the boundaries of a system,” as the boundaries of socio-ecological systems are not always clear. With this in mind, spatial and temporal boundaries can attempt to be defined. Identification of key components, such as resources, their uses, and legal status in relation to stakeholders, is an additional step in this process. Furthermore, part of determining the temporal boundary is the examination of disturbance regimes. Assessment contains past and present disturbances, both ‘press’ and ‘pulse,’ and how they have impacted the SES. Once boundaries are defined, the bounded system makes up the ‘focal system’ of the assessment. However, as in the general resilience assessment framework, influencing factors from larger and smaller systems are also important, and cross-scale system interactions should continuously be considered when examining the focal system. With boundaries identified and the focal system defined, governance structures of the system can begin to be conceptualized. Consideration of institutional influence, decision-making systems, power relations, and the position of system actors and stakeholders are critical in investigating and characterizing an SES's governance structure.

Based on the information gathered on system boundaries, key components and dynamics, and governance structures, main issues pertaining to the system can be identified. The authors note that to identify issues properly, many perspectives must be considered from a diversity of stakeholders. Once the main issues are identified, linkages between issues and considerations of scales and cross-scale interactions are to be considered, as well as change drivers, any potential thresholds, and what transitions to alternate system states might look like. With the main issues in mind, the assessment prompts the exploration of the adaptive cycles of the SES at focal, larger, and smaller, or nested, scales.

In the assessment framework, Walker et al. (2010) emphasize an iterative and reflective approach, encouraging reflection and “referring back to earlier steps and revising as necessary.” This type of formative assessment supports the assertion that information, factors, boundaries, etc., may require adjustment as “understanding of the system deepens” and that this flexibility is a “fundamental part of doing a resilience assessment.”

Application

These two assessment frameworks were applied to the investigation and outlined the methodology for further data collection and analysis. First, using the steps outlined in the Walker et al. (2010) workbook, boundaries of the focal system were defined along with key system elements, interactions, and dynamics, including the governance structure of the SES.

From this point, there was a pivot to investigating general resilience in the system, for which the researcher used Cabell and Oelofses’ (2012) indicator assessment framework. Based on the definitions and descriptions of the indicators outlined by the authors, the activities and methods identified during data collection were classified and compiled into a comprehensive chart based on the subsystems in which they were reported. The researcher expanded some indicators with more ecologically focused definitions to encompass socially based activities and methods. To investigate specified resilience in the SES, the researcher shifted back to the Walker et al. (2010) workbook. By following the steps for identifying key issues and threats based on information obtained about the system, threats determined to be of highest concern for the system were discerned. These threats were then investigated for links and interconnections, forming the foundation of the specified resilience portion of the investigation. The activities and methods used by the system that address these issues, either directly or indirectly, were then identified and categorized.

Limitations

According to Walker et al. (2010), "there is no perfect way to set boundaries of a system," and this statement is reflected in the findings of this research. As noted, the nebulous nature of the SES means that boundaries are dependent upon which dimension or activity is in focus, shifting along with different parameters and sometimes blurring and blending with other systems. Therefore, system boundaries outlined in this research may or may not be consistently representative.

To continue, the interrelated nature of the SES often created difficulty in its investigation, even though this interrelated nature is not uncommon. The interrelatedness of many elements often resulted in repetition and difficulty in dissecting and discussing interconnected topics. Likewise, the overlap of activities and methods to support general resilience indicators and to address specified issues often led to repetition in results, as activities and methods often served multiple functions and spanned across subsystems.

Furthermore, as mentioned by Walker et al. (2010), critical issues and threats may be different for different stakeholders. The issues and threats investigated in this research were identified based on interviews with key actors from the SES with the assumption that these informants have a comprehensive understanding of the system and relevant concerns. However, this procedure is not without potential for error, and it may be that the investigation does not reflect all perspectives of the system. Also, researcher bias could have the potential to have had an impact as most data were collected using semi-structured interviews and then converted and categorized for analysis, leaving opportunity for sematic misinterpretations. Multiple interpretations were mitigated by holding follow-up meetings with key informants where categorized data were reviewed in order to check for accuracy and perform necessary clarifications.

Finally, not everything observed or reported could be discussed in this research due to the legal status of activities or methods. In modeling alternatives for sustainability, the SES performs experimentation and application of sustainable practices; however, applicable laws and codes are not always up to date with these practices. In an effort to respect the viability of the organization, those topics with questionable or unsupported legal status were not discussed in this research. Through more research and advocacy, it is hopeful that these practices may soon be seen as legitimate under these jurisdictions and can be investigated for their contributions to socio-ecological resilience.

Chapter 4: Results

Initial Results

This section covers results on SES boundaries, subsystems and governance structure, and community values and ethics.

SES Boundaries

The boundaries of the SES are nebulous and depend on the dimension in focus. In the physical dimension, the boundaries depend on the activity in question and are linked to the legal status of access and use. The non-profit is the owner of the property on which it operates, meaning the activities on the property are limited only by the extent to which the law dictates. For example, the harvesting of firewood for fuel is permitted on the property as long as it is from fallen dead trees. Crop production, organizational activity, and community habitation are also within this jurisdiction. However, not all the activities of the SES are confined to the boundaries of the property. Some activities extend beyond the property line but still depend on legal access and permitted use. Depending on the activity, some boundaries on the property line are soft, and some are rigid. For example, the organization has permission to access one adjacent private property for grazing, recreation, foraging, and firewood procurement, while access to another adjacent private property for these activities is strictly prohibited. Furthermore, as the property is primarily surrounded by the Los Padres National Forest, the relationship with public land poses a unique dynamic. Some categories of activity are allowed freely, in the case of recreation, some with practice stipulations, such as firewood procurement, and some allowed with permits, such as water catchment from the spring located just outside the property line. For this study, the boundary regarding the physical dimension of the SES will include where organizational related activity is performed. This boundary contains the property the organization owns, adjacent private properties where access is granted, and public land where permitted activities take place.

The extension of the boundary of the physical dimension of the SES past the property line was affirmed in informal conversation with stakeholders and in interviews with key actors, as this loosely bounded area was often referred to as the ‘land,’ as opposed to the ‘property.’ This also reflected how the community maintains a unique relationship with their surrounding environment and the entrusted care they feel for this ecosystem.

Activities in the region also have an impact on the focal system. Some activities are performed as part of the focal system with the intention of spiraling outward to the larger system. Therefore, activities of the SES as they relate to larger scales are also considered relevant. These include community contributions to local legislation and educational partnerships with local community organizations, which are observed as a part of larger, regional scales with direct links to the SES.

SES activities are not solely limited to the physical, however, as social activities that extended these boundaries were also observed. These are predominately founded on the organization's mission to spread knowledge and build community. This takes many forms, including the building of knowledge and relationships in-person but also virtually. Through social media and other online platforms, the virtual presence of the SES extends its social boundaries past its physical location, creating an extended community, or social network, of people learning and working collaboratively. This network is centralized in the Southern California region, yet facets reach throughout the globe. These activities and interactions constitute the social boundaries of the SES.

Lastly, the SES also has a temporal boundary, containing both history and future plans. In the temporal boundary, the focal system is based upon the adaptive cycle that began with the establishment of the non-profit organization in 2007 and includes all the nested cycles within. Likewise, the cycle of the SES in its current configuration is also nested within larger regional cycles; therefore, these cycles are also considered relevant for their influences on the focal system. Historically, the region was a part of the land of the Chumash people. Upon the colonial occupation and privatization of the land in the mid-to-late nineteenth century, cattle grazing became the dominant enterprise in the region. Dominance and land-use shifted when infrastructure was established to access groundwater for irrigation and cropland development. In the previous SES configuration, cattle grazing was the dominant land use type until the establishment of the non-profit organization, initiating a new adaptive cycle with different system configurations. Additionally, a new, nested adaptive cycle for crop production occurred in 2010, when a 100-year flood swept away the existing production area. Therefore, the temporal boundary of the SES is considered to be start in 2007, with the establishment of the organization and the SES as it is known today, continuing to the present, with facets beginning in 2010 with the establishment of the new production area.

Subsystems and Governance Structure

Within the SES, seven major subsystems were identified through which activities and methods are performed. These subsystems, henceforth referred to as systems, are: (1) organizational, (2) community, (3) education, (4) landscape, (5) water, (6) animal, and (7) plant production. The organizational, community, and educational systems constitute the social realm of the SES, while landscape, water, animal, and plant production make up the ecological realm. The subsystems are interlinked in a complex web, indicated in Figure 1, and span the scales of space and time. These demarcations aid the clarification of the dynamics of the SES. Each system is responsible for a set of resources, tangible and intangible, which get cycled between systems. Some systems have strong links between each other, while others have weak links or interact mainly in one direction. Each system has a set of activities and methods (see Appendix C) several of which overlap across systems. These are used to create outputs and support services of social and ecological value. In total, 17 activities and 161 methods to perform the activities were identified. As some methods were reported under more than one activity, duplicated methods are only counted once, leading to 145 uniquely identified methods. These activities and methods are discussed in subsequent results sections in the context of general and specified resilience.

As shown in Figure 1, the organizational system is linked to every other system, with the majority of resources flowing in the outward direction. However, as the organizational system is dependent upon the community and the community system is supported by the remaining systems, a cyclical flow emerges. In this flow, resources like capital and labor flow outward from the organizational system, get taken up and transformed into products and services in other systems, and flow to the community system. This system is the foundation for of the organizational system and its necessary inputs. At the same time, other linked systems cycle resources among each other, such as the plant production and animal systems, which cycle organic material and nutrients. The landscape and water systems are also intrinsically linked, overlapping to foster ecosystem services such as carbon

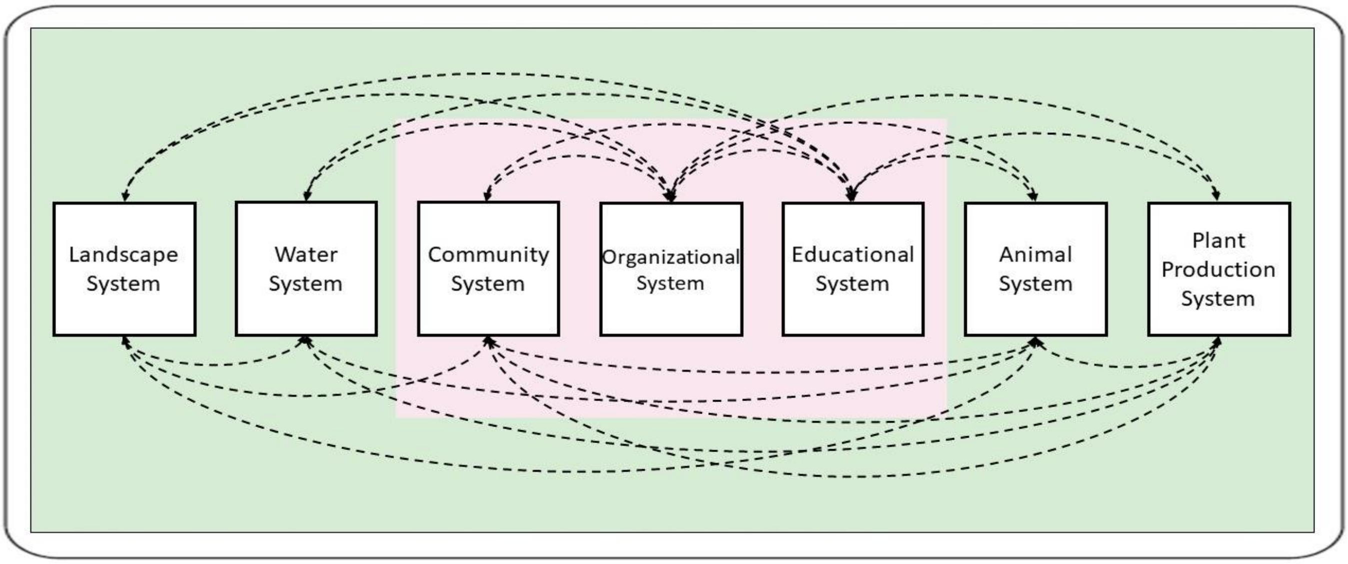

Figure 3. (Sub)system Diagram - Diagram representing the nested (sub)systems of the socio-ecological system (SES) in focus. Arrows represent resource and service flows between (sub)systems, demonstrating system dynamics. The outer rectangle represents the ecological dimension while the inner rectangle represents the social dimension, its placement signifying its embeddedness (diagram by author).

sequestration, biodiversity, and hydrological cycling. These dynamics, made up of elements, interactions, feedback mechanisms, activities and methods, collectively constitute a significant portion of the configuration of the SES, with the last critical element being their management, or governance.

The organizational system, which is at the foundation of the socio-ecological system, contains a method of governance that interconnects all the systems. Based on sociocracy and holacracy models, the method consists of a number of 'Circles' that are composed of both staff and non-staff community members. These members function as teams, meeting regularly and making decisions together (Quail Springs Permaculture, 2020). According to the organization, "This structure intentionally spreads power among people across the organization and community and gives everyone a chance to bring their gifts to the work they care about." (Quail Springs Permaculture, 2020) 18 Circles were reported, each with their own domain, or "clearly defined purpose and decision-making powers," which must be approved by the wider community, and oversee activities and makes decisions within that domain (Quail Springs Permaculture, 2020). Circles also work collaboratively with each other to organize projects that span across Circle domains. All Circles converge at the Village

Business Council (VBC), a weekly meeting where larger discussions and decisions can be made through a codified proposal process with the larger community.

Community Values and Ethics

Community values and ethics appeared to play an important role in the management of the SES. An array of values and ethics were reported by the community (see Appendix D). Many of the reported values and ethics are influenced by the subscription to permaculture, with core permaculture ethics of earth care, people care, and fair share all mentioned. In fact fair share was the most reported ethic, being reported three time. Resilience was mentioned twice as a key ethic, and experimentation was twice reported as a key value.

Another core ethic that arose repeatedly was stewardship. The SES community sees themselves as stewards of and in direct relationship with the land on which they operate. This stewardship includes the responsible management of ecosystem functions within the SES, as well as the local and regional watershed within which the SES is embedded. At the same time, stewardship helps fulfill the needs of the community through the maintenance and regeneration of resources the community utilizes and ecosystem services they benefit from. A key literary work was reported to have influenced the community on this topic: *Tending the Wild* by M. Kat Anderson (2013). According to SES stakeholders, the key ideology presented in this work is that nature does not necessarily flourish in the absence of people, but rather that humans have historically served vital roles in the prosperity of landscapes, expertly tending to the natural environment to develop a greater richness in diversity and symbiosis. Much of the community applies this idea to their perception of stewardship.

General Resilience

This section covers the identified activities and methods of the SES that qualify under each of the thirteen general resilience indicators. Of the 145 unique methods identified, 137 were found to contribute to general resilience indicators, and all 17 activities were represented via these methods. Those activities and methods that apply most aptly to the indicators will be discussed in detail here, though more activities and methods can be found listed under each indicator, as exemplified in the chart in Appendix E. The indicators are listed in order of the adaptive cycle phase(s) in which they are considered most critical to occur according to the general resilience assessment framework.

Ecologically Self-Regulated (Exploitation to Conservation)

Several activities and methods were reported that have the potential to contribute to ecological self-regulation in the SES (4 activities, 40 methods). Through the activity of regenerative crop production, methods such as cover cropping with leguminous species, chop and drop mulch, and alley cropping were reportedly used to promote in-situ creation and recycling of essential nutrients. The creation and cycling of these nutrients support the continuation of biochemical processes and prevent nutrient depletion. In the same vein, techniques that support a robust and complex soil ecosystem for the purpose of nutrient cycling and availability were also reported; these include applying compost, cutting annual crops to the base, and incorporating perennial species. The production area is also under no or reduced till production and employs methods such as broad-forking for intermittent soil aeration. These methods serve to preserve the existing, complex soil ecosystem and the application of compost is used to inoculate the soil with important soil micro-organisms including mycorrhizal fungi. The presence of a complex soil structure containing a buildup of organic matter is supported by all of the aforementioned methods. This is considered favorable because it can contribute to increased water infiltration and moisture retention. Moreover, on-contour production, sunken beds, mulching, and incorporating drought-tolerant species were methods reported to contribute to the self-regulation of the hydrological cycle in the production zone. These methods increase water capture, infiltration, retention, and reduce irrigation needs.

At the landscape scale, consideration of soil resources and hydrological cycles are also taken into account, influencing employed activities and methods. The key reported method in supporting soil nutrient availability and moisture retention was rotational cell grazing. This is a part of the activity of regenerative grazing and contributes to the buildup of soil organic matter in the landscape through depositing manure and crushing and integrating brush into the soil. Furthermore, under watershed stewardship, the creation of a seasonal unlined pond and methods that slow and spread surface water discharged from the spring, including calculated erosion, check dams, and sedge-mat grade controls, were reportedly used based on the manifold ecosystem functions they serve, including potential groundwater recharge and biodiversity support. These activities and methods contribute to the ecological self-regulation of the SES at the landscape scale.

Appropriately Connected (Exploitation to Conservation)

In the SES, connectedness is displayed throughout, as can be observed in the links and overlap of systems demonstrated in Figure 3, with resource flows and services creating an intricate web of activity. Activities and methods contained within these systems create a multitude of relationships between elements (12 activities, 63 methods). These relationships provide essential services, including ecosystem services to the SES, while also weaving a net that serves as a fail-safe in the case of shock or stress. Under regenerative crop production, such methods include interplanting and poly-cropping, cover cropping with leguminous species, alley cropping and woody species/ perennial integration, pollinator attractor integration, and more. These support connectedness in the SES through the relationships that are built between elements. For instance, interplanting and poly-cropping are used based on the benefits they provide through crop interactions, including pest and weed suppression. This interconnectivity extends beyond those systems within the ecological dimension and is reflected throughout the SES.

The connectedness of the SES is also reflected in its governance structure. In enacting a decentralized, non-hierarchical governance structure, the Circles method creates connectedness through domain linkages, activity overlap, cross-coordination, and collaboration. This feature and connections are used to facilitate effective oversight of aspects of the organization and the wider SES. The ability of community members to join several circles creates an additional layer of interconnectivity. With members well-versed in the activities and goals of other circles, this creates opportunities to further develop connections and support between circles. This supports connectedness within the social dimension and throughout the SES.

High Degree of Spatial and Temporal Heterogeneity (Exploitation to Conservation)

A variety of activities and methods employed in the SES support spatial and temporal heterogeneity (7 activities, 36 activities). Within regenerative crop production, methods such as poly-cropping, intercropping, and alley cropping support species and spatial diversity in the production zone. This combination of methods is used to support connection and opportunity for beneficial relationships in the production zone. The result is a high degree of spatial heterogeneity as each method creates an additional layer of heterogeneousness by contributing a different configuration and display of diversity. These methods contribute to spatial heterogeneity in the production zone, but heterogeneity is displayed throughout the SES.

To continue, Cabell and Oelofse (2012) point to broader landscape heterogeneity, particularly connection to wildlife areas, as an essential component for general resilience in agroecosystems. In the SES, a wildlife corridor was established to create uninterrupted habitat for local biodiversity, supporting spatial heterogeneity in the broader landscape. Development and production activity are limited to the Northside of the property while the Southern side is devoted to serving as a wildlife corridor, with a raised road acting as a boundary between the two zones. This segment accounts for roughly two-thirds of the property, close to 300 acres (121 ha), thereby providing a substantial amount of space to support wildlife, harbor biodiversity, and realize associated benefits. In addition to spatial heterogeneity executed in the production zone and broader landscape, methods that create temporal heterogeneity were also reported.

Crop rotation, rotational cell grazing, and seasonal irrigation schemes are methods that support the diversification of elements and the use of space and resources in time, thereby contributing to temporal heterogeneity in the SES. The most novel of these methods is the seasonal irrigation scheme. The seasonal irrigation scheme adjusts water application throughout the year based on water availability, biological phases of vegetation, and climatic scenarios. Changes in precipitation and in plant dynamics throughout the year warrant adjustment to the irrigation scheme; however, the strategies used within this method aim to exploit these changes and dynamics to increase water-use efficiency. For example, by using the relative abundance of available surface water in the wet winter season to flood dormant woody species, the SES can potentially use the high infiltration rate and ability to penetrate deep into the soil to bank water to be taken up later when the species become active again. Similarly, in the winter months, after irrigation in the daytime, surplus water is diverted to the pond, which contributes to groundwater replenishing. These strategies serve to create variation over time and improve resource efficiency by using water when it is most abundant. As well, in the dry summer months, when water is scarcer, irrigation of annual crops is limited chiefly to nighttime in order to prevent evaporative loss and improve water efficiency.

Expanded from ecological applications, the SES employs activities and methods that support heterogeneity in the social dimension. This is shown in SES governance, through promoting diversity of opinions and potential outcomes. As mentioned previously, Circles and the Village Business Council are open to all community members. This allowed for transparency, accessibility, and potential for community members to contribute ideas and perspectives, supporting heterogeneity in the social dimension of the SES.

Globally Autonomous and Locally Interdependent (Exploitation to Conservation)

The SES displays both global autonomy and local interdependence, employing activities and methods that support these features (9 activities, 13 methods). While the community of the SES produces fruits, vegetables, and animal products for their own consumption, it is not currently able to meet the consumption needs and taste preferences of the entire community. Additionally, it is not able to produce staple goods such as grains and oils. For these items, the community sources from local vendors, including directly from local farmers and a food cooperative that partners with farmers and producers throughout the region. These methods can be considered part of the broader activity of supporting sustainable food systems. They were reportedly used to financially support local and regional producers, as well as engage with local cooperative organizations. These methods are believed to support resource efficiency, empowerment, and agency in the food system, which in turn support local interdependence and autonomy from larger forces. The SES also often trades goods and services informally with local farmers and producers. This network supports and maintains a level of autonomy from larger forces through a separation from formal markets, focusing on local scales and social relationships.

The building of social relationships for local interdependence and autonomy also applies to the SES's educational programming and organizational partnerships within the local Cuyama Valley community. One organization is the Cuyama Valley Family Resource Center, which supplies social services to the local community. In cooperation with this organization, the SES engages in community outreach and education through a youth group focused on civic engagement as well as projects related to permaculture and watershed stewardship. These methods support interdependence through collaborative partnerships and supports autonomy through fostering knowledge, capacity, and skill-building for participants. Additionally, these activities are funded by regional and state organizations, adding another layer of local interconnection and support.

Reasonably Profitable (Conservation)

A few activities and methods that support reasonable profitability were identified in the SES (7 activities, 10 methods). During the investigation, it was reported that revenue for the organization was sufficient to meet operational expenses. However, educational programming, typically contributing roughly 40% to organizational revenue, had been severely impacted by county zoning restrictions as well as the COVID-19 pandemic. These disturbances and other concerns for financial insecurity and the activities and methods used to address them will be discussed in the Specified Resilience Results section as these contribute to a main issue. Still, other activities and methods were also reported to support reasonable profitability.

In the general resilience assessment framework, Cabell and Oelofse (2012) assert that in order for an agroecosystem to demonstrate reasonable profitability, workers must receive adequate compensation. According to the authors, "if agroecosystems are to continue to meet human needs, those who manage them must have their needs met as well [and] farmers and farm workers should be able to make a living from work directly related to their labor, if they want to, without depending too much on off-farm income or subsidies." In the SES, several employees indicated they occasionally sought secondary employment to augment their income. However, the desire to ensure adequate financial support for staff is held by the collective community. In order to actualize this desire and address concerns, collaborative discussions were held to generate alternatives, which took place during the time of this investigation. Through this process, the implementation of a flat pay structure, in which all staff earn the same amount regardless of position, was decided. An intention was also set to continue further discussions around what would be considered an equitable pay structure. This structure would include factors that the community agrees are important to consider in regard to how much an employee earns, such as debt, dependents, and necessary expenses, and these factors would play a part in determining employee wages. For now, the flat pay structure supports reasonable profitability as some employees have begun receiving higher, more comparable wages; and while some employees have seen a reduction in their wages, all the employees were in agreement that the new pay structure was satisfactory.

Optimally Redundant (Conservation to Release)

Many identified activities and methods within the SES had intentional overlapping functions, supporting optimal redundancy (13 activities, 65 methods). In regenerative crop production and watershed stewardship, multiple methods were reported for the purpose of increasing infiltration and moisture retention, including contoured micro-swales, mulching, sunken beds, integrating woody species, and alley cropping. In watershed stewardship, several methods to slow, spread, and sink water to increase the potential for groundwater recharge, such as calculated erosion, check dam, one-rock dam, and sedge-mat grade control implementation, and more were also reported. These methods support essential ecosystem services related to the hydrological cycle in the production zone and throughout the landscape. Optimal redundancy is created through the duplication of these functions and provisioned ecosystem services, employing multiple methods that support the same outcomes.

Methods that support redundancy in the social dimension were also reported. In revenue generation, having multiple revenue sources contributes to redundancy in the organization's financials. In enacting decentralized, non-hierarchical governance, the ability of staff and non-staff community members to join Circles supports redundancy in the governance of the SES, reportedly allowing for multiple ‘eyes’ for identifying, coordinating, and carrying out tasks and activities. This method provides oversight through having multiple individuals involved in management, thereby supporting redundancy at the level of governance within the SES.

Carefully Exposed to Disturbance (Release)

The SES uses activities and methods to carefully expose the SES, and its encompassed elements, to disturbance (activities 4, methods 15). Rotational cell grazing allows the SES to continually expose the landscape, including vegetation and soil, to minute disturbances, moving across space through time in an attempt to prevent overgrazing and compaction. This acute, high level of disturbance in long-term cycles is intended to stimulate plant growth and positively alter soil composition and structure, indicating careful exposure to disturbance. To continue, methods used at and below the spring as part of watershed stewardship also expose these areas and included elements to careful disturbance. The creek bed and proximate riparian zone are exposed to disturbance through calculated erosion, implementation of small-scale earthworks, and the diversion of a portion of surface water. These activities and methods disturb the existing ecosystem, including biological and physical configurations. They also prevent destructive erosion and increase the potential for infiltration, groundwater recharge, and water availability for riparian flora. To ensure that none of these activities and methods exposes excessive disturbance and pushes the ecosystem to collapse, small and frequent interventions, observation, and adjustment are guiding implementation principles. This signifies that these disturbances are performed carefully. These activities and methods support careful exposure to disturbance in the SES through action, however, exposure to disturbance in the SESs happens naturally, and therefore not preventing disturbance is also important.

In general, it was observed that the SES does not try to control system dynamics by protecting elements from exposure to disturbances that do not threaten such elements. For example, preventative measures are, for the most part, only taken when there is a specific threat that is anticipated to cause significant damage, while more minor, non-threatening disturbances are often allowed to occur. Collectively, these activities and methods, as well as guiding principles and standpoints, support careful exposure to disturbance in the SES.

Honors Legacy while Investing in the Future (Release to Reorganization)

A few key activities and methods in the SES support the honoring of legacy (4 activities, 6 methods). In the activity of community building, the SES emphasizes the promotion of age diversity. Elders are encouraged to join the community as their wisdom and experience are seen as invaluable. Furthermore, the presence of elders is also favored as it is believed to encourage cross-generational knowledge and perspective sharing. This method and these perspectives support the honoring of legacy. Furthermore, the educational system's focus on land-based education also attempts, where appropriate, to highlight indigenous practices and insights, particularly from the region, including Chumash cultures. The wisdom embedded in these practices and insights is seen as coming from experience in their application over extended periods of time in the same or similar contexts. Many practices and production methods applied in the SES are also based on indigenous wisdom, such as certain intercropping strategies. Therefore, these methods support the honoring of legacy by preserving these insights through teaching and application.

Finally, the SES integrates heirloom varieties and native varieties and cultivars into the production zone to preserve genetic diversity and allow for variation in response. This supports the honoring of legacy by upholding these biocultural resources of genetic diversity and adaptation that have been passed down through time (Cabell & Oelofse, 2012).

Socially Self-Organized (Reorganization)

The SES exhibits social self-organization, using and having used activities and methods that support this indicator (1 activity, 8 methods). In early 2020, through collective decision-making, the Circles governance structure of the SES was created and implemented by the community and non-profit board members. This change suggests a high level of social self-organization as the decision for the structure was made by the community itself, with little external influence. The chosen structure also supports social self-organization through its decentralized, non-hierarchical structure. Circle meetings, where members discuss issues and make decisions within domains, and the Village Business Council, where community members come together to go over organizational happenings and circle updates, as well as to make decisions as a group through a codified proposal process, support social self-organization through accessibility and participation, transparency and information sharing, and agency to contribute to decision making. Similarly, the weekly community meeting, or Town Hall, is held to allocate a common time to identify and address issues pertaining to the community as they come up from week to week. The combination of these methods contributes to the self-organization of the SES.

Reflective and Shared Learning (Reorganization)

Several activities and methods are employed in the SES that support reflective and shared learning (7 activities, 27 methods). In enacting decentralized, non-hierarchical governance, the weekly community and organizational meetings allow for reflective and shared learning. These allocated times for information sharing and discussion support sharing knowledge and collaborative action to address concerns. Moreover, community members can bring proposals to the Village Business Council to propose changes to the SES through the codified proposal process. This process supports collaboration as community members can highlight concerns and suggest modifications to proposals. This process indicates reflective and shared learning as proposed changes have input from the knowledge and experience of fellow community members. These methods support reflective and shared learning in the governance of the SES, but these principles are pervasive in the SES based on the foundational mission of the organization.

To continue, the sharing of knowledge and teaching of skills is pivotal to the organization's work, around which the SES is built. The performing of educational programming supports this commitment and fulfills the indicator of reflective and shared learning. Through this activity, the organization teaches land-based knowledge and skills, emphasizing community involvement and cooperation. Through a methodology incorporating this emphasis into teachings, lessons in programs intend to demonstrate that people working collectively and collaboratively can accomplish more, use resources more efficiently, have more creative solutions and ideas, and feel happier and more connected. This emphasis on cooperation helps to perpetuate reflective and shared learning as the benefits of working collaboratively is instilled in participants and potentially spiraled outward to larger and parallel SESs as participants take and apply this principle elsewhere.

Responsibly Coupled with Local Natural Capital (Reorganization to Exploitation)

Activities and methods are employed in the SES that indicate its coupling with local natural capital (10 activities, 57 methods). Firstly, the production area in the SES is irrigated solely with surface water diverted from the spring located just outside the property line. Awareness and self-regulation of the amount of surface water diverted is based on observation of water availability and ecosystem consumption patterns. This method allows for the utilization of an adequate amount of water for production while maintaining sufficient streamflow to support the ecosystem that depends on it, indicating a coupling to these resources. Furthermore, the production area is kept limited, and methods such as intercropping and alley cropping are used to efficiently utilize space and water. Preserving these two key resources supports coupling with local natural capital as part of regenerative crop production. Comparably, rotational cell grazing is founded on utilizing space and time efficiently to feed livestock while also maintaining biodiversity and soil health. This method allows for production within the bounds of available resources, while also helping to replenish and maintain the resource base, and support ecosystem services. These activities and methods support the coupling of local natural capital in the riparian zone, production zone, and general landscape, but more activities methods exist and are applied throughout the SES that support this characteristic.

To continue, according to the general resilience assessment framework, the capacity to convert waste is also considered important for living within the means of the local resource base (Cabell & Oelofse, 2012). The SES harnesses waste streams, such as utilizing manure, kitchen, and garden waste for compost. This utilizes existing nutrients and organic material and reduces inputs for production. Additionally, the SES harnesses waste streams for chicken feed. Previously, local offsite food waste streams were used for this purpose; however, these have been interrupted due to the COVID-19 pandemic. In the meantime, kitchen and garden waste are predominantly used to supplement chicken feed, though these are not currently sufficient and therefore purchased feed is more heavily relied upon. Furthermore, as water is a vital resource within the SES, greywater, or non-contaminated wastewater from domestic use, is also used to irrigate woody species. Waste is additionally utilized by choosing the most degraded land to cultivate, regenerate, or develop. In this method, otherwise unusable space is made use of, while at the same time contributing services and preventing further landscape degradation.

Finally, another method to support being coupled with local natural capital within the SES is living in community and sharing resources. This method allows for the efficient use of resources, including water, fuel, infrastructure, space, and time. These principles are extended into educational programming, which focuses on community-building and cooperation as well as being in connection to the land and the resources and cycles therein.

Functional and Response Diversity (Throughout)

The majority of activities and methods used in the SES were found to support functional and response diversity (16 activities, 109 methods). Methods that fall under the traditional definition of functional and response diversity were identified, many of which falling under the activity of regenerative crop production. These methods include cover cropping, alley cropping, poly-cropping and interplanting, pollinator attractor integration, mulch, perennial incorporation, coppicing, pond creation, in-situ habitat creation, compost creation and application, drought-tolerant species integration, and more. These methods support a variety of ecosystem services, serving several functions and supporting a diversity of responses in the case of disturbance. For example, in-situ habitat creation for pest regulating species, often done by providing small water reservoirs for amphibious species living in the production zone, supplies these species with vital water in the arid climate. This method therefore supports biodiversity and the associated potential for response diversity in this zone. The presence of these species also supports integrated pest management in the production zone as they eat small pests, including aphids which are abundant and impact yield.

In addition to those previously mentioned services provided by rotational cell grazing, such as supporting nutrient and hydrological cycling, additional services such as fire mitigation and seed dispersal are also supported by this method and the activity of regenerative grazing. This activity and method serve other important functions as well, including supplying feed that supports milk and meat production for the community. This reduces the need for external inputs, and therefore reduces costs for the organization, while at the same time allowing the community to uphold ethics related to supporting sustainable food systems. Having and rearing goats in general under regenerative grazing also supports community happiness and wellbeing through entertainment. Therefore, regenerative grazing, predominately enacted through rotational cell grazing, serves a wide diversity of functions in the SES.

In the social dimension, holding a variety of educational programs supports functional as well as response diversity. This activity serves several functions, including teaching land-based and community skills, and facilitating initiatives such as environmental stewardship, civic engagement, advocacy, empowerment, supplying important revenue streams and sharing knowledge. Additionally, the variety of programs held by the organization allows for response diversity as each has a different potential to be changed or adapted as necessary, as exemplified by the recent adaptation of the Permaculture Design Course to an online platform. Therefore, this activity supports functional and response diversity in the SES by serving a multitude of functions and supporting a variety of response options in the case of disturbance.

Builds Human Capital (Throughout)

Several activities and methods were reported that support the building of human capital in the SES (6 activities, 24 methods). The building and maintaining of relationships with individuals and organizations locally and in the region creates a network that builds valuable human capital. This happens at an organizational level, through educational programming and professional networking, as well as through individual community effort. These efforts are considered an important pathway for mutual support in a variety of ways, including information, advocacy, financial, labor, and other resources. Furthermore, the organization also performs networking and relationship building through social media. This is a vital avenue for building human capital in the modern era, and particularly in the present time of the COVID-19 pandemic, where social distancing mandates severely limit human interaction. These activities and methods support the building of human capital outside of the immediate SES, but the system also employs methods within the boundaries of the SES to support this characteristic.

The SES uses activities and methods that support relationship and skill-building within the community, such as community events, artistic community groups, skill-sharing among community members. These methods help build relationships among community members of the SES and therefore support human capital building. As well, community members can develop new knowledge and skills from hosting and participating in community events. Finally, the cultivation of knowledge, skills, empowerment, and agency of community members is also a valuable form of human capital building within the SES. The SES does this by encouraging creative projects, encouraging agency and self-empowerment, and cultivating the skills and gifts of community members. Collectively, these activities and methods help to support human capital building in the SES.

Specified Resilience

This section covers the main issues identified in the SES and the reported activities and methods that support addressing them. Ten issues to which resilience strategies should be directly geared were identified using the specified resilience assessment framework; these include Watershed Degradation, Groundwater Depletion, Desertification, Biodiversity Loss, Global and Local Climate Change, Economic Instability, Community Dissolvement, Water Insufficiency, Drought, and Product Predation. Several of these issues are linked and therefore considered and discussed together. In total, all 17 activities and 108 of the 145 unique methods were found to support addressing these issues(see Appendix F). Those of highest significance for mitigation and adaptation will be discussed here. The activities and methods will be presented in the context of the issue they address, which will be listed in descending order by the scales they relate to, or from larger to smaller scales.

Watershed Degradation and Groundwater Depletion

During the investigation, watershed degradation, through reduced hydrological capacity based on above and below ground elements, and groundwater depletion were noted as of concern at multiple scales, including the larger, regional system and the nested SES. Watershed degradation has been primarily influenced by agricultural production methods in the region, including clearing land for crop production and overgrazing. Meanwhile, groundwater depletion has been caused by overexploitation of the regional aquifer for crop irrigation, leading to its designation as critically over-drafted. As aboveground practices in the watershed impact groundwater replenishing, these two issues are considered linked, with many of the same activities and methods performed in the SES intended to address both issues. These issues can be considered press disturbances as the slow, cumulative effect of improper resource management puts increasing stress on the regional ecosystem, threatening the ability of the larger SES to remain in its current configuration. This threat indicates a threshold with the potential to cascade and affect the focal system. If surpassed, the alternative stable state would likely look different, with groundwater tables too low, or depleted, to access. This would likely result in water shortages, poor water quality, and the requirement of high levels of expensive infrastructure to access remaining water, if any, and production would be essentially impossible, or at the very least impractical. Furthermore, these impacts would likely affect remaining important groundwater-dependent ecosystems in the region, potentially threatening their existence. This includes the groundwater dependent ecosystem located just outside the property line but within the physical boundaries of the SES. Therefore, while these issues are framed at the larger, regional scale, they have the potential to impact the nested, focal system, making their addressal relevant for the SES. The SES performs a variety of activities and methods to address these issues (9 activities, 25 methods).

To begin, many methods at a range of spatial scales were reported in the SES that aimed to address aspects of watershed degradation and groundwater depletion. At the larger, regional scale, SES community members and organizational staff have advocated for and contributed significantly to the Cuyama Basin Groundwater Sustainability Plan. This ongoing piece of legislation is intended to stabilize groundwater resources through the regulation of groundwater use in the basin, with the aim of reaching what can be considered sustainable rates of extraction by 2040. It also aims to increase awareness of watershed dynamics and issues to prevent further watershed degradation. The involvement of community members in the shaping of this legislation helps to prevent the surpassing of this threshold, and supports the long-term environmental, economic, and cultural health of the region. Additionally, education and outreach on watershed sustainability and stewardship are considered vital methods of the SES for combatting further degradation at the regional scale. Under the activity of watershed stewardship, and overlapping with educational programming, the SES supports addressing these issues through educational projects on watershed stewardship and youth civic engagement. Working with youth groups in the region as part of these projects helps to support watershed stewardship at the local level, intending to encourage and empower Cuyama Valley community members to engage with the water system that supports them and their community. These activities and methods support addressing watershed degradation and groundwater depletion at the larger, regional scale, but activities are also performed within the boundaries of the SES to address these issues at the focal scale.

At the focal system scale, watershed stewardship and methods that promote slowing, spreading, and sinking water support addressing these issues through improved hydrological cycling in the landscape, with potential contributions to groundwater. As previously explained, the method of creating of a pond is used to promote groundwater recharge.

Under this method, there is a greater opportunity for percolation and contribution to groundwater through concentrating water in one place over an extended period of time. This groundwater recharge has the potential to contribute to replenishing immediate and subsequent regional aquifers. It also is likely to support local vegetation, an essential element for effective hydrological cycling. Similarly, the raised road is used for water catchment and infiltration, acting as a berm in the case of heavy precipitation or flooding and holding water until it infiltrates.

Lastly, rotational cell grazing with goats and sheep is the primary method to regenerate the landscape, supporting and improving hydrological cycles and functioning. The goats, which remain on the land all year long, graze in smaller quadrants for relatively short periods, often moved twice a week throughout the year. Meanwhile, the sheep are brought to the land for only a portion of the year and graze in larger paddocks to accommodate their larger numbers. The contribution of these animal's manure and the trampling and crushing of brush helps to build soil organic matter and support the hydrological cycle, thereby attempting to address watershed degradation at the focal scale.

Desertification and Biodiversity Loss

Desertification, framed as a reduction in soil organic matter and its coupled soil biodiversity, was mentioned as a concern for the SES. This issue is linked with high levels of erosion and sparse and fragmented vegetation in the landscape, reducing the provisioning of broad-scale ecosystem services, including hydrological cycling and biodiversity support. Biodiversity loss was also mentioned as of concern, particularly when it came to the degradation of the riparian zone. The building of these issues over time indicates press disturbances, and their materialization would lead the surpassing of two critical thresholds, drastically altering system configurations and resulting in state change. This new system state would likely consist of a sparsely vegetated landscape with very low soil organic matter, highly erosive, and with little biodiversity, and therefore highly vulnerable to a variety of subsequent disturbances. This would also impact benefits and ecosystem services related to high levels of biodiversity, including response diversity and hydrological and nutrient cycling. In order to combat these processes and support healthy, organic materialrich soils, as well as a biodiverse ecosystem, the SES uses a few key activities and methods (4 activities, 15 methods).

Firstly, much like its application to watershed degradation, rotational cell grazing with goats and sheep is considered the most powerful tool against desertification in the SES, with many of the same benefits and services overlapping. As mentioned previously, this method contributes to soil organic matter buildup in the landscape, ultimately supporting landscape vegetation through increasing infiltration, soil moisture retention, and erosion mitigation. It was reported that this method is heavily influenced by the theories of Allan Savory and regenerative agriculture in general. In this method, system planning, monitoring, and adjustment are crucial to prevent under and overgrazing. According to the key actor for the landscape system, both under and overgrazing contribute to desertification in brittle landscapes. Therefore, this method contributes to mitigating desertification through preventing over and undergrazing. The effects of the present rotational cell grazing scheme are yet understood, but the methods appear to be beneficial as overgrazing was reportedly reduced, and manure can be observed throughout the landscape.

To continue, in the riparian zone the discontinuation of open-range grazing with domesticated cattle was reported as the key action to prevent further biodiversity loss in this area. The propensity for the concentration of cattle in the riparian zone had reportedly led to overgrazing and a reduction in plant numbers and diversity in this zone. With the establishment of the organization and the SES in its current configuration, the decision was made to stop open-range cattle grazing with domesticated cattle and begin performing regenerative grazing methods with goats, avoiding grazing in the riparian zone. Heat and drought tolerant goat breeds were chosen to support these methods. Furthermore, other methods such as planting riparian vegetation have also been used to increase biodiversity in this zone. It was reported that this area is regenerating in the absence of the cattle and under these and more watershed stewardship methods.

Global and Local Climate Change

Global and local climate change, and associated threats, are considered relevant issues for the SES. As mentioned previously, flooding, fires, and drought are all predicted to increase in California, which also applies to the SES. As explained, the threat of severe flooding was once already realized in the SES, while the threat of fire was experienced first-hand by the researcher as nearby fires affected air quality and nearly warranted evacuation during data collection. As water insufficiency and drought are closely linked and often addressed with the same activities and methods in the SES, the issue of drought will be discussed alongside water insufficiency. Therefore, this section will focus on those activities and methods used to address flooding, fire, and the threat of climate change to larger and parallel systems. To continue, this issue and encompassed threats represent several different thresholds across scales, all with new unique system configurations if surpassed. Flooding severely threatens soil properties through erosion while both flooding and fire threaten biodiversity and soil characteristics; the surpassing of critical thresholds related to these features as a result of these shocks, or pulse disturbances, would likely push the system into an alternate stable state with new, yet to be known system configurations. Other impacts at bigger and parallel scales are also of concern but can come about in a variety of ways and have cascading effects for the SES and other parallel systems. The SES, therefore, uses many different activities and methods to address this issue across scales (7 activities, 25 methods).

In the SES, methods to reduce flooding include those that increase infiltration and reduce runoff. Much of these methods focus on increasing soil organic matter and, therefore, help improve infiltration, erosion and runoff reduction. This soil organic matter, as well as improved soil structure, also support moisture retention, which allows this vital water to be taken up by crops and vegetation well after a heavy precipitation event. Compost application and rotational cell grazing are two methods that reportedly aim to increase these capacities through soil organic matter input in the production zone and the broader landscape. Mulching and incorporating woody species are also used to increase soil organic matter in the production zone, while at the same time reducing water velocity on the soil surface. Furthermore, the thoughtful placement, construction, and maintenance of the berm that doubles as a road was also reportedly important for flood mitigation. This method is used to divide the valley floor in half so that in the case of a flash flood or extreme weather event, the waters from either side of the berm cannot converge to create a powerful and dangerous surge of water. The berm holds the water in place on the productive side, so runoff potential is significantly reduced. The also provides greater opportunity for infiltration and contribution of this water to groundwater directly under the production zone, recharging the domestic well and banking water for future crop use. These methods intend to address the risk of flooding, while other methods intend to mitigate fire risk.

To continue, regenerative grazing, enacted through rotational cell grazing, is used to mitigate the risk and impacts of wildfires, potentially preventing their occurrence and proliferation. This is predominately done by reducing fuel loads through the eating, trampling, and crushing of brush, thereby reducing the likelihood of wildfire occurrence and magnitude.

Finally, actively working to spread knowledge and skills that mitigate the impacts of climate change and regenerate landscapes is one of the key strategies used to address the threat of climate change at local and global levels. Holding educational programming and using methods that teach these skills helps to perpetuate this knowledge as participants take these learned skills and apply them elsewhere, supporting larger and parallel system mitigation. Additionally, the extension of educational programming to online platforms, as is currently underway, has the potential to expand impact even further as students can access this knowledge and associated skills from far-reaching places, further expanding the potential for mitigation at the global scale. Lastly, the SES offers scholarships to promote access to the knowledge and skills they teach, which are generally understood to be disseminated disproportionally along racial, gender and class line. Meanwhile effects of climate change are seen to affect people of lower socio-economic status disproportionately high in United States. Through this method, the SES attempts to not reinforce existing disparities in access to information on climate change mitigation techniques and uphold accessibility of information to support climate social justice. These activities and methods, therefore, support addressing global and local climate change and associated social impacts at larger and parallel scales.

Economic Instability and Collapse

Economic instability and potential subsequent collapse were identified as threats to the SES as the economic viability of the organization was often mentioned as of concern. Recent disturbances have severely threatened the economic viability of the SES, as enforcement of county zoning codes and the recent COVID 19 pandemic have disrupted critical revenue streams of the system. This issue is bounded at the focal scale and represents a threshold as economic collapse would lead to an alternate state with likely very different system configurations. This indicates a threshold that is subject to both press and pulse disturbances. Economic instability over a long period may put too much stress on the system and cause collapse, or the SES could be afflicted by an economic shock that causes collapse. Alternatively, a combination of both is also possible as long-term economic instability could leave the SES vulnerable to relatively small pulse disturbances. The SES employs activities and methods to address this issue (9 activities, 20 methods).

The primary method for addressing economic instability and collapse in the SES is to have a variety of revenue streams and sources. For example, acquiring multiple grants, donations from various sources, and hosting a variety of programs throughout the year. Having diversity in revenue streams and diversity within each income stream of sources supports the continuation of the organization in its current configuration as even if one stream or source fails, there are others to fall back on. This was shown to be the case after the disruption to the holding of onsite, short-term educational programming. Furthermore, creating cash flow projections is another method that is intended to keep distance from the threshold of economic collapse. The ability to anticipate financial fluctuations through cash flow projections allows the organization and the SES to plan and respond accordingly, potentially preventing the surpassing of an economic threshold. These methods support anticipating and coping with financial insecurity, while other methods have been put into place after a disturbance to the finances of the organization had occurred.

To continue, while the organization has a variety of revenue streams, it does rely heavily on the revenue from educational programming. As mentioned, due to laws and codes that restrict the ability to hold onsite programming as well as the onset of the COVID-19 pandemic, on-site programming has recently become unviable, accounting for a roughly 40% loss in annual revenue. While this loss in revenue has put a financial strain on the organization, these disturbances have also sparked adaptation strategies to combat this loss of income. For example, the organization has begun creating an online, virtual Permaculture Design Course to replace in-person courses. This strategy is intended to supplement revenue while also continuing to uphold the organization’s commitment to education and the spreading of knowledge and skills. Other typically in-person educational activities are now held virtually as well, such as the quarterly farm tour. These new methods are anticipated to help address the current financial insecurity of the SES.

Community Dissolvement

Concerns were raised by some community members over their satisfaction with living and working in the community, posing a threat to the SES if dissatisfaction were to reach a critical level by the community at large. Workaholism, financial feasibility, distance to urban centers, and certain aspects of community dynamics and interpersonal relationships that superimpose a social hierarchy were cited as points for dissatisfaction. As explained, the community of the SES is made up of staff and non-staff residents who live and work cooperatively, sharing resources and infrastructure and performing community tasks. While community happiness and cohesion is ultimately a goal for the SES, dissatisfaction and community dissolvement pose a threat to the continuation of the community and organization and will therefore be discussed from this perspective. This issue pertains to the focal scale, constituting a press disturbance and indicating a threshold as its realization would lead to an alternate system state. If the community of the SES was to dissolve, the SES would cease to exist in its current configuration as the community directly supports the organization and all of its activities. Activities and methods in the SES were reported that help to address the issue of community dissolvement (2 activities, 21 methods).

To begin, several methods that address community dissatisfaction and promote community happiness and fortitude in the SES revolve around dissolving hierarchical structures in governance. Through the activity of enacting decentralized, non-hierarchical governance, the method of allowing community members, regardless of affiliation to the organization, to join circles and attend weekly Village Business Circles is an example. This method allows all community members to have access to information about happenings and weigh in on discussions and contribute to decision-making, aspects which are seen as necessary for equality and the enactment of agency, seen as contributors to community member satisfaction. Additionally, implementing a flat pay structure is intended to dissolve hierarchical notions of labor value within the organization and contribute to equity and feelings of being valued. These activities and methods help address community dissolvement through participation in governance and the shaping of the SES.

Furthermore, activities and methods that support individuals in their creativity, empowerment, and skill development were reportedly used in order to support happiness, well-being. They also contribute to relationship building, seen as another contributor to happiness and wellbeing. These include holding community events, encouraging creative projects, artistic community groups, encouraging or leaving space for agency and self-empowerment, and cultivating and supporting skills and gifts of community members. The promotion of happiness and wellbeing through these methods may help to support community satisfaction. Additionally, an emphasis on beauty in communal and workspaces is another method used to support happiness as it is thought to be linked. Collectively, these activities and methods, and more, support happiness and wellbeing of the community on an individual and collective basis, and in doing so, help to abate community dissatisfaction and dissolvement.

Water Insufficiency and Drought

Water insufficiency and drought were noted as threats for crop production in the SES, having to do with the arid climate but also deficient infrastructure. As diverted surface water is used for irrigation, the availability of water and the quality of infrastructure are limiting factors with the potential to impact crop production. Water availability depends on the amount of water discharged from the spring and is affected by environmental conditions, biological interventions, and geologic configurations. However, even with these factors, the amount of available water that could be diverted for irrigation was reported to typically be sufficient to support production, though it is a limiting factor for expanding the production zone. It is, therefore, infrastructural problems with the water conveyance system that impact the ability to apply enough water consistently, threatening crop production in the arid climate. Issues with the water conveyance system include a lack of pressure to expel water effectively from multiple irrigation sources at one time and the buildup of sediment and air in the pipes, leading to sudden losses in water pressure. It is, therefore, the ability to deliver this water that poses the greatest threat to production as infrastructural issues limit the amount of water that can be applied at once.

Furthermore, a general lack of precipitation in the growing season is to be expected in the region. However, drought exacerbates the issue of water insufficiency due to infrastructural problems as more water is required for production than in average years but is not able to be supplied. As climate-change related cycle shifts are likely to increase the frequency of drought in the region, this issue is becoming pervasive. These issues significantly threaten crop production as press disturbances and increase vulnerability to pulse disturbances. As these issues are related to crop production, they apply to the smaller, nested plant production scale of the SES, impacting the focal scale in terms of fresh food availability. These issues do not represent thresholds that threaten the current system state of the SES, but could pose a significant loss to the system if crops were to fail, potentially having cascading effects. The SES employs activities and methods to address these issues (2 activities, 25 methods).

To begin, activities and methods to address water insufficiency resulting from infrastructural problems predominately revolve around observation and management of the water conveyance system. Diverted surface water discharged from the spring is sent to settling tanks, which are checked nearly daily, often multiple times in the day, and then sent to storage tanks to be used for irrigation, with some sent to reserve tanks to be held as a backup. These methods are intended to prevent problems from arising in the water conveyance systems and have a backup if water availability is reduced. However, when issues arise in water application due to infrastructural problems in the conveyance system, methods to remedy this issue are applied. This includes "belching," or expelling air and sediment from the water conveyance system, to revive water pressure, and teaching all community members to perform this process. The training of community members to perform this activity supports redundancy and time effectivity, as the method ensures that there is always someone able to address the issue. However, as these methods to mitigate the impacts of the insufficient water conveyance system require consistent human oversight and, when necessary, immediate action, this leaves room for potential error, and even short periods without water can lead to crop failure; therefore, focus has predominantly been on utilizing methods to increase infiltration and reduce evaporative loss in the production zone.

As previously mentioned, methods used to increase infiltration and reduce evaporative loss through regenerative crop production include cover cropping, sunken beds, double-dug beds, broad forking, mulching, perennial incorporation, on-contour production, compost creation and application, integration of woody species, as well as drip irrigation. Increasing infiltration rates helps to efficiently use any water applied from irrigation or occurs as precipitation, preventing water loss from runoff and sinking water deeper to be held longer. These methods also help to reduce the potential for evaporative loss. Soil coverage to reduce evaporation is also considered an important strategy; mulch helps to reduce evaporative loss through the holding of moisture and protecting the soil from wind and heat from sunlight. The SES uses different methods and materials for mulching; those most predominantly used are chop and drop, whereby waste plant material from crops or weeds is applied where they are removed, and allowing leaf litter from proximate woody species to lie and cover the production area floor. Straw brought in from outside the SES is occasionally used, though less preferred due to cost and attraction of birds. However, of all practices used to address the threat of water insufficiency and drought in the production zone, the integration of woody species, including in the form of alley cropping, is considered the most influential. These species, either trees or shrubs, create microclimates, reducing air and soil temperatures and wind speed, thereby reducing the potential for evaporative loss. The creation of these microclimates is considered key to production in the arid climate of the SES and with the limited ability to apply surface water for irrigation. Additionally, in support of this practice is the seasonal irrigation scheme, which, as explained previously, can use these woody species and the increase in water availability and precipitation in the winter months to infiltrate water deep into the ground and bank it for later uptake.

Finally, integrating drought-tolerant species and seed saving are also considered important methods to address water insufficiency and drought. These methods help increase the SES's ability to cope with a consistent lack of water availability, taking advantage of and efficiently using water that is available, and building tolerance to water insufficiency and drought.

Product Predation

Product predation was noted by several community members as a present issue as crops are being heavily predated upon by small animals. The cause for the overwhelming presence of these animals is believed to be twofold and largely human-created. The first is the presence of water in drip-lines for irrigation, creating an oasis in the arid climate and attracting wildlife to this concentrated area with water and available food. The second is due to the presence and proximity of the livestock guard dogs, which exist to deter large predators. This dynamic creates an ecosystem imbalance wherein small animals lack predators to regulate populations. Product predation is an issue as it reduces crop yields and the availability of self-produced food for the community, necessitating external food consumption and wasting labor and irrigated water, valuable resources. Product predation is a press disturbance, with many crops being eaten by animals, primarily small and medium-sized rodents and birds. This issue is concerned with the smaller, nested plant production scale, impacting the focal scale with reduced fresh food availability for the community. High crop predation could be considered a significant disturbance but would not likely shift the system into an alternate stable state; therefore, it is not considered a threshold but still of concern. The SES uses a few key methods to address this issue under the activity of regenerative crop production (1 activity, 5 methods).

In order to address product predation, methods that attempt to regulate pest populations have been used in the SES. For instance, periodic hunting of these small game is used to keep populations down. Another is to promote the presence of regulating species such as snakes and owls by creating habitat and not removing those species that do not threaten human life. These population regulation methods have had some success but have not managed to cut down predation sufficiently. Therefore, the organization has taken to physical barriers to address the issue, implementing net-lined hoop-houses and adding additional features to the existing greenhouse. These have shown to be mostly successful adaptation strategies. However, the scalability of this strategy is low as specialized infrastructure is required. Therefore, these methods will likely not be applied to the whole production zone. Furthermore, as products outside of these structures are not protected, this method could potentially increase predation on those crops. For these reasons and more, this method is likely to help the system cope but does not address the fundamental forces driving the issue, which have to do with the created ecosystem balance; and as the guard dogs are necessary to protect livestock, they will likely not be removed. Consequently, some community members have suggested acquiring a dog to hunt pests and protect crops, thereby inducing more ecosystem balance by replicating large predator-prey dynamics, but this has yet to be implemented.

Chapter 5: Discussion

This section presents overall themes, implications, and suggested future research.

Overall Themes

Overlap/ Divergence of General and Specified Resilience

This research showed that many of the activities and methods that support general and specified resilience in the SES overlap. What is more, some methods fulfilled multiple indicators and served to address several main issues. This points to the multifunctionality of these activities and methods to uphold the different forms of resilience. Activities and methods with a high level of multifunctionality, supporting both general and specified resilience and fulfilling multiple indicators and addressing multiple main issues, may be importance for overall resilience in the SES. These activities and methods were also often associated with reported importance in the SES, potentially supporting this claim. Methods that most exemplify this are rotational cell grazing and alley cropping.

Rotational cell grazing appeared to be one of the most important methods employed by the SES, supporting several general resilience indicators and playing a pivotal role in addressing several main issues. Under general resilience, rotational cell grazing is found in more than half (7) of the indicators, making it the most applicable of all the methods to this resilience type. Based on the critical phases of the indicators, it is also the only method represented in every phase of the adaptive cycle. Furthermore, rotational cell grazing addresses several main issues, all with potential thresholds, including desertification, watershed degradation, and fire and flood mitigation under climate-change related threats. The application to a significant number of general resilience indicators and specified resilience issues indicates a high contribution to resilience in the system, as the method is likely to help the system to cope and adapt to a variety of predictable and unpredictable disturbances. Additionally, key actors cited the method as one of the most important in the SES due to it serving a multitude of essential functions for the system, including contributions to the provisioning of vital ecosystem services. However, it is speculated by the researcher that this method's importance could create vulnerability if a disruption in its application occurs. The use of both goats and sheep in different temporal and spatial scales helps address this concern.

However, as the sheep do not remain in the SES throughout the year, there is still potential for vulnerability to disturbance and for loss of functions and benefits of this method. Nevertheless, this methods application to multiple indicators and main issues indicates a high level of importance for resilience in the SES, even if the use of the method itself may be vulnerable to disturbance.

Similarly, through its application to several indicators and main issues, alley cropping appeared to hold a high level of importance for resilience in the SES. This method, closely linked and often overlapping with the implementation of woody species in the production zone, is the second most applicable method to general resilience indicators (6) and is used to address several main issues (3). This prevalence and overlap indicates this method as critical for resilience in the SES by supporting the system to cope and adapt to predicted and unpredicted disturbances. Several key actors mentioned woody species integration in the form of alley cropping to be the most important method used for producing crops in the arid climate. Through these examples, it may be posited that methods that support both general and specified resilience may indicate particular importance and be pivotal for overall resilience in SESs. This also applies to activities, which include sets of methods, with some having additional contributions including supporting the necessary capacities and features for socio-ecological resilience.

Overlapping activities and encompassed methods in the SES serve to fulfill general resilience indicators and specified resilience main issues, contributing to overall resilience. As well, some activities appear to contribute to adaptive capacity and agency, which are necessary for socio-ecological resilience. For instance, enacting decentralized, non-hierarchical governance supports social self-organization, a key indicator for general resilience, and plays a critical role in addressing the threat of community dissolvement. By addressing this threat, this activity contributes to the prevention of surpassing a threshold and therefore contributes to the resilience of the SES. Meanwhile, through supporting social self-organization, the activity improves the ability of the community to enact necessary changes to the SES, supporting adaptive capacity and agency. Therefore, in supporting both general and specified resilience, this activity contributes to the resilience and socio-ecological resilience of the system. This example demonstrates how activities and methods can fill multiple roles in supporting both general and specified resilience as well as support the necessary capacities for socio-ecological resilience. However, while there was significant overlap in activities and methods for various indicators and issues, differences between those to support general and specified resilience uphold the need to consider both forms of resilience.

This research indicated that while general and specified resilience supporting activities and methods may often overlap, there is still divergence in those to support each contributing resilience type, and that this divergence holds significance for the overall resilience of the system. This is observed in methods created in response to an experienced or anticipated disturbance, constituting strategies for adaptation. An example is the raised road that acts as a berm, which was integrated as a method to specifically address the threat of flooding in the SES after the experienced 100-year flood altered system configurations. While this method supports some general resilience indicators, it has much greater significance under a specified resilience lens as it is a central strategy to reduce vulnerability to flooding. Without looking at specified resilience, this method would not appear to be of much significance, while in reality it is a key method to maintaining the system in its current configuration.

Furthermore, the implementation of the raised road that acts as a berm to mitigate flooding exemplifies the adaptive capacity in the SES and how activities and methods that support specified resilience can indicate this capacity. This is also the case for methods such as involvement in developing the Groundwater Sustainability Plan for the region, the design and creation of online educational programming, and the implementation of net lined hoop-houses in the production zone, all of which were created to address specific disturbances and threats. Also, all constitute adaptation strategies and therefore indicate adaptive capacity, showing how in supporting specified resilience, SESs can enact the necessary capacities for socio-ecological resilience. Therefore, looking at specified resilience separately is important to the system's overall resilience, as it can be used to identify issues of concern to the system, including those with potential thresholds, and highlights activities and methods that serve to address these issues.

Likewise, this research reinforced that independently considering general resilience is equally important to overall resilience as the activities and methods that support this resilience type are essential to building the ability to cope and adapt with unpredictable disturbances. This is exemplified by the unexpected disturbances that interrupted the ability to hold short-term, onsite educational programming, a vital revenue stream. In coping with this disturbance, social capital via social networks played a pivotal role in creating and implementing online educational programming. Supporting this general resilience indicator through activities and methods that build social capital facilitated the adaptation necessary to cope with these disturbances. This is also likely to be the case for future unknown disturbances that may come as a result of climate change. While global and local climate change is considered a specified issue in the SES, not all disturbances are predictable under its changes, and therefore activities and methods to support general resilience are fundamental to the resilience of the SES to this threat. This highlights that even where general and specified resilience diverge, they still have the potential to complement one another. Investigating these resilience types made this evident and supports the consideration of both forms of resilience when focusing socio-ecological resilience efforts in agroecosystems.

Importance of Values and Ethics

The values and ethics of the community seem to be of significance for socio-ecological resilience in the SES as they appear to play a role in the activities and methods employed in the SES, many of which contribute to general and specified resilience. In resilience literature, values are often considered contributing factors to resilience, supporting this claim (Walker et al., 2010; Herreria et al., 2010; Brown & Westaway, 2011; Berkes & Ross, 2013). This is seen in values such as diversity, regeneration, and experimentation. The value of diversity likely plays a role in the choice to use the method of promoting age diversity as part of community building in the SES, supporting the general resilience indicator honoring legacy. Similarly, the value of regeneration likely influences the choice of performing the activities of regenerative crop production and regenerative grazing, both of which contribute to several general resilience indicators and specified resilience main issues. Lastly, the value of experimentation, a value reported multiple times in this investigation, also appears to contribute to the socio-ecological resilience of the SES. While not directly related to any one activity or method, interest in experimentation may point to an increase in adaptive capacity as a willingness to try new solutions could lead to a greater ability to cope with change, a point echoed by Chapin et al. (2009). As illustrated through these examples, the community's values appear to impact the resilience of the system through influencing the choice of activities and methods.

Reported ethics also appeared to play an important role in contributing to the overall resilience of the SES by informing choices of activities and methods and how they should be performed. In particular, stewardship and ethics stemming from permaculture, such as earth care, people care, and fair share appeared highly influential. Stewardship can be linked with landscape and watershed stewardship, activities that support several indicators and main issues. This ethic and these activities can also be linked to the community's relationship with the area on which the SES operates. This area, or 'the land,' becomes seen as one that the community is in direct relationship with and is therefore responsible to care for. These notions of stewardship are supported by literature (Chapin et al., 2009), with contribution on the subject as it relates to change in SESs being made by Folke et al. (2016). These authors describe stewardship as "the careful and responsible management of something that you are responsible to care for." The authors go on to write, "as we see it, [stewardship] is an adaptive process of responsibility to shepherd and safeguard the valuables of not just oneself but also of others." In this way, stewardship reflects socio-ecological resilience dynamics and processes while adding dimensions of care for land and people. Therefore, the adherence to the ethic of stewardship in the SES, through the activities and methods chosen to enact it and the outlook applied through it, contribute to general and specified resilience in the system.

The influence of permaculture ethics also appear to contribute substantially to general and specified resilience in the SES as many of the activities and methods used in line with these ethics qualify as strategies to support both resilience types. Earth care, or the caring for the natural environment and its encompassed elements, likely influences methods such as regenerative crop production and regenerative grazing. As these activities intend to improve biogeophysical dynamics, while providing necessary products for the community, they support caring for the earth as well as caring for people. The ethic of people care appeared to impact further activities in the SES, including enacting a decentralized, non-hierarchical governance structure and community building, which are aimed to promote happiness and well-being. These are implemented to care for and support community members in the SES.

Finally, the ethic of fair share implies consuming what is necessary while upholding the needs of other entities, which appeared to influence the use of such activities and methods as the creation of a wildlife corridor and holding educational programming, which have to do with the sharing of resources, including space and knowledge. These activities and methods, and more, support both general and specified resilience in the SES; thus, ascribing to permaculture may be a contributing factor to the general and specified resilience of the SES.

Importance of Governance Structure

Through the analysis of activities and methods to support general and specified resilience in the SES, it can be argued that the most significant contributor to overall socio-ecological resilience is the enactment of a decentralized, non-hierarchical governance structure. In addition to the many indicators and issues it supports, this activity, and encompassed methods, forms the foundation for the adaptive capacity and transformability of the entire system and has made possible many of the adaptive changes to the SES. Through this decentralized, flat structure, community members can directly participate in the governance of the SES, which, as shown through this research, can lead to continual improvements in management that contribute to overall robustness. This is supported by Nightingale and Cote (2011) and Herreria et al. (2020), who point to research linking participatory governance structures with improved resilience. Moreover, this configuration breaks down hierarchical structures in governance and decision making, allowing all community members to contribute and make changes to the system based on the needs and priorities of the community, indicating agency. The building of agency and adaptive capacity supports the continuation of the SES as members have the ability to influence and collaboratively alter system configurations (Scherr et al., 2012). This is illustrated by the process that was undertaken to implement a flat pay structure. This adaptation highlights the ability of the SES to anticipate disturbance, in this case in the form of community dissatisfaction which could lead to community dissolvement, and preemptively adapt through a collective and collaborative process. This example signifies not only adaptive capacity and agency, but also combines other important features for socio-ecological resilience, including equity, accessibility, and effective governance. Hence, this governance structure makes possible the changes that allow the system to continually evolve and adapt, or potentially transform, to meet the changing needs of the system, building robustness to system state change and the necessary capacities and features for socio-ecological resilience.

Implications of this Research

Through the snapshot of the SES presented in this research, the SES can be considered a socio-ecologically resilient agroecosystem through the majority of activities and methods employed in the system supporting general and specified resilience. As well, the unique organizational system and governance structure allows for self-organization and adaptation, supporting adaptative capacity and agency. Therefore, this research can potentially support Southern California agroecosystem managers looking to build socio-ecological resilience in their systems, serving as a resource for activities and methods that support general and specified resilience in their context. In addition to these offerings, this research also points to necessary changes in broader food systems.

In order to realize the benefits of socio-ecological resilience in broader food systems, we must look to and support the factors and features that will make it effective and beneficial for the collective society, and adjust accordingly. For instance, as stated in the introduction, small-scale agroecosystems are considered to have the ability to help mitigate climate change while upholding biodiversity and promoting food security (Gonzalez, 2011). In line with this, it can be argued that the SES's small scale supports its ability to actualize general and specified resilience through having smaller feedback loops and the ability for community members to have an impact and make necessary changes, or adaptations, to the SES. Therefore, there should be a shift in production structures to small-scale systems to build socio-ecological resilience. Furthermore, the building of social networks and connections across systems was also an apparent contributor to socio-ecological resilience in this investigation. Therefore, agroecosystems should focus on building social capital via networks and interpersonal relationships. This is supported by Altieri et al. (2015), who relate adaptive capacity to social organization and networks. At the same time, while there should be an emphasis on small-scale systems and the building of networks across these systems, larger scales, encompassing regional and national governments and institutions, should support these efforts through policy. On these points, Gonzalez (2011) writes, "governments must re-orient resources toward small-scale farmers and toward the protection of the natural resource base necessary for food production." The author also notes the importance of this orientation for effective climate change mitigation (Gonzalez, 2011), a position that is supported by other authors (Berardi et al., 2011; Scherr et al., 2012; Webb et al., 2017). These shifts will require substantial and persistent effort to enact, but they are critical to the future of healthy and productive food systems.

Future research

This investigation brought to light possible questions and topics for future research. One question that became salient to the researcher is how the results of this research compare to the theoretical concepts of general, specified, and socio-ecological resilience. For instance, while analyzing the data for this investigation, it was posited by the researcher that activities and methods use different mechanisms, often via coping and adaptation, at different points in the adaptive cycle and at different scales to support socio-ecological resilience. A future research question, based on the data and results of this investigation, might be: How, or by what mechanisms and processes, do the activities and methods of the agroecosystem contribute to general and specified resilience and the property of socio-ecological resilience? Research into this topic could provide both theoretical and practical insight into these processes and mechanisms.

To continue, the lack of a clear methodology and assessment framework that integrates general and specified resilience in the context of agroecosystems points to the need for the development of a relevant framework. The importance of considering both general and specified resilience when investigating socio-ecological resilience is argued in theoretical frameworks, and is now supported by this research; however, as noted, there is a lack of studies and assessment frameworks that incorporate and give equal emphasis to both dimensions (apart from the recently published Meuwissen et al., 2019). Therefore, this study is unique in its combination of general and resilience assessment frameworks and considerations, potentially offering a new method for investigating socio-ecological resilience in agroecosystems. Further research would need to be done to speak to the viability of this combined assessment framework for investigating these resilience types in other agroecosystems.

Additional knowledge gaps to be addressed in future investigations and literature might include the relationship between permaculture and socio-ecological resilience. As mentioned, the adherence to permaculture and its ethics appeared to influence the socio-ecological resilience of the SES through the activities and methods chosen that uphold these ethics. The researcher also observed an overlap between permaculture principles and practices and those activities and methods found to support general and specified resilience. For instance, permaculture principles such as harvesting waste streams, using small and slow solutions, and applying self-regulation and feedback shared similarities with resilience supporting methods of harnessing waste streams for feed and compost creation and using small and frequent interventions in the riparian zone. Furthermore, in their general resilience assessment framework, Cabell and Oelofse (2012) reference permaculture founder Bill Mollison when mentioning the importance of functional diversity and redundancy, pointing to an existing connection between these two frameworks. Therefore, the link between permaculture and socio-ecological resilience could be a topic to be investigated in future research, particularly the potential of the adherence to permaculture to be a contributor to socio-ecological resilience.

Similarly, many methods in the SES that contributed to general and specified resilience overlap with agroecological practices, including cover cropping, mulching, agroforestry practices, compost application, and more. What is more, agroecology takes a systems approach when looking at agroecosystems, probing dynamics to develop beneficial relationships and feedbacks, much like socio-ecological resilience. Therefore, the relationship between agroecology and socio-ecological resilience in agroecosystems could also be a topic for further research.

Finally, as the governance structure of the SES appeared to play a central role in the socio-ecological resilience of the system, the intricacies of this governance structure and its relationship, or contributions, to socio-ecological resilience could be investigated further in subsequent research.

Chapter 6: Conclusion

This thesis answers the question: What activities and methods have the potential to contribute to general and specified resilience in a Southern California dryland agroecosystem? To investigate this question, the researcher lived and worked at Quail Springs Permaculture, a speculated socio-ecologically resilient agroecosystem, for five months in 2020. Here, the researcher performed participatory observation and conducted semi-structured interviews to understand system dynamics and collect data on activities and methods employed in the SES, which key actors reviewed for accuracy. The data were then analyzed using general and specified assessment frameworks. Initially, it was found that 17 activities and 145 unique methods were employed in the agroecosystem. Through analysis, it was discerned that all the activities and most of the methods contributed to general and specified resilience. The results showed that activities and methods can support both general and specified resilience in SESs but that it is still important to consider both forms of resilience as vulnerabilities can arise if one is omitted. The literature calls for combining general and specified resilience, and this investigation marked one of the first times that these two resilience types have been investigated simultaneously. This research also brought the two specific assessment frameworks by Cabell and Oelofse (2012) and Walker et al. (2010) together for the first time. This combination could be applied to other agroecosystems, which warrants further research.

Overall, this research supports the understanding that agroecosystems are complex and constantly subject to changing conditions and that, because of this, system managers must be ready for predictable as well as unpredictable disturbances. By employing methods and activities to support general and specified resilience, including those that support adaptive capacity and agency, agroecosystem managers can build these resilience types and overall socio-ecological resilience. However, this research raises the question of what are the mechanisms and dynamics that occur through or as a result of these activities and methods that bring about socio-ecological resilience, a topic to be covered in future research. Furthermore, unexpectedly, this research also shed light on the importance of values and ethics in agroecosystems and how these can contribute to general and specified resilience through activity and method choice.

California agroecosystem managers should apply socio-ecological resilience frameworks to their agroecosystems and integrate activities and methods that support both general and specified resilience to reduce vulnerability and build the necessary capacities for adaptation and transformation. This thesis was created to serve as a resource for farmers to contextualize activities and methods as part of general and specified resilience and to provide examples of applicable or comparable activities and methods to be applied in their context. Furthermore, this research can inform and be used by policymakers to support the application of socio-ecological resilience to food systems, focusing on small-scale agroecosystems, especially in California. In a changing world, the socio-ecological resilience of agroecosystems is critical for environmental preservation and regeneration as well as for the health and food security of people. A shift to this focus is founded upon the understanding that people and the environment, including food production systems, are inextricably linked and uphold one another; we must hold this understanding when looking at these systems to prevent contributing to further global collapse.

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Appendix

A: Dryland Context

Concerns over socio-ecological resilience are particularly applicable to agroecosystems in arid and semi-arid regions as temperatures increase and water resources decline or become less predictable (Maleksaeidi & Karami, 2013; Webb et al., 2017). According to Maleksaeidi and Karami (2013), water scarcity and quality reduction can show effects in both the ecological and social realms in the forms of biodiversity loss, soil degradation, food shortages, water conflicts, economic instability, migration and displacement. According to an IPCC report (cited in Altieri et al., 2015), the global surface temperature could rise 1.5 degrees Celcius, likely impacting precipitation patterns, including frequency and quantity. As Altieri et al. (2015) point out, "temperature and water availability remain key factors in determining crop growth and productivity," thereby posing significant threats to crop yields and food supply and access. As arid and semi-arid regions, or drylands, already have low levels of precipitation and often have high temperatures, these changes could have catastrophic effects, threatening agroecosystems and food security in these regions (Altieri et al., 2015). To prevent this collapse, regions and agroecosystems that have access to water for irrigation are predicted will rely on it more heavily, likely having its own impacts as competition for water resources increases (Altieri et al., 2015).

Today, 70% of withdrawn groundwater in the world is used for agriculture, much coming from groundwater reserves (Maleksaeidi & Karami, 2013). This has led to increased groundwater depletion globally, with depletion doubling in arid areas in the last several decades (Bourque et al., 2019). If these numbers were to increase, as they are expected to under continued shifts in precipitation and temperature pattern, it could have serious consequences for broad scale agroecoregions. Altieri et al. (2015) posit that, "falling water tables and the resulting increase in the energy needed to pump water will make the practice of irrigation more expensive, particularly when with drier conditions more water will be required per acre." These activities and reactions often cause positive feedback loops, exacerbating issues and multiplying and expanding detrimental impacts (Bourque et al., 2019). In sum, climate change and overexploitation of groundwater pose threats to water and food security in drylands (Maleksaeidi & Karami, 2013).

Finally, drylands are also more susceptible to change because of the general trend towards sparse vegetation, exposed ground surfaces (Peters et al., 2015), and lower levels of soil organic material (Lal, 2001; Maleksaeidi & Karami, 2013). This, in combination with existing and increasing intensity in flood events, means that drylands "are prone to the redistribution of biological materials, soil, and nutrients by wind and water" (Peters et al., 2015). These characteristics mean that "drylands are especially prone to state change, " often in the form of desertification (Bestelmeyer et al., 2015; Peters et al., 2015). Many definitions of desertification exist (Bestelmeyer et al., 2015; Peters et al., 2015); according to Peters et al. (2015), "it is generally considered to be a persistent and severe broad-scale reduction in biological productivity that results from interactions among land use, climate, and societal factors." Desertified landscapes are often sparsely vegetated with high connectivity, leading to patterned vegetation of often "woody plants separated by bare soil interspaces" (Okin et al., 2015). This arrangement is linked with high erosion in open spaces and deposition around woody plants, leading to a positive feedback loop of patterned vegetation and expansion of woody species, furthering desertification (Peters et al., 2006, Okin et al. 2015). Desertification processes can be sparked or exacerbated by disturbances such as flooding, fire, overgrazing, and other human activities that reduce plant cover and increase soil erosion (Peters et al., 2006). Climate change and intensified anthropogenic force are already believed to have caused degradation of up to 20% of global drylands (Chen & Wang, 2016).

B: California Context

Climate change and related effects are expected to strongly affect California's agricultural sector. According to Pathak et al. (2018), California agricultural production is "highly sensitive to climate change" and "while California farmers and ranchers have always been affected by the natural variability of weather from year to year, the increased rate and scale of climate change is beyond the realm of experience for the agricultural community." Changes and increases in temperature, increasing variability in precipitation amounts and patterns, increasing climate variability and extremes, and changes in water availability are all points of concern (Pathak et al., 2018).

Climatic variability including increasing temperatures, particularly in inland areas, such as the Central Valley, where agricultural production is most prevalent, will likely strongly affect agricultural production (Pathak et al., 2018; Maurer et al., 2020). Effects of this predicted temperature increase on agricultural production will likely be seen in reduced crop yields or potential crop failure due to heat related stress or from reduction in number of chill hours required for some fruit and nut production systems (Jackson et al., 2012; Pathak et al., 2018). Furthermore, temperature change because of climate change is also predicted to increase pest and disease spread (Jackson et al., 2012; Pathak et al., 2018).

Increased variability in precipitation rates and patterns is also anticipated, and with it an increased frequency and intensity of drought and flooding (Lund et al., 2018; IPCC, cited in Pathak et al., 2018). In fact, by the end of the 21st century California is predicted to be 15-35% drier, making the state even more vulnerable to drought (Pathak et al., 2018). In the state, snow and snowpack is considered a primary source of water for freshwater systems as almost 80% of average annual precipitation comes in the form of snow (Pathak et al., 2018). Changes in precipitation patterns and increasing temperatures are impacting snowpack amounts as well as thawing times, resulting in reduced snowpack, thereby reducing key freshwater availability, and likely leading to increased flooding events in parts of the state (Wilson et al., 2017; Lund et al., 2018; Pathak et al., 2018). This, in combination with increased frequency of drought means that California is likely "moving towards a flood-drought pattern" (Pathak et al., 2018). This flooding could further threaten agricultural production through topsoil erosion, root asphyxia, crop diseases, and nitrogen loss (Pathak et al., 2018). These issues are already having an impact on agricultural production systems, as was observed in the 2012 to 2016 drought (Lund et al., 2018), particularly when it comes to water availability for production (Wilson et al., 2017; Maurer et al., 2020).

One of the biggest issues affecting California is water availability and demand. With the lack of precipitation in the growing season and the limited or inaccessibility, as well as reduction, of surface, freshwater resources, the current agricultural sector in the state is highly dependent upon groundwater resources. These groundwater resources have been highly exploited in the state, leaving many groundwater basins, including the major groundwater basins of the Central Valley, to be considered critically over drafted (Critically Overdrafted Basins, 2020). California passed the Sustainable Groundwater Management Act (SGMA) in 2014 in order to address this issue and attempt to "bring over drafted basins back into long-term balance by 2040" (Bourque et al., 2019). However, as water resources continue to decline under the effects of climate change, already over drafted groundwater basins will likely be put under more stress of extraction (Wilson et al., 2017). For example, in dry years, groundwater extraction is observed to rise, making up nearly 60% of water used for irrigation in those years and increasing pumping costs (Wilson et al., 2017, Lund et al. 2018, Hanak et al. cited in Bourque et al. 2019). Meaning that effective and sustainable management of groundwater resources will only become more complicated in these areas as time goes on (Lund et al., 2018).

In addition to the direct effects these issues will have on crop production, as well as those who depend on them for income and food supply, they are also likely to have manifold effects on productive lands and lands providing vital ecosystem services to landscapes, including increasing risk of fire and desertification (Wilson et al., 2017; Pathak et al., 2018). For example, as Pathak et al. (2018) mention, "lower stream flow and groundwater levels as a consequence of drought can harm plants by increasing risk of wildfires as vegetation and soil surfaces dry out." This is also the case for desertification as drought and reduction in soil moisture holding capacity, often in combination with anthropogenic forces, can prompt the transition to woody, sparsely vegetated, erosive lands (Lal, 2001; Bestelmeyer et al., 2015; Peters et al., 2015; Chen & Wang, 2016).

These effects have also impacted regional economics with severe losses in revenue from crop production. Economic losses of $1.7 billion were calculated from 2014-2015 under severe drought conditions (Lund et al., 2018). Furthermore, the southern central valley appeared to be hit hardest under this drought (Lund et al., 2018). What's more, thousands of jobs were lost as a result of this economic downturn (Wilson et al., 2017).

C: Raw Data - Identified Activities and Methods

Table 2. Community System – Identified Activities and Methods		
Activity	**Method**	**Function**
Enacting Decentralized, Non-Hierarchical Governance	Weekly community meeting (Town Hall)	Allocate time to gather (coming together/ community building) and efficiently share information (policies, programming, available food, community events, missing items, necessary physical projects). Common time to identify/bring up and address issues pertaining to the community as they come up week to week. Allocated time for weekly check ins and offering of emotional support.
	Horizontal/ flat community structure	Promote non-hierarchical community structure focused on equity, inclusion, agency, and empowerment.
Community Building	Community events	Create time and space to gather (coming together/ community building). Community/ individual happiness and well-being. Opportunity for empowerment, creativity, and skill building through event coordination.
	Encouraging creative projects	Opportunity for agency, empowerment, collaboration, creativity, skill building/ sharing, art making/ beauty creation. Community/ individual happiness and well-being.
	Living communally/ cooperatively: sharing tasks, responsibilities, infrastructure, and resources	Model sustainable human settlement (community) and cooperative living. Increase time and resource efficiency. Increase wellbeing/ reduce stress (reduce daily workload, share tasks and responsibilities).
	Artistic community groups (ex: Muddy Daughters singing group)	Create time and space to gather (coming together/ community building). Community/ individual happiness and well-being. Promote creativity and art making/ beauty creation.
	Diversity promotion (conscious inclusion of community members from multiple age groups and backgrounds)	Promote community heterogeneity (diversity of viewpoints, input, and skills). Encourage cross-generational, cultural, experiential knowledge and perspective sharing.
	Encourage/ leave space for agency and self-empowerment	Capacity building, self-assurance, happiness and wellbeing.
	Cultivating and supporting skills and gifts of community members	Skill, capacity, and confidence building. Potential for future knowledge and skill sharing/ spreading. Happiness and wellbeing.
	Emphasis on beauty in communal and workspaces	Manifestation of value (beauty). Community/ individual happiness and wellbeing.
	(In development/ recurring) Establish Community Agreements	Establish shared agreements on community wide basis, as well as individual, in order to have common understanding of expectations and codes of conduct. Have agreement/ document to refer to in case of misunderstanding or disagreement.
	Skill sharing among community members	Skill and capacity building. Community building. Knowledge sharing.
	Cuyama Valley community engagement and support	Community/ relationship building. Mutual aid. Knowledge sharing and empowerment.

	Coming together over music, food, and celebration with larger regional community (e.g., concerts)	Community/ relationship building. Happiness and wellbeing.
Supporting Sustainable Food Systems	Purchasing staple goods from local cooperative/ farmers	Support local and regional producers. Participate/ engage in cooperative organization. Support efforts for sustainability (resource efficiency).
	Purchase organic or agroecological, in bulk, and with plastic-free packaging whenever possible	Reduce environmental impact of offsite food production and consumption.
	Considering social and ecological impact of food grown offsite	Ensure upholding of values and ethics of community.
	Trading goods and services	Mutual aid. Relationship building. Reduce expenses.

Table 3. Educational System – Identified Activities and Methods

Activity	**Method**	**Function**
Holding Educational Programming	Holding long-term programs (on-site)	Teach land-based and community skills. Promote/facilitate environmental stewardship, civic engagement, advocacy, empowerment. Fulfillment of permaculture ethic of sharing knowledge. In-depth community skill building (short-term community members). Provide labor source. Network building.
	Holding short-term programs (on-site)	Teach land-based and community skills. Promote/facilitate environmental stewardship, civic engagement, advocacy, empowerment. Fulfillment of permaculture ethic of sharing knowledge. Provide revenue stream. Network building.
	(New) Holding online/virtual programs (online PDC and virtual farm tours)	Teach land-based and community skills. Promote/facilitate environmental stewardship, civic engagement, advocacy, empowerment. Fulfillment of permaculture ethic of sharing knowledge. Adaptive strategy to augment revenue stream in response to loss of short-term on-site programming (alternative revenue stream).
	(New) Online/virtual, informal educational content (i.e., Patreon)	Teach land-based skills and concepts. Promote environmental stewardship and empowerment. Fulfillment of permaculture ethic of sharing knowledge. Supplementary revenue stream.
	Online/virtual, informal educational content (social media/ website)	Share information/ explain concepts related to land-based skills and practices. Promote environmental stewardship, civic engagement, advocacy, and empowerment. Fulfillment of permaculture ethic of sharing knowledge. Network building.
(Methodology)	Emphasis on kinesthetic/ experiential/ hands-on teaching/learning.	Increased retention of information and ability/skill.

	Emphasis on community involvement/ cooperation.	Gain experience working/ collaborating/ cooperating with others. Participants observe/learn that people working cooperatively/ collaboratively, rather than individually, have the ability to accomplish more, use resources more efficiently, have more creative solutions and ideas, feel happier and more connected.
	Classroom/ lecture-based teaching/learning.	Convey information/ techniques otherwise unable/ give examples from different contexts.
	Highlighting local and indigenous practices and insights.	Highlight practices based on applications in similar context over extended periods of time (sustainability). Present examples of cultural practices that arise through connection to place.
Relationship/ Network Building (Educational)	Building and maintaining networks (individuals)	Develop and secure partnerships for group participation/ program creation and holding (parents, educators, activists, etc.)
	Building and maintaining networks (organizations)	Develop and secure partnerships for group participation/ program creation and holding (organizations working with environment, education - including schools, social services, etc.)
	Virtual/ indirect network building and engagement (social media)	Procure participants.
Promoting Accessibility of Programming	Offering scholarships	Facilitate equitable access to programs. Contribute to commitment to diversity, equity, and inclusion.
	Sliding scale payment option	Increase accessibility of programs for those with less economic means. Contribute to commitment to diversity, equity, and inclusion. Generating higher revenue (from participants who can afford) and channel portion to scholarships.

Table 4. Organizational System – Identified Activities and Methods

Activity	**Method**	**Function**
Enacting Decentralized, Non-hierarchical Governance	Divide organizational realms into Circles	Break down organizational/ community work/ realms into functional working groups. Allow for collaboration/ multiple perspectives/ "eyes" for identifying, coordinating, and carrying out tasks. Ensure oversight on aspect of organization (through dedicating circle to aspect, with multiple individuals having oversight). Move toward less hierarchical structure (make input and decision making accessible/ open to all community members). Staff/ personal development/ wellbeing (allow staff to learn/ play a part in aspect of organization not explicitly a part of their position). Transparency in work and decision making.
	Circles develop domain (to be approved at VBC) and make decisions within that domain	Define clear parameters for what is included (and not) in Circle's oversight. Allow for effective and efficient decision making. Transparency in work and decision making.
	Ability for community members (staff and non-staff) to join Circles	Move toward less hierarchical structure (make input and decision making accessible/ open to all community members). Promote cooperation/ sharing of responsibilities and tasks. Personal/ skill development of community members.
	Weekly Organizational Meeting (Village Business Council)	Allocated time for staff to gather/meet, give updates (projects, communications, financials), ask clarifying questions, identify issues to be addressed and assign break-out groups. Space/time to hold organization wide discussions and proposals.

	Formation of Break-Out Groups	Allow for smaller group of skilled/ knowledgeable/ interested people to address specific issue outside of larger group setting (time efficiency).
	Weekly meeting (VBC) open to staff and non-staff community members	Dismantle hierarchical structure within organization (allow for accessibility/ openness of information, input, and decision making to all those living on land- technically also those visiting).
	VBC Proposal Process (decisions made as group)	Ensure that larger decisions (heavily impacting whole organization/community and/ or costing large amount of money) are deliberated/ decided upon communally. Allow for clarification, comments/input/adjustments, and approval/passing or vetoing by members. Dismantle/ do away with hierarchical decision-making processes (make decision making accessible/ open to all staff and community members).
	(New) Flat Pay Structure	Move away from hierarchical pay structure (payment variation based on position and/or type of work) and move toward flat pay structure (pay independent of position and/or type of work); value all forms of labor, and individuals performing that labor, and reflect that in equal compensation.
	(In process) Equitable pay structure	Design new pay structure that moves away from typical organizational hierarchy of compensation and instead reflects values (ex: equity, fairness, care, mutual support,* etc.). Collaboratively designed to ensure equitable input, consensus in design, and buy in/willingness to uphold.
Revenue Generation	In-person programs (short-term)(not currently possible - County Codes and COVID-19 Pandemic)	Provide revenue for organization to spend on hosting/running programs, facilities and infrastructure, employee salaries (stipends), community food, etc.
	(New) Virtual program(s)	Alternative method to provide revenue for organization to spend on facilities and infrastructure, employee salaries (stipends), community food, etc.
	Grants (public and private)	Secure monetary support for projects to cover associated costs (ex: inputs, labor/ compensation, etc.)
	Fundraising (donations)	Obtain monetary support for projects and/ or operational expenses (programs, facilities and infrastructure, employee salaries (stipends), community food, etc.)
	Maintaining relationships with donors (of large amounts)	Increase likelihood to continue to receive monetary support to be used for projects and/ or operational expenses (programs, facilities and infrastructure, employee salaries (stipends), community food, etc.)
Financial Management	(New) Cash Flow Projection	Inform monetary allocation (how money is divided/ allocated), decisions (what money should be spent on), and strategy (how and when is should be spent). Anticipate monetary fluctuations and plan/ respond accordingly (spending and revenue strategy).
Relationship/ Network Building (Organizational)	Personal contact/ support/ exchange with individuals	Maintain and grow network with common interests and goals. Build social capital to allow for exchange of information, resources (monetary or otherwise), skills, etc. Support individuals in carrying out parallel work (upholding values and larger goals).
	Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region)	Obtain and/ or give support (monetary, resource, labor, services/skills) at organizational (and sometimes individual) level. Establish or enter into professional/ organizational networks (expand/ multiply interactions/ relationships). Support local and regional initiatives (engage with community and build healthy interdependence).
	Social media coordination (virtual communication)	Reach broader/larger audience. Maintain and grow network with common interests and goals. Build social capital to allow for exchange of information, resources (monetary or otherwise), skills, etc. Support individuals and organizations in carrying out parallel work (upholding values and larger goals).

Table 5. Water System – Identified Activities and Methods		
Activity	**Method**	**Function**
Watershed Stewardship	Discontinuing open-range grazing with domesticated cattle	Prevent associated negative impacts (overgrazing - species preferences ex: willow and cottonwood, erosion from wallowing and animal trailing, compaction).
	Rotational cell grazing (goats and sheep)	Increase soil organic matter and mulch (manure and knocking down/ crushing brush/ standing dead) in an effort to increase moisture retention, infiltration, and plant occurrence/growth. Reduce propensity for compaction.
	Calculated erosion: Engaging meander	Slow and spread water to allow for increased infiltration/ groundwater recharge/ plant availability (creation of flood-plain/ bank deposition, counteract channeling, increased area surface water covers- more time/ opportunity for infiltration). Prevent erosion (counteract channeling, spread material coming down gradient over wide area).
	Calculated erosion: Promoting widening/ flattening	Increase potential for infiltration/ groundwater recharge (slow water flow/ increase time in area). Prevent channeling/ vertical erosion/ promote horizontal instability/ widening (slow water and base load). Increase availability for plant/ expand riparian zone (increased bank saturation).
	Check dam implementation (i.e., Gabions)	Catch sediment. Hold back water/ slow flow to allow for increased infiltration/ groundwater recharge (bank widening and increased time in one location).
	One rock dam implementation	Grade control (prevent erosion at head cut).Flatten channel/ spread sediment horizontal. Slow flow to allow for increased infiltration/ groundwater recharge (bank deposition and increased time in area).
	Sedge-mat grade control implementation (inoculation of sandbags with propagated riparian material)	Prevent erosion. Increase biodiversity. Regeneration of riparian zone. Contribute to soil organic matter and moisture retention/ infiltration.
	Riparian flora cultivation (creek)	Regeneration of riparian zone. Erosion prevention. Increase biodiversity. Provide habitat. Contribute to soil organic matter and moisture retention/ infiltration. In connection with engaging meander (tandem work).
	Observation of intervention effects and adjustment	Attempt to ensure positive impact/ prevent negative or harmful impact through observing intervention effects and adjusting methods. Abide by permaculture principle of slow and steady improvements. Continually learn and improve methods.
	Small and frequent interventions	Attempt to ensure positive impact/ prevent large scale negative or harmful impact through small interventions rather than large (which, if the intervention had a negative effect, can be more damaging). Abide by permaculture principle of slow and steady improvements. Continually learn and alter methods.
	Awareness/ self-regulation of water diversion	Prevent over diverting water and associated negative impacts (biodiversity loss - flora and fauna, continued desertification, prevent groundwater and watershed replenishing/ regeneration). Uphold permaculture ethic of Fair Share. Restrict development to availability (sustainable yield).
	Pond creation	Habitat creation (biodiversity support). Groundwater replenishing.
	Berm/ swale implementation on erosive slopes	Hold back water/ slow flow to allow for increased infiltration/ groundwater recharge (increased time in one location). Prevent erosion below catchment (capture water coming from above catchment/ load reduction).

	Integration of woody species (production zone)	Create microclimate to reduce evaporation (shade - air/soil temperature, evapotranspiration - relative humidity). Increase soil moisture retention (leaf litter - mulch and soil organic matter). Increased infiltration and retention (roots - preferential flow). Erosion prevention (leaf litter - mulch and soil organic matter, tree trunks and roots - barriers, roots - increased infiltration rate/preferential flow). Potential for groundwater recharge (roots - preferential flow).
	Contoured micro-swales (production zone)	Increased infiltration (catchment of water from rainfall and irrigation). Erosion prevention (catchment of water from rainfall and irrigation). Leaf litter catchment.
	Sunken beds (production zone)	Increased infiltration (catchment of water from rainfall and irrigation). Erosion prevention (catchment of water from rainfall and irrigation). Leaf litter catchment.
	Mulching (straw, wood chips, not removing leaf litter) (production zone)	Increase soil moisture retention. Contribute to soil organic matter. Prevent erosion (slow/ prevent run-off). Increase infiltration (slow/ prevent run-off). Reduce evaporation (reduce and cool soil).
	Raised road (berm)	Mitigation of flash-flood impact/ removing garden from flood plain (prevention of accumulation/ combining of water from other half of valley - area of valley surface cut into two). Increased infiltration (catchment and retention of rainfall from in and up-slope of garden). Erosion prevention (intercept high velocity water, prevent from entering channel/ accumulating/ combining with water from other half of valley).
	Road maintenance	Direct/ deter water flow. Prevent channeling. Prevent erosion.
	Support for local legislation on sustainable groundwater use and management	Stabilize groundwater resources through the regulation of groundwater use in the basin (aim to reach sustainable rates by 2040). Prevent further degradation of the regional watershed. Increase awareness of watershed dynamics and issues regionally.
	Education and outreach on watershed sustainability and stewardship	Encourage and empower Cuyama Valley community members to engage with the local water system.
Irrigation Management	Training staff and community members on "belching" water system (expelling air and sediment)	Resilience to threat of water insufficiency due to water conveyance system.
	Diverted surface water to holding tanks	Water storage. Increase water pressure. Serve as settling tanks (reduce sediment that feeds into system below).
	Reserve tanks	Storage tanks for water reserves/ back-up (in case of lack of pressure, heavy rain/ storm events, etc.).
	Greywater use	Irrigation. Groundwater contribution. Waste stream harnessing.
	Seasonal irrigation scheme	Irrigation management. Impact success rate of trees and annuals. Bank water for later uptake. Contribute to groundwater recharge.

Table 6. Landscape System – Identified Activities and Methods		
Activity	**Method**	**Function(s)**
Landscape Stewardship	Discontinuing open-range grazing with domesticated cattle	Prevent associated negative impacts (overgrazing - species preferences ex: willow and cottonwood, erosion from wallowing and animal trailing, compaction).
	Rotational cell grazing (goats and sheep)	Rangeland management/ landscape regeneration. Add microbiology and nutrients (manure). Increase soil organic matter (manure and knocking down/ crushing brush/ standing dead). Fire mitigation (knock down/ crush brush/ standing dead). Carbon sequestration. Prevent landscape degradation. Stimulate plant growth.
	Breed selection (Goats)	Reducing impact on riparian zone (Nubian goats do not need/ strongly desire wet areas or riparian flora). Heat tolerance.
	Wildlife Corridor creation (limiting infrastructural development on south side of road/ spring)	Create/ ensure uninterrupted habitat (wildlife corridor/ zone).
	Removing dead/ dying Pine (mostly fallen but occasionally standing)	Firewood procurement. Attempt to reduce beetle bore spread. Fire mitigation (removing flammable material).
	Designating and protecting (not removing) specific standing dead trees	Habitat protection. Carbon storage.
	Thoughtful road placement and design	Prevent creating gully/ water pathways (not building in way that will pool or keep/ direct water flow). Stack functions (Road for driving and used as berm).
	Road Maintenance	Prevent creating gully/ water pathways.
	Raised road (berm)	Catch, retain, (potentially) infiltrate water (precipitation). Flood mitigation (prevent runoff from entering creek and accumulating).
	Habitat Creation in Zone 1 (Trees, etc.)	Increase biodiversity. Insect predation/ management.
	Bee Keeping	Pollination services. Honey production.
	Pond Creation/ Maintenance	Habitat creation. Increase Biodiversity. Groundwater recharge.
	Choose most degraded land to cultivate/ regenerate or develop	Regenerate the most degraded land. Conserve less degraded land and manage in different ways (restoration/regeneration).
	Divert a portion of surface water to production zone	Irrigation (grow plants- food, shade, carbon, habitat). Infiltrate water (with hope to recharge groundwater).
	Integrating adapted non-native species.	Fulfill more niches. Create redundancy. Increase biodiversity. Create more opportunity for habitat. Provide food/ usable products. Increase opportunity for microclimate creation.
	Partner with local regenerative sheep grazing operation.	Realize the benefits of rotational cell grazing but in short-term, broad-acre application.

Table 7. Animal System – Identified Activities and Methods		
Activity	**Method**	**Function**
Regenerative Grazing	Goat rearing/ having goats	Perform regenerative grazing. Provide products to community (milk, yogurt, cheese, occasional meat). Entertainment/ community happiness. Uphold ethics for sustainability.
	Grazing (in general)	Provide feed. Reduce costs (feed on uncultivated land). Build soil organic matter -carbon (trample dead material). Build soil organic matter though improve decomposition rate (trample dead material). Build soil organic matter and fertility - processed organic material containing Nitrogen* (distribute manure). Stimulate plant growth through disturbance (grazing back plants). Fire suppression (removing material, trampling brush).
	Rotational Cell Grazing (goats and sheep)	Realize benefits of grazing AND Prevent/ minimize overgrazing and under grazing (strategic movement through landscape, ensuring areas do not get grazed too often or are missed). Reduce time on erosive areas. Contribute to landscape restoration/ regeneration.
	Deep Bedding	Material for compost for organic matter accumulation and fertility. Reduce labor (less cleaning). Take advantage of time and elements by letting compost in place.
	Pen Manure Harvesting	Material for compost for organic matter accumulation and fertility. Keep pen clean.
	Feed Milking Does in addition to grazing.	Provide extra nutrients to milk productive goats.
	Fodder production	Food supplementation. Reduce costs. Reducing external inputs. Produce biomass. Support cyclical production.
	Breed Selection and Breeding	Breed selection: Choose breed suitable for climate (water availability), vegetation, and terrain. Breeding: Breed goats suitable for climate, vegetation, and terrain.
	Culling young bucks	Meat source. Reduce heard size (potential impact on land - grazing, improve manageability of herd). Reduce likelihood of milk being lost to baby consumption.
	Guard dogs	Ward off predators.
Chicken and Egg Production	Chicken rearing	Provide products to community (eggs and occasional meat). Uphold ethics for sustainability.
	Cell Rotation	Intensive grazing (picking over available food in area and then letting rest). Build soil organic matter and fertility- processed organic material Nitrogen* (distribute manure intensively- in small area).
	Deep Bedding	Material for compost for organic matter accumulation and fertility.
	(In process) Cover Crop for Feed	Feed. Reduce costs (feed). Build soil organic matter (adding/ incorporating remaining organic material).
	Food waste for feed (onsite and local)	Reduce costs (feed). Resource efficiency (utilizing waste stream, "Slowing the process of entropy"). Nutrient supplementation (particularly whey).
	Garden waste for feed	Reduce costs (feed). Resource efficiency ("Slowing the process of entropy"*). Nutrient supplementation. Uneaten remains contribute to soil organic matter build up.
	Back stocking surplus eggs	Store surplus for later use. Available for trading and bartering.

	Breed Selection	Choosing breeds that are more suited to climate, good in meat production and laying, and less prone to flight.
	Annual Breed Variation	Distinguishing age for tracking of laying cycle and, later, culling for meat.
	(Potential) Breeding and Incubation	Breeding: Breeding birds that are adapted to climate, good in meat production and laying, are less prone to flight, and potentially display preferable traits. Incubation: Produce chicks that have been bred for above characteristics. Reduce costs.
	Flock of Chickens in Goat Pen	Pest management (control fly populations).
	Shade/ Canopy Creation (tree canopy and structures)	Meet chickens needs for overstory (protection from elements/ predation). Reduce temperature/ impact of heat.
Planning, Monitoring, and Adjustment (Animal System)	Planning (goats, sheep, chickens)	Prevent overgrazing/ under grazing. Gauge availability of feed. Inform possibility to expand/ understand needs of community and potential to expand.
	Monitoring/ Observation	Try to discern what impact the current system is having (exploration of relationships and impact to inform adjustment of system/ methods).
	Adjusting of System/ Methods	Prevent/stop negative impact. Improve resource efficiency and effective utilization. Experimentation.
	Record Keeping	Support planning, monitoring, and adjustment.
	Purchase feed and supplies from local suppliers	Support local suppliers.

Table 8. Plant Production System – Identified Activities and Methods

Activity	**Method**	**Function**
Regenerative Crop Production	Cover cropping (with leguminous species)	Reduce evaporation. Erosion prevention. Fertility improvement (nitrogen fixation).
	Alley cropping	Microclimate creation (sun protection, temperature control). Reduce evaporation (wind protection). Increased infiltration and moisture retention Fodder production. Provide habitat. Leaf litter acting as mulch.
	Drip Irrigation	Reduce evaporative loss of water during irrigation (compared to overhead sprayers)
	Transplanting	Higher germination rates than direct seeding (because of climatic factors). Prevent stunting (due to extreme temperatures). Season extension (before last frost.
	Sunken beds	Increase infiltration. Reduce runoff (from rainfall or irrigation).
	Double dug beds	Increase infiltration (deeper layers). Amend soil in cropping areas (organic material added).
	Path mulching	Weed suppression. Soil building (moisture, biome, fungi). Reduce runoff.

	Cutting annuals to base (leaving root system intact)	Not disturbing/ removing root micro-biome. Leaving to contribute to soil organic matter. Soil structure. Preventing erosion.
	No-till	Not disturb soil biome. Increase infiltration (soil structure). Moisture retention/ reduce evaporative loss (soil organic matter buildup). . Erosion prevention (soil organic matter buildup).
	Broad-forking	Improve aeration and infiltration (particularly for hydrophobic soils). Maintain soil biome.
	Hand-watering transplants/ direct seeded beds	Ensure moisture while plants germinate and establish roots.
	Crop rotation	Pest/ pathogen prevention/ mitigation. Nutrient availability.
	Poly-cropping	Deter pests. Beneficial relationships.
	Interplanting	Deter pests. Space use (stacking). Beneficial relationships.
	Pollinator attractor integration.	Attract pollinators. Attract predatory insects. Deter pests (strong smell).
	Leguminous species integration.	Nitrogen fixation (nutrient availability).
	(In past) Straw mulch	Cover soil (prevent evaporation loss) and hold moisture.
	Mulch (leaf litter)	Cover soil (prevent evaporation loss) and hold moisture.
	Greenhouse production	Climate control (warming), take off hard freeze. Maintain moisture/ humidity. Deter predators (raised beds).
	Seed saving	Cultivate plants with preferred traits.
	Woody species/ Perennial incorporation	Reduce labor. Carbon storage. Soil biome building. Root anchoring. Creating self-sustaining/ resilient food systems long term.
	Coppicing	Fodder and firewood production.
	On-contour production/ micro-swales	Water catchment and retention.
	Hoop-house production	Protection from predation. Shade structure (extreme temp and sun).
	Pond creation.	Habitat creation (biodiversity support). Groundwater replenishing.
	Seasonal irrigation scheme	Irrigation management. Impact success rate of trees and annuals. Bank water for later uptake. Contribute to groundwater recharge.
	Remay covering	Predator and element protection.
	Compost creation and application.	Build soil structure (soil organic matter). Improve nutrient availability and functioning (mycorrhizal fungi).
	Introducing pest regulating species (parasitic wasps)	Pest regulation.
	In situ habitat creation for pest regulating species (toads/frogs, snakes, owls)	Pest regulation. Biodiversity support.

	Drought tolerant species integration	Tolerance to water insufficiency.
	Native cultivar integration.	Tolerance to water insufficiency. Adapted to local conditions.
	Heirloom variety integration	Increased potential for water insufficiency tolerance. Preservation of biodiversity/ genetic heritage.
	Surface water use for irrigation.	Use of an available resource for crop production. Prevent the use of groundwater (contribution to groundwater depletion). Potentially recontribute water to groundwater.
	Trapping/ Hunting	Reduce pest populations.
Planning, Monitoring, and Adjustment (Plant Production System)	Planning	Prevent nutrient depletion and pest/ pathogen susceptibility. Gauge community needs and plan accordingly.
	Monitoring/ Observation	Try to discern what impact the current system is having (exploration of relationships and impact to inform adjustment of system/ methods).
	Adjusting of System/ Methods	Prevent/stop negative impact. Improve resource efficiency and effective utilization. Experimentation.
	Record Keeping	Support planning, monitoring, and adjustment.

D: Values and Ethics Data

Table 9. Values and Ethics Data	
Values	**Ethics**
Advocacy	Support Local
Anti-consumerism	Resilience **X2**
Communication	Environmentalism
Community Based Outlook	Living Convictions (as best we can)
Creativity	Stewardship
Creativity, Arts, and Crafts	Recycling
Diversity	Earth Care
Experiential education	People Care
Experimentation **X2**	Fair Share **X3**
Frugality	Participation
Gratitude	Simplicity
Imagination	Return Abundance
Inclusiveness	
Integrity	
Inter-connection	
Kindness	
Music/Singing	
Non-judgmentalness	
Patience	
Place to grow personally/ professionally	
Positivity	
Regeneration	
Renegade	
Resourcefulness	
Restoration	
Sustainability	
Teaching	
Visionary	
Wilderness	

E: General Resilience Data

Table 10. General Resilience – Activities and Methods to Support Indicators				
Indicator + (Phases)	**Activities**	**Activity (Count)**	**Methods**	**Method (Count)**
Ecologically self-regulated (Exploitation to Conservation)	Watershed stewardship. Landscape stewardship. Regenerative grazing. Regenerative crop production.	4	Rotational cell grazing (goats and sheep). Check dam implementation. One rock dam implementation. Sedge-mat grade controls. Riparian flora cultivation. Berm/ swale implementation on erosive slopes. Integration of woody species (production zone). Contoured micro-swales (production zone). Sunken beds (production zone). Mulching (straw, wood chips, not removing leaf litter) (production zone). Raised road (berm). Breed selection (goats). Wildlife corridor creation. Designating and protecting specific standing dead trees. Thoughtful road placement and design. Habitat creation in Zone 1. Bee keeping. Integrating adapted non-native species. Grazing (in general). Deep bedding. Flock of chickens in goat pen. Cover cropping (with leguminous species). Alley cropping. Sunken beds. Cutting annuals to base. No-till. Crop rotation. Poly-cropping. Interplanting. Pollinator attractor integration. Leguminous specie integration. Mulching (leaf litter). On-contour production. Pond creation. Compost creation and application. Introducing pest regulating species. In situ habitat creation for pest regulating species. Drought tolerant species integration. Native cultivar integration. Heirloom variety integration.	40
Appropriately connected (Exploitation to Conservation)	Community building. Supporting sustainable food systems. Holding educational programming. Relationship/ network building (Education). Enacting decentralized, non-hierarchical governance. Revenue generation. Relationship/ network building (Organization). Watershed stewardship. Landscape stewardship. Regenerative grazing. Chicken and egg production. Regenerative crop production.	12	Community events. Living communally/ cooperatively. Artistic community groups. Diversity promotion. Skill sharing among community members. Cuyama Valley community engagement and support. Coming together over music, food, and celebration with larger regional community. Purchasing staple goods from local cooperative and farmers. Holding long-term programs (on-site). Holding short-term programs (on-site). Holding online/virtual programs (new). Online/virtual, informal educational content. Building and maintaining networks (individuals). Building and maintaining networks (organizations). Virtual/ indirect network building and engagement (social media). Dividing organizational realms into Circles. Ability for community members (staff and non-staff) to join Circles. Weekly Organizational Meeting (Village Business Council). Weekly meeting (VBC) open to staff and non-staff community members. (New) Virtual program(s). Personal contact/ support/ exchange with individuals. Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region). Social media coordination (virtual communication).Rotational cell grazing (goats and sheep). Calculated erosion (engaging meander). Calculated erosion (promoting widening/ flattening). Check dam implementation. One rock dam implementation. Sedge-mat grade controls. Riparian flora cultivation. Berm/ swale implementation on erosive slopes. Raised road (berm). Grey water use. Wildlife Corridor creation. Designating and protecting (not removing) specific standing dead trees. Thoughtful road placement and design. Habitat Creation in Zone 1. Bee keeping. Goat rearing/ having goats. Grazing (in general). Deep bedding. Pen manure harvesting. Fodder production. Chicken rearing. Cell rotation (chickens). Deep	63

			bedding (chickens). Food waste for feed. Garden waste for feed. Flock of chickens in goat pen. Cover cropping (with leguminous species). Alley cropping. Crop rotation. Poly-cropping. Interplanting. Pollinator attractor integration. Mulch (leaf litter). Seed saving. Woody species/ Perennial incorporation. Pond creation. Seasonal irrigation scheme. Compost creation and application. In situ habitat creation for pest regulating species. Surface water use for irrigation.	
High degree of spatial and temporal heterogeneity (Exploitation to Conservation)	Community building. Holding educational programming. Enacting decentralized, non-hierarchical governance. Watershed stewardship. Landscape stewardship. Regenerative grazing. Regenerative crop production.	7	Hold variety of community events and activities over time (Community events, Artistic community groups, Coming together over music, food, and celebration with larger regional community). Diversity promotion. Hold/ produce variety of educational programs throughout year (Holding long-term programs (on-site), Holding short-term programs (on-site), (New) Holding online/virtual programs, (New) Online/virtual, informal educational content, Online/virtual, informal educational content). Divide organizational realms into Circles. Ability for community members (staff and non-staff) to join Circles. Weekly meeting (VBC) open to staff and non-staff community members. VBC Proposal Process. Calculated erosion (engaging meander). Calculated erosion (promoting widening/ flattening). Check dam implementation. One rock dam implementation. Sedge-mat grade control implementation. Riparian flora cultivation. Small and frequent interventions. Integration of woody-species (production zone). Rotational cell grazing (goats and sheep). Wildlife corridor creation. Designating and protecting specific standing dead trees. Habitat creation in Zone 1. Pond creation. Cover cropping (with leguminous species). Alley cropping. Crop rotation. Poly-cropping. Interplanting. Pollinator attractor integration. Greenhouse production. Pond creation. Seasonal irrigation scheme. In situ habitat creation for pest regulating species.	36
Globally autonomous and locally interdependent (Exploitation to Conservation)	Community building. Supporting sustainable food systems. Holding educational programming. Relationship/network building (Education). Relationship/ network building (Organization). Watershed stewardship. Landscape stewardship. Planning, monitoring, and adjustment (Animal). Planning, monitoring, and adjustment (Plant Production).	9	Cuyama Valley community engagement and support. Purchasing staple goods from local cooperative and farmers. Trading goods and services. Emphasis on community involvement/ cooperation. Building and maintaining networks (individuals). Building and maintaining networks (organizations). Virtual/ indirect network building and engagement (social media). Personal contact/ support/ exchange with individuals. Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region). Social media coordination (virtual communication). Support for local legislation on sustainable groundwater use and management. Partner with local regenerative sheep grazing operation for short-term, broad-acre rotational grazing. Purchase feed and supplies from local suppliers.	13

Reasonably profitable (Conservation)	Enacting decentralized, non-hierarchical governance. Revenue generation. Watershed stewardship. Landscape stewardship. Regenerative grazing. Chicken and egg production. Regenerative crop production.	7	(New) Flat Pay Structure. In-person programs (short-term - not currently possible). (New) Virtual program(s). Grants (public and private). Fundraising (donations). (New) Cash Flow Projection. Diverted surface water for irrigation. Removing dead/ dying Pine (fuel for community). Goat rearing/ having goats (milk, yogurt, cheese, meat for community). Chicken rearing (Egg and meat for community).	10

Optimally redundant (Conservation to Release)	Enacting decentralized, non-hierarchical governance. Community building. Supporting sustainable food system. Holding educational programming. Relationship/ network building (Education). Revenue generation. Relationship/ network building (Organization). Watershed stewardship. Irrigation management. Landscape stewardship. Regenerative grazing. Chicken and egg production. Regenerative crop production.	13	Weekly community meeting - Town Hall. Horizontal/ flat community structure. Community building: Multiple strategies for promoting community building, happiness and well-being, empowerment, creativity, and skill building (Community events, Encouraging creative projects, Living communally/ cooperatively, Artistic community groups, Diversity promotion, Encourage/ leave space for agency and self-empowerment, Cultivating and supporting skills and gifts of community members, Emphasis on beauty in communal and workspaces, Skill sharing among community members, Cuyama Valley community engagement and support, Coming together over music, food, and celebration with larger regional community). Purchasing staple goods from local cooperative and farmers. Trading goods and services. Multiple formal and informal educational programs (Holding long-term programs (on-site), Holding short-term programs (on-site), (New) Holding online/virtual programs, (New) Online/virtual, informal educational content, Online/virtual, informal educational content). Multiple methods for building relationships (Building and maintaining networks (individuals), Building and maintaining networks (organizations), Virtual/ indirect network building and engagement (social media)). Ability for community members (staff and non-staff) to join Circles. Weekly organizational meeting- Village Business Council (VBC). Multiple methods for revenue generation (In-person programs (short-term), (New) Virtual program(s), Grants (public and private), Fundraising (donations)). Relationship/ network building: multiple methods for building relationships/ network (Personal contact/ support/ exchange with individuals, Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region), Social media coordination (virtual communication)). Rotational cell grazing (goats and sheep). Multiple methods to slow, spread, and sink water for potential groundwater recharge (Calculated erosion (engaging meander), Calculated erosion (promoting widening/ flattening), Check dam implementation, One rock dam implementation, Sedge-mat grade control implementation, Riparian flora cultivation, Pond creation, Integration of woody specied (production zone), Raised road (berm)). Multiple methods to promote infiltration and moisture retention in production zone (Integration of woody species, contoured micro-swales, sunken beds, mulching). Training staff and community members on "belching" water system. Reserve tanks. Multiple methods for harboring biodiversity and related services (Wildlife corridor creation, Designating and protexting specific standing dead trees, Habitat creation in zone 1, Pond creation). Bee keeping. Multiple methods for sourcing organic material for compost creation (Deep bedding (goats), Pen manure harvesting, Deep bedding (chickens)). Multiple sources for chicken feed (food waste for feed, garden waste for feed). Multiple methods for increased infiltration and moisture retention (Cover cropping (with leguminous species), Alley cropping, Sunken beds, Double-dug beds, Path mulching, No-till, Woody species/ Perrenial Integration, On-contour production/ micro-swales, Compost creation and application, Mulch). Multiple methods for soil nutrients and microbiome building (Cover cropping (with leguminous species), Cutting annuals to base, No-till, Crop-rotation, Leguminous species integration, Mulch, Woody species/ Perennial Integration, Compost creation and application).	65

Carefully exposed to disturbance (Release)	Watershed stewardship. Landscape stewardship. Regenerative grazing. Regenerative crop production.	4	Calculated erosion (engaging meander). Calculated erosion (promoting widening/ flattening). Check dam implementation. One-rock dam implementation. Sedge-mat grade control implementation. Observation of intervention effects and adjustment. Small and frequent interventions. Rotational cell grazing (goats and sheep). Removing dead/ dying Pine. Divert a portion of surface water to production zone. Integrating non-native species. Cutting annuals to base. Broad-forking. Coppicing. Introducing pest regulating species.	15
Honors legacy while investing in the future (Release to Reorganization)	Community building. Holding educational programming. Enacting decentralized, non-hierarchical governance. Regenerative crop production.	4	Diversity promotion. Highlighting local and indigenous practices and insights. Ability for community members (staff and non-staff) to join Circles. Weekly meeting (VBC) open to staff and non-staff community members. Heirloom variety integration. Native cultivar integration.	6
Socially self-organized (Reorganization)	Enacting decentralized, non-hierarchical governance.	1	Weekly community meeting - Town Hall. Horizontal/ flat community structure. Weekly organizational meeting- Village Business Council (VBC). VBC open to all community members. VBC proposal process. Dividing organizational realms into Circles. Circles develop domain and make decisions within that domain (after community approval). Formation of Break-Out Groups.	8
Reflective and shared learning (Reorganization)	Enacting decentralized, non-hierarchical governance. Community building. Holding educational programming. Promoting accessibility of programming. Watershed stewardship. Planning, monitoring, and adjustment (Animal). Planning, monitoring, and adjustment (Plant Production).	7	Weekly community meeting - Town Hall. Community building: Community events. Artistic community groups. Diversity promotion. Skill sharing among community members. Holding long-term programs (on-site). Holding short-term programs (on-site). (New) Holding online/virtual programs. (New) Online/virtual, informal educational. Online/virtual, informal educational content (social media/ website). Emphasis on kinesthetic/ experiential/ hands-on teaching/learning. Emphasis on community involvement/ cooperation. Classroom/ lecture-based teaching/learning. Highlighting local and indigenous practices and insights. Offering scholarships. Sliding scale payment option. Divide organizational realms into Circles. Circles develop domain and make decisions within that domain (after community approval). Ability for community members (staff and non-staff) to join Circles. Weekly Organizational Meeting (Village Business Council). Weekly meeting (VBC) open to staff and non-staff community members. VBC Proposal Process. Observation of intervention effects and adjustment. Planning (goats, sheep, chickens). Monitoring/ Observation. Adjusting of system/ methods. Record keeping.	27

Responsibly coupled with local natural capital (Reorganization to Exploitation)	Community building. Supporting sustainable food systems. Holding educational programming. Watershed stewardship. Irrigation management. Landscape stewardship. Regenerative grazing. Chicken and egg production. Planning, monitoring, and adjustment (Animal). Regenerative crop production. Planning, monitoring, and adjustment (Plant Production).	10	Living communally/ cooperatively. Purchasing staple goods from local cooperative/ farmers. Purchase organic or agroecological, in bulk, and with plastic-free packaging whenever possible. Consider social and ecological impact of food grown offsite. Holding educational programs on-site (short and long term). Emphasis on kinesthetic/ experiential/ hands-on teaching/learning. Rotational cell grazing (goats and sheep).Calculated erosion (engaging meander).Calculated erosion (promoting widening/ flattening).Check dam implementation. One rock dam implementation. Sedge-mat grade control implementation. Riparian flora cultivation. Pond creation. Integration of woody species (production zone).Raised road (berm). Observation of intervention effects and adjustment. Small and frequent interventions. Awareness/ self-regulation of water diversion. Integration of woody species. Contoured micro-swales. Sunken beds. Mulching. Grey water use. Seasonal irrigation scheme. Wildlife corridor creation. Removing dead/ dying Pine (firewood procurement). Designating and protecting specific standing dead trees. Habitat creation in Zone 1. Bee keeping. Choose most degraded land to cultivate/ regenerate or develop. Divert a portion of surface water to garden. Grazing (in general). Multiple methods for sourcing organic material for compost creation (Deep bedding (goats), Pen manure harvesting, Deep bedding (chickens)). Fodder production. Multiple sources for chicken feed (food waste for feed, garden waste for feed). Planning, monitoring, and adjustment: Planning (goats, sheep, chickens), Monitoring/ Observation. Adjusting of system/ methods. Record keeping. Multiple methods for increased infiltration and moisture retention (Cover cropping (with leguminous species), Alley cropping, Sunken beds, Double-dug beds, Path mulching, No-till, Woody species/ Perennial Integration, On-contour production/ micro-swales, Compost creation and application, Mulch). Multiple methods for soil nutrients and microbiome building (Cover cropping (with leguminous species), Cutting annuals to base, No-till, Crop-rotation, Leguminous species integration, Mulch, Woody species/ Perennial Integration, Compost creation and application). Seed saving. Surface water use for irrigation.	57
Functional and response diversity (Throughout)	Enacting decentralized, non-hierarchical governance. Community building. Supporting sustainable food systems. Holding educational programming. Relationship/ network building (Educational). Promoting accessibility of programming. Revenue generation. Financial management. Relationship/ network building (Organizational). Watershed stewardship. Irrigation	16	Weekly community meeting - Town Hall. Horizontal/ flat community structure. Community events. Encouraging creative projects. Living communally/ cooperatively. Artistic community groups. Diversity promotion. Encourage/ leave space for agency and self-empowerment. Cultivating and supporting skills and gifts of community members. Emphasis on beauty in communal and work spaces. Establish Community Agreements. Skill sharing among community members. Cuyama Valley community engagement. Coming together over music, food, and celebration with larger regional community. Purchase staple goods from local cooperative and farmers. Trading goods and services. Holding educational programs on-site (short and long term). (New) Holding online/virtual programs. Online/virtual, informal educational content. Emphasis on community involvement/ cooperation. Highlighting local and indigenous practices and insights. Building and maintaining networks (individuals and organizations). Offering scholarships. Sliding scale payment option. Dividing organizational realms into Circles. Circles develop domain and make decisions within that domain (after community approval). Ability for community members (staff and non-staff) to join Circles. Weekly Organizational Meeting (Village Business Council). Weekly meeting (VBC) open to staff and non-staff community members. VBC Proposal Process. (New) Flat Pay Structure. In-person programs (short-term). (New) Virtual program(s). Cash flow projections. Personal contact/ support/ exchange with individuals. Relationship building/	109

	Management. Landscape stewardship. Regenerative grazing. Chicken and egg production. Planning, monitoring, and adjustment (Animal). Regenerative crop production.		mutual support/ partnerships/ exchange with organizations (locally and in the region). Social media coordination (virtual communication) . Calculated erosion (engaging meander). Calculated erosion(promoting widening/ flattening). Check dam implementation. One-rock dam implementation. Sedge-mat grade control implementation. Riparian flora cultivation. Observation of intervention effects and adjustment. Small and frequent interventions. Awareness/ self-regulation of water diversion. Berm/ swale implementation on erosive slopes. Integration of woody species (production zone). Contoured micro-swales (production zone). Sunken beds (production zone). Mulching (production zone). Diverted surface water to holding and reserve tanks. Greywater use. Seasonal irrigation scheme. Wildlife corridor creation. Removing dead/ dying Pine. Designating and protecting specific standing dead. Habitat creation in Zone 1. Bee keeping. Pond creation/ maintenance. Thoughtful road placement and design. Road maintenance. Raised road (berm). Choose most degraded land to cultivate/ regenerate or develop. Divert a portion of surface water to production zone. Integrating adapted non-native species. Goat rearing/ having goats. Grazing (in general). Rotational cell grazing (goats and sheep). Deep bedding. Pen manure harvesting. Fodder production. Breed selection and breeding. Culling young bucks. Chicken rearing. Cell rotation (chicken). Food waste for feed. Garden waste for feed. Flock of chickens in goat pen. Shade/ canopy creation. Planning (goats, sheep, chickens). Monitoring/ Observation. Adjusting of system/ methods. Cover cropping (with leguminous species). Alley cropping. Transplanting. Sunken beds. Double dug beds. Path mulching. Cutting annuals to base. No-till. Broad-forking. Crop rotation. Poly-cropping. Interplanting Pollinator attractor integration. Mulch (leaf litter). Seed saving. Greenhouse production. Seed saving. Coppicing. Hoop-house production. Remay covering. Compost application. In situ habitat creation for pest regulating species. Drought tolerant species integration. Native cultivar integration. Heirloom variety integration. Surface water use for irrigation.	
Builds human capital (Throughout)	Community building. Supporting sustainable food systems. Holding educational programming. Relationship/ network building (Education). Promoting accessibility of programming. Relationship/ network building (Organization).	6	Community events. Encouraging creative projects. Living communally/ cooperatively. Artistic community groups. Encourage/ leave space for agency and self-empowerment. Cultivating and supporting skills and gifts of community members. Skill sharing among community members. Cuyama Valley engagement and support. Coming together over music, food, and celebration with larger regional community. Trading goods and services. Holding/ producing educational programming onsite and online (Holding long-term programs (on-site), Holding short-term programs (on-site), (New) Holding online/virtual programs, (New) Online/virtual, informal educational content, Online/virtual, informal educational content (social media/ website)). Emphasis on community involvement/ cooperation. Building and maintaining networks (individuals). Building and maintaining networks (organizations). Virtual/ indirect network building and engagement (social media). Personal contact/ support/ exchange with individuals. Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region). Social media coordination (virtual communication). Offering scholarships. Sliding scale payment option.	24
	Total Unique	17	**Total Unique**	137

F: Specified Resilience Data

Table 11. Specified Resilience – Activities and Methods (Watershed Degradation and Groundwater Depletion)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (9)**	**Methods (25)**
Watershed Degradation and Groundwater Depletion (Press)	Larger, Focal.	Yes/ Yes. Alternative stable states: Low hydrological cycling capacity of regional/ focal ecosystems /Water tables too low to access (potential for water shortages, need for high levels of infrastructure, poor water quality - low production possibility). Distance from thresholds: Fairly close/ Extremely close.	Hydrological cycling capacity of the watershed, impacted by soil characteristics and biological factors, and groundwater levels and extraction rates.	Larger scale influences: relationship of the organization and community with the larger Cuyama Valley community, the influence of large-scale farmers on legislation and public opinion, impact of regional agricultural production and grazing on the watershed and groundwater levels. Smaller scale influences: values and ethics of community, soil depletion, erosion, vegetation and groundcover loss.	Community building. Holding educational programming. Relationship/ network building (Educational). Relationship/ network building (Organizational). Watershed stewardship. Landscape stewardship. Regenerative grazing. Planning, monitoring, and adjustment (Animal System). Regenerative crop production.	Cuyama Valley community engagement and support. Building and maintaining networks (organizations). Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region). Discontinuing open-range grazing with domesticated cattle. Rotational cell grazing (goats and sheep). Calculated erosion (engaging meander). Calculated erosion (promoting widening/ flattening). Check dam implementation. One rock dam implementation. Sedge-mat grade control implementation. Riparian flora cultivation. Observation of intervention effects and adjustment. Small and frequent interventions. Awareness/ self-regulation of water diversion. Pond creation. Berm/ swale implementation on erosive slopes. Raised road (berm). Planning (goats and sheep). Monitoring/ observation. Adjusting of system/ methods. Record keeping. Alley cropping. Woody species/ Perennial incorporation. Seasonal irrigation scheme.

Table 12. Specified Resilience – Activities and Methods (Desertification and Biodiversity Loss)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (4)**	**Methods (15)**
Desertification and Biodiversity Loss (Press)	Larger, Focal.	Yes/ Yes. Alternative stable states: Sparsely vegetated landscape with very low soil organic matter, highly erosive, and with little biodiversity= low response diversity, reduced hydrological and nutrient cycling. Distance from thresholds: unknown but somewhat close.	Soil organic matter content, biodiversity levels, plant spacing (density and exposed areas), potentially plant species/ guilds.	Larger scale: institutions in production methods (political, business, etc.), state/ federal/ county laws on production (probably in favor?), agriculture and grazing impact on desertification and biodiversity loss, changes in weather patterns (linked to climate change?). Smaller scale: values and ethics of community, soil nutrient depletion, erosion, and vegetation cover/ biodiversity loss (species).	Watershed stewardship. Landscape stewardship. Regenerative grazing. Planning, Monitoring, and Adjustment (Animal System).	Discontinuing open-range grazing with domesticated cattle. Rotational cell grazing (goats and sheep). Breed selection (Goats). Wildlife Corridor creation. Designating and protecting. Habitat Creation in Zone 1. Pond creation. Riparian flora cultivation. Woody species integration (production zone). Choose most degraded land to cultivate/ regenerate or develop. Partner with local regenerative sheep grazing operation. Planning (goats and sheep). Monitoring/ observation. Adjusting of system/ methods. Record keeping.

Table 13. Specified Resilience – Activities and Methods (Global and Local Climate Change)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (7)**	**Methods (25)**
Global and local climate change - Fire and Flood (Press and Pulse)	Larger, Local.	Yes. Alternative stable state (fire/ flood): vastly different configurations as a result of fire or flood (elimination of many elements, eroded soil (flood), low biodiversity, low hydrological cycling capacity, etc.) Distance from threshold: unknown.	Global and local weather patterns and practices that increase vulnerability (ex: fuel loads).	Larger scale influences: public conceptions and opinions about climate change, international/ federal/ state/ county laws regarding climate change, changes in global and local weather patterns, fuel loads in region (fire), general environmental and watershed degradation. Smaller scale: values and ethics of community, soil nutrient/ organic matter depletion/ erosion and vegetation cover/ biodiversity loss (including in soil), shifts in vegetation and fuel load.	Supporting sustainable food systems. Holding educational programming. Promoting accessibility of programming. Watershed stewardship. Landscape stewardship. Regenerative grazing. Regenerative crop production.	Purchase organic or agroecological, in bulk, and with plastic-free packaging whenever possible. Considering social and ecological impact of food grown offsite. Holding long-term programs (on-site). Holding short-term programs (on-site). (New) Holding online/virtual programs. (New) Online/virtual, informal educational content. Online/virtual, informal educational content. Highlighting local and indigenous practices and insights. Offering scholarships. Sliding scale payment option. Rotational cell grazing (goats and sheep). One rock dam implementation. Sedge-mat grade control implementation. Riparian flora cultivation. Berm/ swale implementation on erosive slopes. Integration of woody species (production zone). Contoured micro-swales (production zone). Sunken beds (production zone). Raised road (berm). Thoughtful road placement and design. Partner with local regenerative sheep grazing operation. Grazing (in general). Cover cropping (with leguminous species). Alley cropping. No-till.

Table 14. Specified Resilience – Activities and Methods (Economic Instability and Collapse)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (9)**	**Methods (20)**
Economic Instability and Collapse (Press and Pulse)	Focal.	Yes. Alternative stable state: different system configurations (SES would cease to exist). Distance from threshold: varies over time.	Annual revenue amounts, expenses, viability of revenue sources.	Larger scale influences: Federal/ state/ county laws that impact revenue streams (for example codes that limit educational programming), financial support opportunities for education (in general and right now- COVID-19), ecosystem collapse (inability to live/ work on land or have revenue streams). Smaller scale influences: effective management of finances or organization, ability to continue to access necessary resources for revenue generation (grazing land, educational activity land, etc.).	Supporting sustainable food systems. Relationship/ network building (Educational). Enacting decentralized, non-hierarchical governance. Revenue generation. Financial management. Relationship/ network building (Organizational). Regenerative grazing. Chicken and egg production. Regenerative crop production.	Trading goods and services. Building and maintaining networks (individuals). Building and maintaining networks (organizations). Virtual/ indirect network building and engagement (social media). (New) Flat pay structure. In-person programs (short-term - not currently possible). (New) Virtual program(s). Grants (public and private). Fundraising (donations). Maintaining relationships with donors (of large amounts). (New) Cash flow projection. Personal contact/ support/ exchange with individuals. Relationship building/ mutual support/ partnerships/ exchange with organizations (locally and in the region). Goat rearing/ having goats. Grazing (in general). Chicken rearing. Food waste for feed. Garden waste for feed. Back stocking surplus eggs. Divert a portion of surface water to production zone.

Table 15. Specified Resilience – Activities and Methods (Community Dissolvement)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (2)**	**Methods (21)**
Community and Staff Dissatisfaction/ Community Dissolvement (Press)	Focal.	Yes. Alternative stable state: different system configurations (SES would cease to exist. Distance from threshold: varies over time/ unknown.	Community member happiness (thought to be contributed to through relationship building, personal development, agency, and economic viability). Along with other reported influencing factors: distance to urban centers, culture of workaholism.	Larger scale influences include Laws that impact ability of community to continue (for example: living/ building codes, laws around ability to perform economic activities), Environmental degradation and inability to inhabit land (threshold surpassing, climate change effects, etc). Smaller scale influences include Dissatisfaction of individuals, Inability of land to meet physical resource needs of community.	Enacting decentralized, non-hierarchical governance. Community building.	Weekly community meeting (Town Hall). Horizontal/ flat community structure. Community events. Encouraging creative projects. Living communally/ cooperatively. Artistic community groups. Diversity promotion. Encourage/ leave space for agency and self-empowerment. Cultivating and supporting skills and gifts of community members. Emphasis on beauty in communal and workspaces. Establish community agreements. Skill sharing among community members. Coming together over music, food, and celebration with larger regional community. Divide organizational realms into Circles. Circles develop domain (to be approved at VBC) and make decisions within that domain. Ability for community members (staff and non-staff) to join Circles. Weekly Organizational Meeting (Village Business Council). Weekly meeting (VBC) open to staff and non-staff community members. VBC proposal process. (New) Flat Pay Structure. (In process) Equitable pay structure.

Table 16. Specified Resilience – Activities and Methods (Water Insufficiency and Drought)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (2)**	**Methods (25)**
Water Insufficiency and Drought (Press and Pulse)	Smaller (plant production).	No (but could lead to crop failure= reduction in available fresh fruits and vegetables for community/ other possible unknown effects).	Soil organic matter content, biodiversity (response diversity), water availability for irrigation.	Larger scale: Laws for water catchment (spring), larger watershed management (effect on groundwater- not currently but potentially in future), changes in weather patterns (linked to climate change), effect of larger watershed management on eventual groundwater availability. Smaller scale influences: Inadequacy of water conveyance system (technology and infrastructure), infiltration and moisture retention ability of soil, genetic response of species (response diversity).	Irrigation management. Regenerative crop production.	Training staff and community members on "belching" water system. Diverted surface water to holding tanks. Reserve tanks. Greywater use. Seasonal irrigation scheme. Cover cropping (with leguminous species). Alley cropping. Drip Irrigation. Transplanting. Sunken beds. Double dug beds. Path mulching. Cutting annuals to base. No-till. Broad-forking. Hand-watering transplants/ direct seeded beds. Interplanting. Mulch (leaf litter). Seed saving. Woody species/ Perennial incorporation. On-contour production/ micro-swales. Compost creation and application. Drought tolerant species integration. Native cultivar integration. Heirloom variety integration.

Table 17. Specified Resilience – Activities and Methods (Product Predation)						
Main Issue(s) (Disturbance Type)	**Scale(s)**	**Threshold(s) (Yes/No) + Alternative Stable State Characteristic(s) + Distance from threshold(s)**	**Key Variables**	**Scale Influences**	**Activities (1)**	**Methods (5)**
Product Predation (Press and Pulse)	Smaller (plant production).	No (but leads to reduced yields= reduction in available fresh fruits and vegetables for community)	Pest population numbers. Pest predator presence and dynamics. Accessibility of crops.	Larger scale: Ecosystem dynamics (lack of predators due to guard dogs). Creation of oasis in arid landscape/ lack of readily available food and water in landscape.	Regenerative crop production.	Greenhouse production. Hoop-house production. Remay covering. In situ habitat creation for pest regulating species. Trapping/ Hunting.

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