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► **To cite this version:**

Kaitlyn Spangler, Emily K. Burchfield, Claudia Radel, Douglas Jackson-Smith, River Johnson. Crop diversification in Idaho's Magic Valley: the present and the imaginary. *Agronomy for Sustainable Development*, 2022, 42 (5), pp.99. <10.1007/s13593-022-00833-0>. <hal-04243130>

HAL Id: hal-04243130

<https://hal.science/hal-04243130v1>

Submitted on 16 Oct 2023

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Crop diversification in Idaho's Magic Valley: the present and the imaginary

Kaitlyn Spangler¹ · Emily K. Burchfield² · Claudia Radel³ · Douglas Jackson-Smith⁴ · River Johnson³

Accepted: 15 September 2022 / Published online: 13 October 2022
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Abstract

The simplification of agricultural landscapes, particularly in the United States (US), has contributed to alarming rates of environmental degradation. As such, increasing agrobiodiversity throughout the US agri-food system is a crucial goal toward mitigating these harmful impacts, and crop diversification is one short-term mechanism to begin this process. However, despite mounting evidence of its benefits, crop diversification strategies have yet to be widely adopted in the US. Thus, we explore barriers and bridges to crop diversification for current farmers, focused on the Magic Valley of southern Idaho—a region with higher crop diversity relative to the US norm. We address two main research questions: (1) how and why do farmers in this region enact temporal and/or spatial strategies to manage crop diversity (the present) and (2) what are the barriers and bridges to alternative diversification strategies (the imaginary)? Through a political agroecology and spatial imaginaries lens, we conducted and analyzed 15 farmer and 14 key informant interviews between 2019 and 2021 to gauge what farmers are doing to manage crop diversity (the present) and how they imagine alternative landscapes (the imaginary). We show that farmers in this region have established a regionally diversified landscape by relying primarily on temporal diversification strategies—crop rotations and cover cropping—but do not necessarily pair these with other spatial diversification strategies that align with an agroecological approach. Furthermore, experimenting with and imagining new landscapes is possible (and we found evidence of such), but daily challenges and structural constraints make these processes not only difficult but unlikely and even “dangerous” to dream of. Therein, we demonstrate the importance of centering who is farming and why they make certain decisions as much as how they farm to support agroecological transformation and reckoning with past and present land use paradigms to re-imagine what is possible.

Keywords Crop diversity · United States · Political agroecology · Spatial imaginaries · Cover cropping · Crop rotation

1 Introduction

Globally, agrobiodiversity is declining (Kleijn et al. 2011; Dainese et al. 2019). Agricultural production—particularly

in the United States (US)—is becoming increasingly homogenized in its number of crops (Baines 2015; Aguilar et al. 2015; Auch et al. 2018) and associated genetic diversity (Harlan 1975; Heal et al. 2004). Specialization of commodity production has resulted in simplified agricultural landscapes that are intrinsically reliant on external chemical inputs (Nassauer 2010; Brown and Schulte 2011; Meehan et al. 2011; Aguilar et al. 2015; Landis 2017; Spangler et al. 2020). This simplification and input intensification of agricultural landscapes has contributed widely to environmental degradation, including pollinator diversity loss, nutrient pollution in waterways, greenhouse gas emissions, among others (Ramankutty et al. 2018; Kremen and Merenlender 2018; Sponsler et al. 2019; Prokopy et al. 2020). To counteract these processes of simplification, increasing agrobiodiversity throughout the agri-food system is a crucial goal toward mitigating such harmful impacts and working toward a more

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sustainable future (Aizen et al. 2019; Spangler et al. 2020; Waha et al. 2020; Petersen-Rockney et al. 2021).

Crop diversification is one short-term mechanism that can be implemented by current farmers to increase agrobiodiversity across agricultural landscapes. It encompasses a suite of on-farm practices to diversify the crop and non-crop species and land uses of an operation temporally and spatially. Temporal diversity can be achieved through practices such as diverse crop rotations (Davis et al. 2012) or cover cropping (Schipanski et al. 2014; Bell et al. 2014). Spatial diversity is measurable at a given point in time for a defined spatial unit and enacted through wide-ranging practices: intercropping or polycropping (Mead and Wiley 1980; Daryanto et al. 2020), precision conservation (Delgado and Berry 2008), buffer strips, riparian corridors, and hedgerows (Kremen et al. 2012), creating wildlife habitat patches within and across plots (Pywell et al. 2015), or integrating crops and livestock (Franzluebbbers and Stuedemann 2014; Sulc and Franzluebbbers 2014). Accumulating evidence exhibits broad benefits to implementing these practices, such as improved crop yields (Smith et al. 2008; Gaudin et al. 2015; Pywell et al. 2015; Schulte et al. 2017; Burchfield et al. 2019), decreased yield volatility over time (Di Falco and Perrings 2005; Abson et al. 2013; Li et al. 2019), improved pest management (Chaplin-Kramer et al. 2011; Bommarco et al. 2013), improved soil health (Postma et al. 2008; Berendsen et al. 2012; McDaniel et al. 2014; Albizua et al. 2015; Ghimire et al. 2018), increased pollinator diversity (Schulte et al. 2017; Hass et al. 2018; Guzman et al. 2019; Raderschall et al. 2021), and overall greater productivity, or output per acre, than standard industrial operations (Kremen and Miles 2012; Virginia et al. 2018). Moreover, conserving the diversity of on-farm crops can improve agroecosystem resilience and food security in the face of climatic change and disturbance (Massawe et al. 2016; Matsushita et al. 2016; Isbell et al. 2021).

However, such diversification strategies are yet to be widely translated from research to practice across the US. First, diversified farming lacks a clearly defined and accepted conceptual framework, and, thus, what differentiates it from non-diversified farming is often unclear (Hufnagel et al. 2020). This has obfuscated discussions and implementation of diversification strategies, particularly the differences between temporal and spatial diversity (Aramburu Merlos and Hijmans 2020). Second, perceptions of agricultural biodiversity differ between researchers and farmers: researchers may hold idealistic views of the value of diversification, whereby farmers may not view those same processes positively (Maas et al. 2021). Finally, highly input-intensive production systems, specifically those relying on inputs such as genetically modified crop breeds and glyphosate-based herbicides, are socially, technologically, and economically locked into modern agricultural systems; these lock-ins impede crop diversification at

all levels of the value chain and promote short-term profit over long-term resilience (Roesch-McNally et al. 2018a; Meynard et al. 2018; Cradock-Henry 2021; Clapp 2021). These factors amount to significant micro- and macroscale barriers to diversification.

This paper provides additional, contextualized insights into the barriers and bridges to agricultural crop diversification in a region with high crop diversity. Using a qualitative approach through semi-structured interviews and participant observation, we seek to better understand farmers' and agricultural stakeholders' lived experiences of and perspectives on managing crop diversity in the Magic Valley of southern Idaho—a region that exhibits higher crop diversity relative to the US norm. We address two main research questions: (1) how and why do farmers in this region implement temporal and/or spatial strategies to manage crop diversity and (2) what are the barriers and bridges to alternative diversification strategies? Understanding how and why farmers in this area have developed strategies for managing crop diversity can clarify the dynamics of diversification and potential transformation of agricultural landscapes and what enables or constrains them. Considering and imagining alternative diversification strategies helps elucidate what farmers would (or would not) do to change their operation's level of diversity. In this process of imagining new landscapes, we aim to gauge how farmers envision their land and its transformative potential within current and new realities (Watkins 2015; Sippel and Visser 2021). Assessing these two dynamics in tandem—the present and the imaginary—points to the values and barriers of the current US agricultural system, contextualized within the Magic Valley, as well as potential pathways for change and transformation.

1.1 Political agroecology and spatial imaginaries: a framework of transformation

This research draws on the established fields of political ecology and agroecology and their convergence into an emerging framework of political agroecology. Political agroecology is an ideological framework grounded in the need for a new agri-food system (or *regime*), since the sociopolitical factors of our current regime have resulted in asymmetrical and unjust distributions of material goods, information, and other resources (González De Molina 2013; González de Molina et al. 2019). Rather than a suite of practices to implement, agroecology is an approach, framework, and movement that, at its core, aims to minimize external, chemical inputs, and maximize ecological health and social equity (Altieri et al. 2015; Dumont et al. 2021). Diversification is a central tenant of agroecology, whereby intentionally diversifying crop and non-crop species within a farm or landscape can counteract the ecological and socioeconomic conditions of industrialized monocultures (Kremen et al. 2012; Stratton et al. 2021). The diversification

process serves as a mechanism to begin and support the “agroecological metamorphosis” of the agri-food regime—a systems-level transition that gradually builds from contextualized changes and radically breaks systemic order at the same time. Within political agroecology, the need for scaling agroecology to “ever-greater numbers over ever-larger territories” is urgent and essential for this scope of change.

Fundamental to political agroecology is the assumption that technological innovation alone is insufficient for sustainable metamorphosis; social and economic change must accompany technological change, wherein agroecosystem sustainability reflects structural power relations as much as biophysical properties (González De Molina 2013). Without the politics of this institutional change at the heart of agroecology, “experiences will be condemned to be ‘islands of success’ amid a sea of privation, poverty and environmental degradation” (González De Molina 2013, p. 46). For agroecology to be most transformative, it must be centered on the synergies between and agency of people and nature and decentered away from the sole focus on profit and “the market” (Anderson et al. 2019).

Spatial imaginaries are crucial to systems-level transformation as the ability to “dream of abundant and diverse futures” (Collard et al. 2015) and, ultimately, imagine a new agri-food regime. Spatial imaginaries are stories and ideas about spaces and places that are both individually constructed and shared collectively (Driver 2005; Watkins 2015). Research has expanded this concept rooted in human geography to focus on agrarian realities (Wolford 2004), land transformation (Sippel and Visser 2021), and how the sociopolitical context within which our imagination befalls can limit and constrain the possibilities of climate change adaptation (Nightingale et al. 2020). We conceptualize spatial imaginaries in this study to encompass the current values and views of agricultural landscapes (“the present”) and how they relate to (or differ from) visions of political agroecological metamorphosis (“the imaginary”). In understanding what farmers are currently doing to diversify the landscapes of the Magic Valley, as well as how they imagine alternatives, we contribute to the growing body of literature that seeks to identify sustainable and diverse pathways of agricultural systems transformation.

2 Materials and methods

2.1 Study site

The Magic Valley officially comprises eight counties: Blaine, Camas, Cassia, Gooding, Jerome, Lincoln, Minidoka, and Twin Falls counties (Figure 1), where producers raise all of Idaho's top commodities, including hay, wheat, sugar beets, barley, potatoes, dry edible beans, corn grain, and lentils (Mertz and Welk 2018; Hines et al. 2018). Furthermore, it is

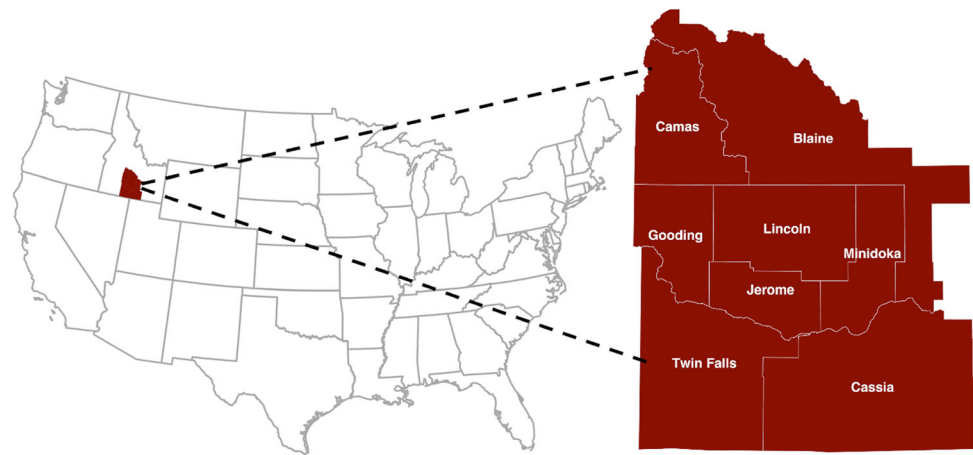
a major center of large-scale dairy production (Leytem et al. 2021; Spiegall et al. 2020). Idaho has the fourth highest number of dairy cows nationwide, and the Magic Valley is home to 71% of those cows (Hines et al. 2018).

Based on prior analysis of national-level data (Burchfield et al. 2019), Idaho's Magic Valley is ranked as one of the most agro-diverse regions in terms of the number and types of crops grown in the US. Recent research corroborates these findings, identifying southcentral Idaho as a place with high temporal diversity (Aramburu Merlos and Hijmans 2020) and high spatial diversity with exceptionally high yields for major commodities (Nelson and Burchfield 2021; Burchfield and Nelson 2021). In addition to its diverse crop production, we selected this region for its strong commercial agribusiness; agribusiness contributes to over half of the region's jobs and annual revenue (Hines et al. 2018). We hoped this combination of commercialization and diversification would advance our understanding of how agricultural landscapes become diverse within and across farm operations, as well as provide a framework for transition toward greater diversification nationally.

2.2 Participant sampling

This study relied on mixed qualitative methodologies, including a total of 13 key informant interviews, 15 farmer interviews, engagement with two farmer group meetings, and participant observation across the Magic Valley. This number of interviews was based on prior research suggesting that six to ten in-depth interviews is an adequate sample size to reach data saturation and converge on common metathemes (Guest et al. 2006, 2020). We conducted a first phase of fieldwork in 2019 with the key informants selected through purposive snowball sampling (Tongco 2007) based on their role within each county. Key informants included stakeholders from the National Resource Conservation Service (NRCS), Farm Services Agency (FSA), County Extension agents and researchers, Soil and Conservation District Board members, employees of Valley Agronomics LLC, a local input supplier, and a manager of a local irrigation canal company. These key informants connected us to four crop and dairy farmers to interview, as well. In 2021, we interviewed an additional 11 farmers over phone and video calls (due to the COVID-19 pandemic). In this second phase, we invited farmer participation through two main channels: (1) a recruitment flyer circulated through virtual networks of participants from 2019 and (2) direct recruitment calls and emails. For the latter, we obtained names of Magic Valley farmers who operated 100 or more acres from the private FarmMarketID and public USDA Organic Integrity databases. The recruitment flyer described the nature of the study, noted the \$50 compensation, and detailed the

Fig. 1 Counties of Idaho's Magic Valley.



eligibility criteria, namely that (1) they are 18 and older, (2) they are actively managing farmland in the Magic Valley, (3) farming is their main source of income, and (4) they have access to a computer or phone. We made over 100 initial phone calls and emails with a follow-up contact after 2 weeks of no response. Farmers who agreed to participate during this phase were compensated \$50. In total, from 2019 to 2021, we conducted interviews with 14 different farmers (one farmer was interviewed twice); three were recruited from the recruitment flyer and 11 from direct phone calls or emails. Of these participants, two were women and 12 men, all between the ages of 22 and 91 from Twin Falls (2), Cassia (3), Minidoka (1), Lincoln (4), Gooding (2), and Blaine (1) counties (see Table 1). All were white, which is representative of the overwhelming whiteness of US agriculture (Horst and Marion 2019). Four were certified organic, and operation sizes ranged from 300 to 4000 acres (roughly 120 to 1620 ha).

2.3 Data collection

We used two different interview approaches between 2019 and 2021. In 2019, all 13 key informants and four farmers were interviewed in-person by two researchers, with dynamic and open-ended interviews occurring in farmers' homes or on their operations and in key informants' offices. Because these interviews occurred at the beginning of the study, the format was exploratory and loosely structured to identify factors to

explore more deeply. Questions addressed (1) factors that are important in managing their land, (2) how they relate to their broader landscapes, (3) improvements they want to make in the next decade, and (4) perspectives on federal subsidy and conservation programs. Participant observation occurred at farmer group meetings, where researchers observed and took notes on meeting procedures and discussions, asking questions when appropriate. During these observation events, researcher involvement was kept at a minimum, whereby all relevant conversations were descriptively noted in field notes and relevant quotes were transcribed verbatim. In 2021, virtual interviews were conducted using a standardized, semi-structured interview protocol that was informed by analysis of the prior interviews to explore important concepts. Conversations flowed naturally and often went beyond the questionnaire, although every interview addressed each question. The questions guided discussions about (1) farmer livelihoods and backgrounds, (2) current diversification strategies, (3) labor challenges, (4) imagined alternatives with unlimited resources, (5) relationships with neighbors, (6) current engagement with federal policies and programs, and (7) sources of trusted information. Interviews lasted between 30 min and two hours and, with consent, were audio recorded. All interview procedures and questionnaires were reviewed and approved for exemption by the Institutional Review Board (IRB).

Table 1 Basic demographics of interviewed farmers by county

County	Men	Women	Average age	Average farm size (acres/hectares)
<i>Twin Falls</i>	3		72	800 acres (324 ha)
<i>Cassia</i>	3		59	675 acres (273 ha)
<i>Minidoka</i>	1		31	> 2,000 acres (> 809 ha)
<i>Lincoln</i>	3	1	60	1,700 acres (688 ha)
<i>Gooding</i>	1	1	31	> 2000 acres (> 809 ha)
<i>Blaine</i>	1		22	800 acres (324 ha)

2.4 Data analysis

We transcribed farmer interviews, first using the Otter.ai software and then manually checking for accuracy. We next coded the transcripts using the qualitative coding software ATLAS.ti and a closed and open coding scheme (Saldana 2016). This scheme was first drafted prior to the coding process using notes and reflections taken during the data collection phase and informed by relevant literature. We then discussed and refined draft codes based on “test coding” of three transcripts to capture unexpected and unincluded themes (Nowell et al., 2017). Once finalized, one person applied the codebook to all interview transcripts, and no new codes were added. The final codebook included five code groups and 40 codes (see SI Table 1 for the full codebook). We summarized each code across the farmer interviews, noting thematic patterns and diverging opinions and identifying illustrative quotes. We used key informant interviews and participant observation to provide broader perspectives on the region's history and current agricultural production. Thus, they were audio recorded but not transcribed, and detailed notes were taken during these interviews and observation events. These notes were coded for desired background information using the same coding scheme. Illustrative quotes were transcribed from audio recordings based on time markers noted during the interviews.

3 Results and discussion

This section presents the results of the thematic analysis and their implications in the context of relevant literature. We first explore the “diversification present”—a contextualized look at how farmers are currently managing crop diversity in the Magic Valley. This section characterizes the regional farming practices that achieve such high crop diversity and, therein, establishes a baseline of what has become normalized for agricultural production in this region. The baseline provides needed clarity to then discuss and distinguish what alternative diversification strategies (those that continue to increase crop diversity rather than maintain it) might look like—the “imaginary” (Hufnagel et al. 2020). This dynamic between the diversification present and imaginary illustrates where farmers in the Magic Valley are starting from and where they envision going (and not going).

3.1 Managing diverse crops: the present

The Magic Valley is home to a diverse suite of crops raised year to year. Main crops in the area are grass and alfalfa hay, pasture, corn (silage and grain), barley, wheat, beans (edible and for seed), potatoes (edible and for seed), sugar beets, peas,

and oats. Sugar beets, potatoes, and bean seeds are the primary cash crops—those that farmers raise for the largest profit and that often define the rest of their operation. Sugar beets can only be grown by purchasing “shares” from the Amalgamated Sugar Cooperative that allocates quotas to members that dictate how many acres any one farmer can raise. Amalgamated Sugar Company was created in 1902 and consolidated all the sugar companies across Utah and Idaho, concentrating sugar beet production in central Idaho and ultimately leading to the abandonment of the crop in Utah (Arrington 1956; Albiston 2006). Farmers describe sugar beets as “the ideal cash crop” because, given the tightly regulated market supply, their market price is consistently stable and highly profitable. Potatoes—often considered Idaho's trademark—are another important cash crop (Figure 2). Most producers are raised under annual contracts with large processing firms that specify a certain price per acre for a specified variety of potato established before the farmer even plants them. Beans (edible and seed) are prevalent as well, but some farmers say that business has recently “for some reason, left the area.” Some speculated that this was due to the rapid expansion of large dairy operations over recent decades that generated growing demand for hay and other forages. Dairying and beef production have been a major farm enterprise in the region since the late 1880s due to the availability of high-quality grazing land across the valley (Arrington 1956). However, partly in response to growing regulatory oversight in California starting in the 1990s, a number of very large dairy operations have relocated to the Magic Valley (Jackson-Smith and Gillespie 2005; Cross 2006).



Fig. 2 Potato field in Blaine County, Idaho.

The established suite of crops grown in this region has been structurally reinforced by the presence of these major industries and competition for contracts and market shares, necessitating farmers be flexible with respect to their primary enterprise from one year to the next. Particularly since the availability of sugar beet shares is low, and potato and bean contracts can vary from year to year, this flexibility relies on several crops being raised in any one given year, as well as the willingness to adjust how much of each crop is grown. Being flexible helps minimize risk and uncertainty. As one farmer described,

“You never know what's gonna make you money one year to the next, so I don't think there's any one thing... A combination of them all tend to be a better thing. Usually when you think, ‘Oh, one thing is gonna make me money,’ and it turns out, it's one of the other things, so you just never know.”

Furthermore, despite year-to-year volatility in market prices, most farmers report a net positive income over recent years and decades. Although in some individual years they report a negative income, farmers feel that these crops work in their operations, primarily because they are well-suited for the environmental and ecological conditions of their area.

To manage these crops, farmers rely primarily on temporal diversification strategies—crop rotations and cover cropping—that also help to increase the diversity of crops grown each year. Broadly, these diversification strategies have been found to contribute positively to the ecological health and productivity of farm operations (Tamburini et al. 2020) and the stabilization of crop yield from year to year (Manns and Martin 2018; Renard and Tilman 2019). In this particular region, organic and non-organic farmers alike use these strategies along a gradient of implementation and normalize them as “the way we do things here.”

3.1.1 Crop rotations

Unlike some other major agricultural production areas in the US (Wang et al. 2021), a multi-year crop rotation with at least three different crops (but often more) is the dominant cropping system in the Magic Valley. Farmers describe the ability to rely on these diverse rotations as “an advantage over Midwest farmers” and specifically commented that a Midwestern “corn-soy rotation is not a good rotation.” Magic Valley rotations rely on rotating alfalfa hay into cash crops every two to six years, and they avoid growing commodities like corn, wheat, or barley two years in a row on the same field. Alfalfa is seen as essential to the crop rotation, particularly if it stays in the ground for three to five years. One farmer described, “That's been the standard for us for 40 years. We've

always had a good rotation of alfalfa; that always helps your fertility of the soil since it's nitrogen-fixing.” Alfalfa is also great for weed control—“good rest for the crops”—due to the frequent required cutting that means “the weeds eventually give up and the hay takes over.” Furthermore, in this area, it is a great crop to grow given the numerous large dairies who use it for fodder or silage; farmers may even engage in trading alfalfa for manure (and vice versa) with willing neighbors—an example of how the close proximity of livestock and crop production can be mutually beneficial for farmers involved and the broader landscape (Costa et al. 2014; Bonaudo et al. 2014).

Primary cash crops dictate the flow of crop rotations, and this rotation schedule is revised each year, even multiple times a year. To manage pests and diseases (Myers et al. 2008), farmers can rely on, for any one plot, one potato harvest every five years. This leads potato producers to seek out landowners to rent land from (and ideally establish a long-term relationship with), rather than own all the land they cultivate. The prioritization of potatoes creates a “puzzle” for farmers to work around, figuring out what crops go where and how to maximize their potato yields each year. Furthermore, farmers can expect two to three sugar beet harvests every five years. When describing how they plan their crop rotation schedules, an organic farmer discussed how “every six months [the rotation schedule] changes based on how crops are performing or market pressure, but, principally, how crops perform” (namely, their yield). Furthermore, they described a spreadsheet they use to plan their crop rotations several years in advance for each plot they farm. Of this plan, they said, “I built this spreadsheet the way I did particularly to demonstrate where we needed to move potatoes around, because they are really key cash crops for us. ... Everything else has to work around them in many ways.” Other farmers, typically those who are older and have been growing the same crops in rotation for decades, said that to plan their fields for the coming year, they “sit down in the winter and figure it out with the team.”

The availability of irrigation infrastructure is also a large part of this decision-making process. The type of irrigation used on each field is crucial in determining when and how farmers rotate crops. For example, some crops (e.g., corn) require pivot irrigation, and other crops (e.g., beans) require gravity irrigation; bean seeds must be gravity-irrigated to be certified Idaho seed and be eligible for sale within the state. Furthermore, nearly every farmer described a decades-long process of updating all their irrigation infrastructure to pivot systems—an expensive but highly desirable outcome that saves them time, energy, and money. In this process, the boundaries of their fields have been restructured by the placement and reach of each center pivot. One farmer stated specifically that, after 50 years of slowly updating all their infrastructure to center pivots, they went from 14 fields down to six, requiring a total redesign of what crops go where and how

to rotate them. In this way, technological improvements and how they intersect with political factors (e.g., market demand) can serve as a driver of landscape transformation and strongly influence diversification decisions.

3.1.2 Cover cropping

Cover cropping is an emerging practice in the Magic Valley but is still relatively uncommon. According to the 2017 Census of Agriculture, merely 3.2% of cropland across the region's eight counties was used for cover cropping, and 10.8% of all operations had cropland with cover crops (USDA NASS 2019). Nonetheless, they have become an important part of soil health management and, ultimately, diversifying the suite of crops grown. Common cover crops in this area include triticale, rye, barley, mixes like vetch, triticale, peas and radishes, as well as phacelia. They are described as something to use on "deeper, rougher ground" or the "sandy ground" to prevent erosion from wind or water so that "the good soil doesn't just blow away." Other stated benefits of cover cropping include improving the soil health (e.g., increasing earthworm populations), suppressing weeds in-between planting cash crops, and producing more forage and feed for the cattle. A conventional farmer described their changing perspective on cover crops in recent years: "We're learning that it's so important and normal for bacteria in the soil being fed all winter. By leaving those roots in, particularly the growing plants, it fixes a lot of nitrogen and increases the organic matter in the soil. That's what we're trying to do with the cover crops."

Although beneficial, cover cropping was consistently described as a labor-intensive endeavor that must be constantly balanced with profitability. The timing of planting cover crops presents a challenge, occurring immediately following a fall harvest. Figuring out the "right" cover crop is also a challenge, depending on what cash crop follows the cover crop. For example, one farmer, for whom beans are their main cash crop, described their disappointing realization that a winter wheat cover crop was suppressing their bean yields. Another farmer who tries to plant cover crops each winter season detailed how difficult this process can be:

"We just didn't get cover crops in behind our potatoes and same thing with most of our bean fields. You've gotta have your planting cover crops in a limited season environment. You've gotta have your seed on site before you harvest your cash crop. You've gotta have the seed in the drill and the tractor running when the combine of the potato digger, or whatever, pulls out of the field. Otherwise, you're just putting yourself in a bind, and you may just spend money on seed, and you don't get anything back. That's true if you're planting cover

crops in July or August or September or November. And the other thing, of course, is to choose the right species."

Infrastructural updates, such as installing pivot irrigation systems, can make managing and watering cover crops less burdensome, especially compared to gravity-fed irrigation systems. However, it does not eliminate the fact that cover crops are "an extra step, more work, and another expense"—a reality that continues to deter farmers from expanding their cover cropping efforts in both the Magic Valley and in other US agricultural regions (Roesch-McNally et al. 2018b). For example, in response to an NRCS-proposed cover cropping project, a board member from a conservation district meeting expressed opposition to the project by describing cover crops as weeds, saying, "The definition of a weed is the wrong plant at the wrong time."

3.2 Experimenting with and envisioning alternatives: the imaginary

3.2.1 Experimenting

Farmer experimentation with new cropping practices and landscape designs within agroecosystems has long been identified as a crucial step toward enhancing resilience of these landscapes (Biggs et al. 2012). In the Magic Valley, experimentation with new crops, rotations, and on-farm practices is occurring but is not widespread. Most farmers follow their standardized crop rotation patterns, largely because that pattern has proven to be both successful and profitable over several decades. This crop rotation pattern may be adjusted season to season based on different market pressures, soil quality, and labor availability, but, for the most part, the crops and the objectives stay the same. Choosing the right variety from season to season is a choice based on the nexus of several factors: availability of seed, disease tolerance, past experiences and the variety's "track record," expected weather patterns for the upcoming season, "popularity on the market," and ultimately, what is expected will turn the greatest profit. One non-organic farmer described a philosophy that has guided their career for decades: "When I took Agricultural Economics in college, the professor said, 'In farming, you always choose the right job,' and he spelled out 'right' using dollar signs." Thus, given the importance of the market and its potential for profit, the ability to experiment with new varieties was described as a privilege. Another organic farmer stated, "Very few of our acres do we just get to say, 'Oh, let's grow this variety.' No, most of it is market driven; the markets call for a specific variety." Such experimentation was also described as a risk that needs to be balanced with time and energy requirements because, even with a high financial return, learning to cultivate and manage a new

specialty crop may demand a “really high intensity of work that makes my [a farmer’s] satisfaction disappear.”

While many older, non-organic farmers felt satisfied in finding what works and sticking with it, several younger, organic farmers expressed a direct desire to try new things on their operation and push the boundaries of what is possible. One organic farmer put it this way:

“I refer to this quote a lot of times: ‘If you always do what you’ve always done, you’ll always get what you’ve always got.’ A lot of people are just happy to get what they’ve always got. But we ask ourselves, ‘How can I get more out of this day? How can I get more out of this field? How can we be more effective? How can we push it and find out just how far we can do?’ It’s the drive to get as much done as we possibly can with what we’ve got... It’s like there’s an end goal with what we want to achieve and accomplish, and if we can get there faster by being a little more creative, then golly, let’s go full throttle!”

This creativity was expressed in being willing to try uncommon cover crop mixes and entirely new crop rotations without proven success by other farmers. Rationale for employing such experimentation included the philosophy that, “You don’t know what you don’t know,” as well as the goal of trying to “disrupt the standardization and the predictive cycles you might have for pests or nutrient deficiency.” Such desire for change can be, in part, attributed to the ways in which organic production systems often require a more agro-ecological approach to limit external chemical inputs, and organic markets often provide sufficient premiums to help support these approaches (Lamine and Bellon 2009).

3.2.2 Envisioning beyond

When asked how they would diversify their farm if they could do anything with unlimited resources (e.g., time, money, labor), most farmers did not describe a desire to implement diversified alternatives to their current operation. Ultimately, they responded saying either they (1) would not change anything about their operation or (2) would downsize to free up more of their time, with the caveat that if they had not already transitioned to pivot irrigation, they would do that because of how much time and energy it saves them. These responses were grounded in the need to grapple with their current reality, rather than hope for another one. Farmers said they are “happy where we are,” they “have all the ground we need,” and what they’re currently doing “makes us a living and pays the bills and the labor,” helping them navigate the volatility of agricultural markets and land “right in the middle.” Their current practices were attributed to decades of optimizing crop choices, seed varieties, machinery, and rotation schedules, of

which they were proud. One older, non-organic farmer explained how instead of diversifying their crop production, they would raise fewer crops to free up more of their time and take more vacations:

“I think reality being what it is, I don’t think that we would want to raise any other crop. The beans are a lot of trouble, and sometimes I wish we only raised hay. If I continue to farm here, say in five years, and we decided that we can make it financially just raising the hay and the wheat, that’s what we’ll do... We are stuck on the farm all summer long from sometime in April until sometime in October. So, we’ve never taken a summer vacation! If we weren’t raising beans, then we could probably take a few more days off.”

In contrast, some farmers (only four of the 14 interviewed, all of whom were organic) did describe—or imagine—alternative landscapes and farming systems that expanded from their current ones. The farmers who described alternative landscapes include building a demonstration farm in partnership with the Nature Conservancy to showcase soil-building practices (e.g., intercropping), as well as raising more warm-weather cover crops to “bank more nutrients,” trying out new cover crops, and adding new cash crops to their rotations. With the ability to update irrigation equipment and tractors, some wanted to expand more on current markets and add a whole new product to their operation (e.g., adding cheese-making on to an organic dairy operation). In addition to wanting more time in the day to “go back to squeezing in a run once a day,” a younger, organic farmer imagined a farm that expanded its influence to have global impacts:

“We have beliefs of more to this life than just eat, sleep, drink and die; there’s more purpose to it. So, we’ve talked about that all the time—to be a part of something bigger than just what we are. Our goal is to create an operation that has outreaching impacts on accomplishing good in parts of the world where they don’t have that opportunity. It’s gonna take 30 years, maybe, to get there but...”

Through this process of imagining, these farmers revealed the passion woven into their operation’s success and its future potential. In describing the resources that they would want and need to “juice up” their organic operation, one farmer even exclaimed that they did not want to talk more about this because such wishful thinking was “dangerous” and, therein, difficult.

The danger and difficulty of imagining alternatives for both organic and non-organic farmers is likely rooted in hesitancy to dream outside of present constraints and toward future

landscapes, particularly because such imaginings are inextricably linked to one's own land use decisions and agency. In this way, past and present experiences shape the possibilities we can imagine (Mische 2009; Sullivan-Wiley and Teller 2020). While organic farmers exhibited more of a direct desire and ability to experiment with alternative practices than non-organic (as is consistent with organic farmers across the US [Lyon et al. 2011] and beyond [Catalogna et al. 2018; Kummer et al. 2017]), these desires cannot often be enacted. Broadly, envisioning beyond farmers' present reality is inherently stifled by the dominant capitalist agricultural paradigm in the US (Roux-Rosier et al. 2018; Rissing 2021), as well as day-to-day logistical and economic challenges that make agricultural livelihoods difficult and exhausting.

3.2.3 Daily challenges and structural limitations

Imagining (and, thus, enacting) alternative diversification strategies is constrained by the daily challenges and sociopolitical context within which farmers in the Magic Valley operate. Generally, farmers have to make daily decisions with great uncertainty and imperfect information as they balance financial, familial, political, gendered, racialized, and other dynamics (to name a few) with the physical demands of their job (Jarosz 2011; McGuire et al. 2013; Valliant et al. 2017; Eitzinger et al. 2018; Emerton and Snyder 2018; Findlater et al. 2019; Leslie et al. 2019; Isbell et al. 2021). Beyond these daily challenges, structural factors, such as financial assistance programs, machinery development, or genetic crop breeding, can "lock" farmers in to their current perspectives and practices, pushing alternative ways of farming and thinking farther out of their current reality (Meynard et al. 2018; Magrini et al. 2018). We identify these sources of daily struggle and structural constraints to illuminate how they disincentivize and limit farmers' ability to envision alternative landscapes.

Performing daily on-farm labor was consistently cited as one of the most difficult challenges of both managing their current operations and enacting potential changes. In general, the workload of farming is incredibly demanding, and duties vary by season. One farmer described what a typical workday is like for them during the summer season:

"Leave at four o'clock in the morning, check the water with a flashlight before we have to go out, brand and move cattle, come back in the dark, check the water again, go to bed at midnight, get up again at 4 or 5 AM or earlier. It's not that way year-round; we're just like any farmer that puts the effort in to manage."

The workload, although seasonally variable, is a constant pressure, making it difficult to get away for a rest or holiday. A dairy farmer recollected a sentiment from their father: "The cows do not know it's your birthday. They do not know when

it's Christmas. They do not know that it's Thanksgiving. So, I suggest you get out there and get your work done." Such obligations can strain personal time and relationships and inherently limit the ability to take on more responsibilities by increasing crop diversification or to begin imagining more radical alternative pathways.

Moreover, maintaining a full-time and seasonal workforce poses its own challenges to the ability to manage and diversify their operations. Farmers asserted that retaining full-time employees is difficult because "they seem to come and go, and it don't matter what you're paying them; it's just the fact that there's too many other options out there." Those who have had a consistent full-time staff for several years considered themselves "incredibly lucky." For farmers relying on seasonal laborers, it is difficult to find laborers, pay them a living and fair wage, and ensure that each person is properly trained. Of this process, one farmer lamented, "It's a constant cycle of retraining: every year we're training new people and making sure they understand, only to, when wintertime comes, to lay them off." Finding help locally is difficult and has led several farmers to turn to the H-2A visa program for seasonal migrant workers for the physically demanding "grunt labor" and other specialty labor. Farmers who utilize the H-2A program spoke highly of the work ethic and quality work from these migrant workers. Several said that they get the same workers each year, and those workers will bring their cousins and siblings; some have had the same group of workers for roughly 30 years. However, this program is described as somewhat restrictive and difficult to keep up with because "they [the program] keep upping the wage"—a necessary requirement to adequately value and protect migrant farmworkers' knowledge, dignity, and physical effort in a system that too often has not done so (Minkoff-Zern and Sloat 2017; Klocker et al. 2020). One farmer described it as follows:

"We're dictated on what we have to pay them. We have to pay for their transportation, and meals, and hotels on their way up from Mexico and on their way back, and we have to provide them the housing. That was one requirement that was a little hard to overcome. Being able to find housing 1) in the housing market that we're in right now, and 2) that is affordable as well. That was definitely a challenge, for sure."

Often, the Spanish-English language barrier between farm managers and workers adds to these difficulties, for both farm managers and workers alike. Taken as a whole, this consistent struggle of maintaining a labor force constrains farmers' willingness to engage in more labor-intensive practices, such as cover cropping and no-till, and makes it difficult to seriously imagine the potential for more deeply diversified production practices and agricultural landscapes in this region.

Beyond labor demands, reliance on federal subsidies and crop insurance present barriers to diversification by incentivizing only certain commodities on which farmers rely to be competitive. Most farmers participate in federal subsidy programs, even if they wish they did not have to. The most frequently used programs are the Price Loss Coverage (PLC) and Agricultural Risk Coverage (ARC) programs that pay farmers the difference when the actual revenue from a certain covered commodity falls below the effective reference price or market average price for that year; each commodity must be separately covered to receive these payments. The amount of money received from these programs was consistently described as “not a lot, but every little bit helps.” Another farmer said, “It’s usually so small that I’m like, ‘Well, that’ll buy a pair of socks.’” In contrast, the payment programs in response to the COVID-19 pandemic were described as bigger than those regular subsidies and much more helpful. Another farmer described the impact of that support: “If we had not had that COVID-related government assistance, we would not have been able to make our payrolls this year because of crop failures, not because of COVID.” Farmers in the Magic Valley expressed reluctance about taking advantage of these federal subsidy programs and acknowledged feelings of guilt and frustration regarding taking “free handouts” and “corporate welfare.” Yet, without that assistance, they state that they could not compete with other farmers, and it has been a “necessity over the eons of time—from the 1930s on up.”

Farmers described a mixed relationship with crop insurance and its ability to mitigate risk for their operation. Disaster, fire, and hail insurance are the most common, but most have never (luckily) had to collect on them. Several farmers have never needed to enroll in or rely on crop insurance based on their farm’s microclimate and diversity of crops, saying that southern Idaho “has the advantage over the farmers in the Midwest: We raise a variety of crops... some will be down and yet others will be up, so it makes a good balance.” Several organic farmers described the crop insurance programs negatively, stating they have yet to find a good option to insure all their different crops. One described it as follows:

“The payment wouldn’t cover all of our losses because we can’t insure all of the beans because we grow stock seed to comply with Idaho bean laws that can be planted back here, but that stock seed can’t be insured. The crop insurance program doesn’t work for diverse operations in counties that don’t have good data sets for that crop. It’s really designed to keep people on a treadmill, in my opinion. Keep people on a treadmill of a few key crops in areas where they’re traditionally grown.”

This lack of support and flexibility from crop insurance is a theme that resounds through prior research studies, affirming

the notion that it too often fails to mitigate maladaptive outcomes (Müller et al. 2017). This reality has driven the farmers in the Magic Valley, for whom it provides limited support, to work with other organizations as alternative risk mitigation strategies, like the Nature Conservancy, that provide capital and support to farmers to experiment with new diversification practices.

Finally, market volatility and pressure to secure contracts presents ongoing challenges to alternative diversification strategies. Although “spreading out one’s eggs into different baskets” on the crop market was identified as a desirable and lucrative goal, the market prices of crops and commodities largely dictate what farmers grow and, ultimately, specialize in. The volatility of these prices is consistently a concern for dairy farmers and crop producers alike. The price of wheat can change dramatically from one year to the next, directly affecting how much corn they grow in comparison to the wheat. The price of milk often changes, presenting a source of stress and instability, even month to month. In some years, the premium for organic milk can help ensure the investment to transition to organic is profitable, but, in other years, it is just the opposite. In the same way, the organic crop and commodity markets may not be reliable enough to provide a profitable return within the first few years of investment and transition, especially because “the market is smaller so it’s easier to flood.” If there is not a market for certain crops, farmers will likely not grow it. Thus, producing crops for which a supply and demand market is not yet well-established puts farmers at too high of a risk for investing money up front that they may not earn back, on top of an already volatile profit return.

Securing contracts (both formal and informal) for cash crops is important for ensuring a profit from year to year. These contracts are typically secured during the year prior to cultivation, ideally before anything is in the ground, to help plan how much land is dedicated to each crop. Sugar beets, given that they are operated through a market-share cooperative, have maintained stable pricing and profit returns for several decades. Farmers cite this as one of the most desirable cash crops: “When I say it’s been consistent, I mean, I have a brother-in-law that grows sugar beets, and he pretty much can pencil in the same profit every year, year in and year out. Because of that, [the costs] to purchase those shares have skyrocketed.” Unlike sugar beets, potato prices can fluctuate dramatically from year to year, and producers are relatively powerless in negotiating with a relatively consolidated processing sector. This volatility is, in part, buffered by maintaining a diversity of potato varieties that can secure contracts across different companies. The ability to secure formal contracts was described as desirable and an ongoing process of maintaining good relationships with

vendors and representatives. Nonetheless, some prefer informal agreements in place of formal contracts to gain more flexibility and access to fair deals:

“Well, these efforts are really based on relationships, whether you have a contract or not. A contract is sometimes only as good as the people behind it, and so it doesn't really matter in many cases. There's just a lot of trust involved in a lot of these operations. If you have dairy customers and dairy partners who you've grown forward for over a long time, you know what to expect from them: you know when you can get paid or you know they're willing to work with you (or you're willing to work with them if they're behind on payment or something). Whereas if you had a contract, you might not have that flexibility.”

Every farmer described the need to adapt to market pressures and the status of their contracts every year to be able to turn a profit. The necessity to keep up with market demand dictates what farmers can (and will) do on their operation. This narrative of market limitation reverberates across the US, specifically in the Corn Belt where “corn is king” (Roesch-McNally et al. 2018a, pp. 211–212), making production of alternative crops outside the corn-soy (and occasionally wheat) rotation seem largely unviable. These limitations make it intrinsically difficult for farmers to “think outside the box” to imagine more radical departures from their current crop mixes or even push back against local and regional production norms (the diversification present). In this way, political, economic, and cultural feedbacks construct narrow expectations for what is required to achieve profitability and also create established ideas of what makes them a “good farmer” to their neighbors and community (McGuire et al. 2013; Lavoie and Wardropper 2021).

4 Conclusions

This research contributes several important findings toward understanding barriers and bridges to crop diversification and, ultimately, agroecological transformation. Given that the Magic Valley is a region characterized by quantitatively agriculturally diverse landscapes as compared to the rest of the US, we expected, through a qualitative approach, to gain a deeper understanding of how farmers are able to achieve current levels of crop diversity and to find a model for how to imagine transitions toward diversification. We did find that farmers have established a regionally diversified landscape relying primarily on temporal diversification strategies—crop rotations and cover cropping. Interestingly, this diverse landscape has been supported by the presence of industrial food processing facilities and buyers in the area which provide

stable prices and the availability of contracts for primary cash crops.

However, we did not find evidence that these temporal diversification strategies are paired with other spatial diversification strategies (e.g., intercropping or non-crop habitats) to be representative of an agroecological approach. We also found mixed evidence of farmers experimenting with and imagining alternatives to current strategies, suggesting that different forms of agricultural diversification is possible, but most farmers pointed to daily logistical challenges and structural market realities that make diversification changes not only difficult but unlikely and even “dangerous” to explore. Most farmers did not express an intrinsic interest in or desire to extend their current strategies to encompass a new, more diversified reality. Crop diversification was done to maintain balance to their operation and ensure they were competitive in crop markets, but not seen as a normative good or something they were necessarily aiming toward.

By using qualitative methods in this study to contextualize and interrogate the quantification of crop diversity from prior studies (Burchfield et al. 2019; Aramburu Merlos and Hijmans 2020), we find that the implementation of certain crop diversification strategies within a landscape—and locating places and farmers currently engaged in strategies of diversified cropping—does not inherently promote or enact agroecological transformation. In the ways that agroecology cannot be reduced to a set of practices, the accumulation of crop diversification practices across a landscape may not inherently lead to pathways of sustainable change. While crop diversification in and of itself is still likely to boost ecological benefits, the prevalence of temporal diversification strategies in the Magic Valley reflects the regional normalization of crops and their economically proven—successful rotations rather than an active and intentional process of diversification that decenters profit and markets centers agroecological “metamorphosis”. Such normalization of specific crop rotations and practices may even limit future diversification innovations, “locking out” (as opposed to locking in) agroecological alternatives (Boulestreau et al. 2021). Thus, the work of scaling agroecology must go beyond field boundaries toward paradigmatic shifts.

The agricultural imaginaries of the farmers in this study reflect a reality that is physically and emotionally demanding, as well as structurally constrained. Political agroecology posits that transformation can occur when profit and “the market” are decentered (Anderson et al. 2019), but farmers' present realities must value such factors to maintain their livelihoods. Moreover, the imagination of future, “abundant” landscapes reflects dominant social values and paradigms at present (Sullivan-Wiley and Teller 2020). This means that farmers are not simply reluctant to

enacting and envisioning alternative strategies but also repetitively disincentivized to do so through federal policies (like commodity subsidies and crop insurance) that fail to reward diversification, as well as the daily physical and emotional demands of farming. In this sense, we find that transformational imaginaries are constrained by current structural conditions (Schmook et al. 2022). For agroecological transformation to take place, the realities of who is farming and why they make the choices they make must be centered as much as how they farm. Furthermore, while structural market forces have traditionally discouraged agricultural diversification, changing consumer preferences may push for more sustainable food and valuation of ecosystem services along the food chain. Future work with other supply chain actors and across different US regions could provide important insights into the potential power of consumers, processors, and distributors in providing economic rewards to producers who utilize diversified rotations. Building and supporting realistic pathways of change requires a reckoning with the often-indomitable challenges associated with farming and rural livelihoods and a broader social, political, and economic reimagining of what is desirable and, ultimately, possible.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s13593-022-00833-0>.

Acknowledgements We would like to acknowledge, first and foremost, the farmers and participants in this study that took time out of their intensely busy schedules to chat with us and share their stories; what a gift. We also thank Britta L. Schumacher for her assistance in conducting and reflecting on interviews in 2019, as well as Dr. Matt Yost for helping us connect with farmers in the Magic Valley. Finally, we thank Drs. Roslynn Brain McCann and Andrea Rissing for feedback on the interview questionnaire.

Authors' contributions Conceptualization, K.S., E.K.B., and C.R.; methodology, K.S., E.K.B., C.R., and D.J.S.; validation, K.S., and R.J.; formal analysis, K.S., and R.J.; investigation, K.S.; resources, K.S., and R.J.; data curation, K.S., and R.J.; writing—original draft preparation, K.S., E.K.B., C.R.; writing—review and editing, K.S., E.K.B., C.R., D.J.S., and R.J.; visualization, K.S.; supervision, K.S., E.K.B., C.R., and D.J.S.; project administration, K.S., E.K.B., and C.R.; and funding acquisition, K.S., and E.K.B.

Funding This research was supported, in part, by USU's Climate Adaptation Science Program through the National Science Foundation under Grant No.1633756 and USU's Presidential Doctoral Research Fellowship. This work was also supported, in part, by US Department of Agriculture National Institute of Food and Agriculture grant number 2020-67019-31157. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the US Department of Agriculture.

Data availability The datasets generated and analyzed during the current study are not publicly available due to risk of the loss of anonymity of its

participants, but they are available in their de-identified form from the corresponding author on reasonable request.

Code availability The codebook used to analyze datasets for this study is provided in Supplemental Information (SI Table 1). The coded datasets are not publicly available due to risk of loss of anonymity of participants.

Declarations

Conflict of interest The authors declare no competing interests

Ethics approval This study was reviewed and granted exemption by Utah State University's IRB office under protocol #11601 given that it posed minimal risk to participants with justifiable benefit.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication The authors affirm that human research participants provided informed consent for publication given that their identities remained anonymous.

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