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EDITED BY
Elsie Moore,
Cornell University, United States

REVIEWED BY
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University of Georgia, United States
Daniel Eisenberg,
Naval Postgraduate School, United States

*CORRESPONDENCE
Natalia Pinzón
✉ npinzon@ucdavis.edu

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Farmers and ranchers weave the social fabric shaping wildfire resilience

Natalia Pinzón[1]* and Ryan E. Galt[1,2]

[1]Department of Human Ecology, University of California, Davis, Davis, CA, United States, [2]Agricultural Sustainability Institute, University of California, Davis, Davis, CA, United States

Wildfires are one of the most significant threats to California's food and farming systems, endangering a state that produces diverse crops and livestock critical to national and global food security. This study examines the role of social fabric—mutual aid, cooperation, and collective action—in shaping wildfire adaptive capacities among California farmers and ranchers. Using survey data from 403 producers directly impacted by wildfires between 2017 and 2023, we conducted regression analyses to identify how social, operational, and demographic factors influence adaptive behaviors, including making changes, wildfire mitigation practices, knowledge acquisition, and farm continuity. A key finding of this study is the role of the social fabric—an intricate web of social relationships—mutual aid, and collective action—in supporting resilience. Farmers who are deeply integrated into their communities and actively participate in mutual aid demonstrate a higher capacity to adapt to wildfire threats. This suggests that the strength and durability of farmers' community ties may be a critical factor in their ability to innovate and apply effective risk management strategies. More broadly, farmers embedded in strong social networks exhibited greater adaptive capacities, leveraging mutual aid and collective action to facilitate resource sharing, knowledge dissemination, and motivation. Knowledge emerged as a central driver, with frequent wildfire exposure enhancing experiential learning and confidence in risk management. Ecological and diversified farming practices, alongside direct-to-consumer markets, were associated with higher rates of adaptation and stronger social networks. Financial and land ownership factors, including access to social safety nets and off-farm income, further supported long-term mitigation efforts. However, the cumulative burden of adaptive actions, compounded by social influences like peer decisions to quit farming, led some producers to consider exiting agriculture, exposing vulnerabilities within the food system. In light of these findings, we recommend strengthening farmer networks through cooperative models, such as fire-safe councils and farmer-led preparedness groups, while incentivizing sustainable practices like agroecological and mosaic landscapes to buffer wildfire impacts and promote resilience. Agriculture, we propose, represents an underexplored but critical facet of broader wildfire resilience. This study contributes to the discourse on food system resilience by highlighting the interplay between social fabric, adaptive capacity, and sustainable agriculture in the face of climate-induced disasters.

KEYWORDS

wildfires, social fabric, disaster resilience, farmers, ranchers, ecological agriculture

1 Introduction

As extreme weather events accelerate, communities around the globe are experiencing more catastrophic storms, floods, and droughts. Increasing extremes mean that more places are faced with wildfires, which are an increasingly urgent global challenge, with escalating impacts on ecosystems, human communities, and agricultural systems. Wildfires can impact the entire food system, yet their main direct impact is upon farms, ranches, and agricultural producers, which is our focus here.

Recent studies have begun documenting the devastating impacts of wildfires on agricultural production, including the loss of crops, livestock, and infrastructure. These impacts threaten the economic viability of farming operations (Bergtold et al., 2024; Herrera Farfán, 2019; O'Hara et al., 2021; Pinzón et al., 2024a, 2025; Rozaki et al., 2022; White, 2019; Zakowski et al., 2023) as well as the safety of farmworkers (Méndez et al., 2020; Salinas, 2021).

While severely impacted by wildfires, farmers and ranchers are also identified as crucial players in mitigating wildfire risks (Bergtold et al., 2024; Kouassi et al., 2022; Pinzón et al., 2025; Rozaki et al., 2022). Their livelihoods depend on the land, making it essential for them to develop strategies to protect their operations from fires. Their extensive local knowledge, familiarity with the terrain, and deep investment in, and attachment to, place make them potential allies in wildfire management and response (Abrams et al., 2017; Stasiewicz and Paveglio, 2017). This is evident in efforts such as community-based fire management enacted by Rangeland Fire Protection Associations (McCormick et al., 2016), traditional fire and fuel load practices maintained by pastoralists and farmers around the world (Amissah et al., 2011; Coughlan, 2013; Uyttewaal et al., 2024), and the multigenerational fire knowledge, and mutual aid practices that enable farmers and farmers to cope with and recover from wildfires (Amissah et al., 2011; Prior and Eriksen, 2013; Jakes and Langer, 2012; McGee and Russell, 2003; Pinzón et al., 2025; Rozaki et al., 2022).

Much research has thus far focused on wildfire drivers, such as land-use change, climate change, and agricultural abandonment, yet how this articulates with the role of agricultural communities in mitigating and adapting to wildfire risks remains underexplored. Studies from Mediterranean Europe, for example, have demonstrated how agricultural abandonment increases wildfire risks by allowing fuel accumulation on unused land (Martínez-Fernández et al., 2013; Ortega et al., 2012; Silva et al., 2011). Conversely, maintaining an agricultural mosaic, or "edible fire buffers," in the wildland-settlement interface (WSI)[1] suggests that irrigated agricultural land can protect communities during wildfires by creating a barrier that slows the spread of fires and aids recovery efforts through a landscape with diverse and multifunctional land uses (Aquilué et al., 2020; Carmo et al., 2011; Fu et al., 2023; Roos et al., 2016; Thacker et al., 2023). Despite growing evidence on wildfire mitigation, the adaptive strategies of agricultural communities have received limited attention. While social scientists have documented the central role of rural communities' cohesion and ecological knowledge in wildfire resilience, they have paid comparatively less attention to the specific contributions and adaptive practices of agricultural producers, whose land stewardship is crucial for building resilience in the face of increasing wildfire threats.

While much research on wildfires has focused on biophysical drivers of wildfires, comparatively less attention has been given to the social dimensions of wildfire adaptation—despite their fundamental role in helping communities learn how to co-exist with fire. Social scientists have documented how cooperation, collective action, place attachment, and strong community networks form the bedrock for effective wildfire response and mitigation strategies (McCaffrey, 2015; Paveglio et al., 2015a). This is supported by case studies of real-life experiences of communities across diverse regions such as California, the Great Plains, the Pacific Northwest, Mediterranean Europe (Spain, Portugal, Italy), Australia, South Africa, and rural areas of Latin America, emphasizing the need for flexible governance systems that can adapt to a wide diversity of local social and ecological conditions (Bihari and Ryan, 2012; Palaiologou et al., 2019; Fischer et al., 2016). Without considering the heterogeneous local social conditions, landscape-level wildfire risk management is not feasible (Paveglio et al., 2015a, 2015c). Additionally, a strong connection to place and community identity motivates people to take proactive steps to reduce risks. These factors—encompassing local social conditions, place attachment, and community cohesion—are crucial in rethinking how we approach and live with fire (Prior and Eriksen, 2013; Stoof and Kettridge, 2022; Roos et al., 2016). Studies emphasize that communities, particularly in rural areas, are more adaptive when they are well-organized and have strong informal communication networks (Lambrou et al., 2023; Paveglio et al., 2019). This strong sense of place, coupled with local knowledge, empowers residents to ameliorate wildfire threats (Paveglio et al., 2024; Uyttewaal et al., 2024; Paveglio et al., 2018). Furthermore, social capital—comprising networks of relationships, shared norms of reciprocity, and trust that foster cooperation and resource-sharing within communities (Bihari and Ryan, 2012)—is developed through ongoing local interactions that enhance the exchange of vital information and supports coordinated community actions during wildfires (Uyttewaal et al., 2023; Uyttewaal et al., 2024). Studies show that communities learn from and are motivated by past fire experiences, helping them adjust and improve their strategies over time (Fischer et al., 2016; Paveglio et al., 2015a, 2015b). Understanding these social dimensions is essential to prepare communities and ecosystems to face the evolving challenges of wildfires in the Anthropocene (Stoof and Kettridge, 2022; Roos et al., 2016).

The findings from wildfire-prone communities mirror those from wider research on disasters, which has documented the importance of social capital in how communities respond to and recover from disasters. Social capital, defined as social resources embedded in local networks that are mobilized for collective benefit (Flora, 1998), has been identified as a central adaptive force in various natural hazards, including earthquakes, hurricanes, floods, and tsunamis. Aldrich (2010, 2012, 2017), a central scholar in the field, examines post-disaster case studies across Japan, India, the U.S. and beyond, and finds that social capital—not financial aid or the severity of damage—is the central determinant of long-term recovery. These social ties enable mutual aid, information exchange, and political voice during critical recovery windows. Aldrich and Meyer (2015) distinguish

1 We use wildland-settlement interface (WSI) instead of the widely-used term "wildland-urban interface (WUI)" because many if not most of the settlement types occurring at the interface with wildlands are distinctly non-urban (e.g., dispersed rural residences).

among three types of social ties: bonding, bridging, and linking—each of which supports different phases of recovery. They find that tight-knit local relationships can help with immediate survival, while institutional and cross-community ties are important for rebuilding. However, social capital is not universally accessible. It can also spread exclusion when trust, institutional access, or local norms are uneven, especially in rural areas where social connections may strengthen existing hierarchies or limit participation in adaptation and recovery efforts (Flora, 1998; Reimer, 2005; Uekusa et al., 2022).

While research on social capital in disasters has expanded our understanding of how networks facilitate recovery, recent discussions contend that social capital theory risks framing social connections in functional terms—as assets for the exchange of information, coordination of aid, or access to resources—instead of centering relational ties as deeply rooted in culture, history, and ethical values (Uekusa et al., 2022). Scholars have attempted to broaden social capital as multidimensional frameworks of cohesion, including aspects such as belonging, participation, and inequality. However, these models risk being conceptually diffuse and can be influenced by policy agendas rather than local community praxis (Addeo et al., 2017). We therefore draw on the Latin American concept of *tejido social*—not merely as a direct translation of "social fabric"—but an alternative conceptual framework rooted in the sociological and community development traditions (Fals-Borda, 1985; Getz, 2008; Lorusso, 2021). Halpern (2005) proposes that the term social fabric could be considered a synonym for social capital. However, this usage is rare and generally does not capture the political and historical significance that is central to Latin American interpretations of *tejido social*.

Despite recent attempts to redefine it as dynamic and contested, we deliberately avoid the term social capital because it still tends to frame relationships as assets to be accumulated and exchanged, thereby reducing complex social dynamics to individual transactions (Uekusa et al., 2022). In contrast to social capital or social cohesion (which usually entails a group's sense of belonging, solidarity, and trust in institutions), social fabric emphasizes the active, ongoing process of weaving communal life through mutual aid, cultural memory, and relational repair—particularly in contexts of marginalization or rupture (Fals Borda, 1985; Lorusso, 2021). As pointed out by Lorusso (2021), social fabric goes beyond merely describing existing relationships; it serves as a conceptual framework for understanding the collective, ethical, and affective labor involved in building community amid structural fragmentation. In rural communities facing disasters, social fabric can illuminate how resilience is fomented through place-based cooperation and interdependence. Unlike the instrumental, economistic, and state-centered logic of social capital—social fabric foregrounds lived practices, cultural memory, territorial rootedness and the weaving, defense and repair that is needed to sustain it. The social fabric holds these essential functions that underpin agroecological transformation and collective resilience (Tittonell, 2020). Mier y Teran et al. (2021) show that the expansion of agroecology has been driven not only by technical innovation, but also by the development of the social fabric, nurtured through farmer-to-farmer networks, territorial movements, and long-term investment in collective wellbeing. We use this concept to better capture the ways in which agricultural communities survive, adapt, and resist—often invisibly—in fire-prone landscapes.

California, with its diverse agroecological landscapes and history of catastrophic wildfires since fire suppression from Anglo-European colonization, provides a unique context to examine the adaptive capacities of agricultural communities facing increasing wildfire threats. As a critical contributor to local, national, and global food systems, California encompasses a variety of socio-ecological systems and farming practices, making it an ideal site for studying how agricultural communities adapt to fire-prone environments. The state's Mediterranean climate, characterized by hot, dry summers and mild, wet winters, historically supported fire as a natural ecological process. However, decades of fire suppression and changes in forest management, land development in the WSI, and increasingly dry conditions in soils and forests from higher temperatures, have resulted in dense, fuel-laden landscapes that are now prone to catastrophic wildfires (Keeley and Syphard, 2021; Norgaard, 2022; Pyne, 2016).

Through a statewide survey of California farmers and ranchers, this study seeks to answer the question: What elements of the social fabric facilitate the adaptive capacities of farmers[2] facing wildfires? We define adaptive capacity as the potential of farmers to prepare for, respond to, and recover from wildfires. In line with Beever et al. (2016), we distinguish between *foundational* and *realized adaptive capacities*. Foundational adaptive capacities, akin to a species' fundamental adaptive capacity, represent the intrinsic resources and traits that enhance a farmer's potential to adapt, such as social networks, knowledge, and fire-related skills. Realized adaptive capacities, like the realized niche, reflect how external constraints, such as wildfire severity, economic resources, and social support, shape the observable actions farmers take to mitigate wildfire risks. This framing enables us to explore the interplay between underlying capacities and adaptive outcomes, focusing not only on the resources that facilitate adaptation but also on the barriers that hinder the full realization of adaptive capacity.

We focus on the role of the social fabric because it captures the dynamic, place-based processes of mutual aid, collective action, and shared knowledge that enable communities to adapt, recover, and transform in the face of wildfire threats. 'Social fabric'—defined as the intricate web of social relationships, mutual aid, and collective action that binds agricultural communities together—emphasizes the evolving, collective processes of building trust, solidarity, and interdependence that are central to community resilience in agroecological systems.

This study explores how the social fabric of farmers affects their realized wildfire adaptive capacity. These adaptations align agricultural practices with the realities of living in a fire-prone area, suggesting that the strength and resilience of farmers' connections within their community could be a key factor in their ability to innovate and apply effective risk management strategies. By examining these dynamics, this research provides insights into the social fabric so that agricultural communities and the agents that support them can implement strategies to strengthen their social fabric to better adapt to increasing wildfire threats.

2 Defined from hereinafter as anyone who owns or manages a farm that produces crops and/or livestock.

2 Materials and methods

This study employed a statewide survey to examine the adaptive capacities of California farmers in response to wildfires. The following section provides a detailed overview of the methodological approach. It begins with a discussion of the survey design, the rationale behind sample selection, and the data collection process. We then outline the analytical methods, including the processes for building regression models and selecting dependent and independent variables.

2.1 Survey design and implementation

We administered a 34-question, descriptive, cross-sectional survey to California agricultural producers impacted by wildfires between 2017 and 2023. Participants had to be owners, operators, and/or decision-makers of farms or ranches. To be impacted by wildfires, respondents had to have experienced: a fire on or near[3] their operations' property; a wildfire evacuation order; wildfire-induced power outages; and/or prolonged[4] smoke, ash, or poor air quality due to wildfires. The survey consisted of closed-ended and open-ended questions and had three main sections: wildfire exposure and impacts, wildfire disaster response and recovery, and operation background and producer demographics. After the survey was developed, the face and content validity were established by a panel of experts. Before distribution, the survey was pilot-tested for reliability with 18 producers randomly selected from the sampling frame below. Pilot test results were analyzed to identify and address any ambiguities, inconsistencies, and technical issues, ensuring the clarity and effectiveness of the final survey. Pilot surveys were excluded from the analysis.

The survey was developed in Qualtrics and distributed via four distribution channels: (1) direct email invitation to a verified list of 19,518 producers, (2) social media, (3) industry newsletters, and (4) word of mouth. The email list was compiled from three sources. First, we obtained contacts from DTN's FarmMarketID (FMID), as recommended by Ulrich-Schad et al. (2022). However, in California, FMID generally underrepresents ranchers as well as diversified, organic, and beginning producers (J. Lopp of DTN, personal communication, Jan. 2021). To address these gaps, we therefore added the California Certified Organic Farmers (CCOF) list of organic farmers and the Community Alliance with Family Farmers and Farmer Campus lists of producers who participated in wildfire programs. We distributed the survey through email to the final list compiled from these three sources. We also distributed the survey via the California Cattlemen's Association e-newsletter and word of mouth through UC Cooperative Extension County Advisors.

To incentivize participation, respondents who completed the survey were offered a $20 gift card and the opportunity to enter a lottery for eight $200 prizes. The survey was open from April to August 2023. To ensure data integrity, a rigorous data cleaning process was implemented (Pinzón et al., 2024b), including removing incomplete, non-consenting, and disqualified responses; a total of 505 valid responses were obtained. Of those, only respondents who directly experienced wildfires near, or on, their properties, and/or evacuations or power outages due to wildfires were retained for this analysis. Respondents who only experienced prolonged exposure to smoke or ash were excluded. This resulted in a total sample of 403 respondents who experienced direct wildfire impacts as defined above. Of these 403, 91% responded from the email list while 9% responded through being contacted by word-of-mouth by UC Cooperative Extension or through the CCA newsletter distribution.

Although the emails went to 19,518 producers and the CCA e-newsletter and word-of-mouth channels reached, aggregating these should not be considered the population we were trying to reach, which was producers impacted by wildfires, since they make up a relatively small proportion of total producers in the state. Since the number of producers directly impacted by wildfires in California has not been documented, we aimed for a sample size of more than 384 survey responses to achieve a representative sample size for the 69,200 operations in California (NASS, 2023), which, if the sample is representative of the population, would produce a 95% confidence level with a 5% margin of error (Ary et al., 2018). Elsewhere (Pinzon, 2024: 34–36) we assessed the spatial representativeness of the full sample at the county level by comparing the sample to the California Department of Forestry and Fire Protection (CALFIRE) wildfire incident reports that document acres burned per county and region (CAL FIRE, 2024), and the 2017 census data from the National Agricultural Statistics Service (NASS) on the number of agricultural producers in the state (NASS, 2017). The analysis showed that two regions were relatively under-represented and one was over-represented—largely because of the mismatch between the spatiality of wildfire and the distribution of farmers—and the overall analysis suggests "that the survey sample under consideration is geographically representative of its target population—California farmers affected by wildfire" (Pinzon, 2024: 35).

2.2 Analysis

To examine our research question—"What elements of the social fabric facilitate the adaptive capacities of farmers facing wildfires?"—we used a combination of descriptive analysis and modeling, including univariate and multivariate regression analysis and factor analysis. Data analysis was carried out with STATA (version 18.0).

2.2.1 Purposeful variable selection

In building the regression models, we used the purposeful variable selection process recommended by Hosmer et al. (2013) to create statistically sound, transparent, and practically meaningful explanatory and descriptive models. Research by Bursac et al. (2008) examined the effectiveness of purposeful selection, finding that it retains significant covariates and confounders more reliably than automated techniques such as stepwise selection, especially in sample sizes ranging from 240 to 600. Its strength is thus in modeling the relationship between variables, rather than predicting future outcomes. The purposeful variable selection process as outlined by Hosmer et al. (2013) involved both theoretical tenets and empirical data analysis. Initially, we chose independent variables based on their potential influences on wildfire adaptive capacities based on a review of the literature and the first author's background knowledge gained through 7 years of field

3 "Near" was not defined, leaving interpretation to respondents.

4 "Prolonged" was not defined, leaving interpretation to respondents.

experience (Heinze et al., 2018). The preliminary analysis included bivariate regressions between the dependent and independent variables to determine which independent variables met the inclusion criteria of $p < 0.25$, suggesting a potential relationship with adaptive capacities. This more inclusive cutoff helps prevent the premature exclusion of variables that may not appear significant in isolation but could become important within a multivariable context due to confounding or joint effects. Following this, all identified variables were included in a multivariate regression model to assess their contributions to the dependent variable in the presence of the other variables. An iterative process of refinement of the model followed by excluding variables that did not significantly contribute at $p < 0.1$ (Bursac et al., 2008). This approach supports descriptive and explanatory modeling by reducing the risk of Type II errors and retaining variables that meaningfully influence the model's structure and interpretation. Hosmer et al. (2013) and Bursac et al. (2008) emphasize that more conservative thresholds (e.g., $p < 0.05$) may lead to underfitting, particularly in models addressing complex social or ecological dynamics with moderate sample sizes. Variables or groups of variables that altered the coefficients of other explanatory variables by more than 20% when removed were considered confounding variables and thus were retained regardless of their statistical significance.

Once a stable, preliminary main effects model was constructed, the model was again assessed for important missing variables that had not been selected during the bivariate selection stage. Those additional variables were added with attention to their statistical significance and conceptual relevance. While this step involved empirical testing, it remained grounded in a purposeful selection process (Hosmer et al., 2013; Bursac et al., 2008), which is designed to balance theoretical guidance with empirical sensitivity analysis. This approach aligns with the goals of descriptive—not predictive—modeling, where the aim is to explore and interpret underlying relationships rather than to optimize predictive accuracy (Shmueli, 2010). The R-squared was occasionally monitored for improved model fit; however, it was not a primary criterion for variable selection. The purposeful variable selection process, a form of sensitivity analysis of independent variables, gave way to documented and replicable processes and allowed us to systematically observe the effects of variables on overall model dynamics. Notably, the final models arrived at through the above process were more parsimonious and stable compared to when using other methods, including automated forward and backward stepwise regression and unstructured specificity analysis.

All dependent variables were analyzed using robust estimates of ordinary least squares regression (OLS) due to the interval and rank-ordered nature of the categories that comprise them (explained in detail below). Given that the dependent variables are rank-ordered Likert scales and we have a sufficiently large dataset, the use of OLS regression is justified by the Central Limit Theorem, which ensures that the distribution of the sample means approaches normality, thus satisfying the normality assumption required for OLS (DeWees et al., 2020). This is further supported by the Shapiro–Wilk tests, which returned a W value above 0.95 across all models, indicating normally distributed residuals. OLS with robust estimation was used to produce heteroskedasticity-consistent standard errors, thereby improving the reliability of inferences in the presence of potential violations of classical OLS assumptions. To further assess model specification and potential sources of bias, we conducted three diagnostic tests: the Variance Inflation Factor (VIF) test for multicollinearity, White's Test for non-linear forms of heteroskedasticity, and the Shapiro–Wilk test to assess the normality of the residuals.

2.2.2 Dependent variables (realized adaptive capacities)

The dependent variables represent *realized adaptive capacities*—observable outcomes of farmers' responses to wildfire risks. These variables were derived from survey responses and operationalized as follows:

- **Made changes**: The degree to which farmers reported making significant changes to their operations in response to wildfires.
- **Mitigation scale**: The extent to which farmers now prioritize established wildfire risk mitigation practices (see Table 1).
- **Knowledge**: Farmers' self-assessed knowledge of how to deal with wildfire-related threats.
- **Considered quitting**: Whether farmers have considered quitting farming due to the impacts of wildfires.

All dependent variables were modeled using ordinary least squares regression due to their interval and rank-ordered nature and the robustness of the dataset's size (described above). Table 1 provides a detailed list of all the dependent variables used in the regression analysis.

Two of the dependent variables—*Made Changes*[5] and *Mitigation Scale*—are closely related[6] but capture different dimensions of adaptive responses to wildfire risks. *Made Changes* reflects whether farmers took action in response to wildfire impacts; however, these actions were not specified and may encompass a broad range of changes in agricultural production or operational management, not all explicitly tied to established wildfire risk management practices. For example, changes might include altering the scale or varieties of crops grown or livestock raised, changing agroecological practices, relocating operations, or shifting market strategies.

In contrast, the *Mitigation Scale* specifically evaluates the extent to which adaptive actions translate into targeted wildfire risk mitigation strategies, capturing the breadth and depth of practices such as fuel reduction, defensible space creation, implementation of emergency systems, and wildfire risk training and planning. By including both variables in the analysis, this study captures both the initiation of adaptive responses and the degree to which those responses align with established wildfire risk management practices.

2.2.3 Independent variables

The independent variables in this study were organized into seven groups: wildfire exposure, wildfire impacts, operation characteristics, fire-related skills and resources, socioeconomic indicators, demographics, and foundational adaptive capacities.

Foundational adaptive capacities refer to resources or traits that support farmers' ability to adapt, such as self-assessed wildfire knowledge, social fabric, and fire-related skills. These capacities provide insight into the relationships between prior experiences and farmers' ongoing adaptations. Importantly, some realized adaptive capacities—such as *Knowledge*, *Made Changes* and *Mitigation*

5 Henceforth, all variable names will be italicized.

6 Pearson's correlation of 0.47.

TABLE 1 Dependent variables used in regression analysis.

Variable	Question	Type	*n*	1	2	3	4	5	Min	Mean	Std.	Max^
Knowledge	I know how to deal with wildfire-related threats to the farm/ranch	Ordinal	395	3%	12%	13%	49%	24%	1.00	3.79	1.02	5.00
Made changes	I have made significant changes to my farm/ ranch as a response to wildfire	Ordinal	397	3%	11%	26%	39%	21%	1.00	3.63	1.03	5.00
Considered quitting	I have considered stopping farming/ ranching as a result of wildfire	Ordinal	397	47%	16%	12%	19%	7%	1.00	2.23	1.38	5.00
Mitigation scale	Which wildfire risk management practices does the farm/ranch now prioritize? (1) grazing, (2) prescribed burning, (3) thinning, (4) annual fire breaks, (5) defensible space, (6) building hardiness, (7) evacuation comms. plan, (8) livestock evacuation plan, (9) employee fire response training, (10) water storage/supply, (11) off-grid systems, (12) emergency warning systems, and (13) community prep. group	Interval†	395						0.00	0.31	0.20	0.92

1 = Strongly Disagree, 2 = Disagree, 3 = Neutral or unsure, 4 = Agree, 5 = Strong Agree.
^ Decimal maxima occurs when no respondent selects all variables comprising an index.
†A composite mean score index coded from a select-all-that-apply question of 13 binary (yes/no) variables. A higher value indicates a higher number of risk mitigation practices prioritized. This is a normalized index with scores ranging from 0 to 1, representing the proportion of mitigation strategies selected (e.g., 0.92 = 12 out of 13).

Scale—were also used as independent variables in some models and as dependent variables in others. This reflects the iterative and descriptive nature of adaptation processes, where earlier actions and accumulated knowledge can shape future decisions and priorities.

For instance, farmers who reported making significant operational changes (*Made Changes*) may also be more likely to consider quitting farming (*Considered Quitting*) if those changes were resource-intensive or unsustainable. Similarly, self-assessed wildfire knowledge (*Knowledge*) may correspond with the extent to which a farmer prioritizes mitigation strategies (*Mitigation Scale*).

In line with resilience research, which highlights feedback loops and interdependencies in socio-ecological systems (Darnhofer, 2021; Meuwissen et al., 2019), this approach allows us to explore how adaptive capacities function as both outcomes and contributing factors in farmers' adaptation trajectories. This descriptive framework does not seek to establish causality but rather to identify patterns and relationships that inform resilience and vulnerability.

Table 2 provides a list of all the independent variables used, their descriptions, variable types, and corresponding survey questions which are found in Supplementary material.

2.2.3.1 The social fabric index

Efforts to measure social capital in disaster contexts have largely relied on two approaches: surveys or interviews that capture subjective dimensions such as trust and altruism, and index-based models that use aggregated proxy data from secondary sources (Jang et al., 2024). While surveys can provide insight into lived relationships, their use is often constrained by time, cost, and feasibility. Consequently, most social capital indices rely on demographic or institutional proxies which are more readily available. The field has become heavily urban-centric and dependent on such proxies (Engbers et al., 2017), which frequently obscure local nuances and fail to capture the dynamic ways in which social capital is enacted (Jang et al., 2024; Pendley et al., 2020). This is particularly concerning in rural areas, where social connections tend to be informal, highly localized, and less visible in aggregated datasets (Pendley et al., 2020).

One notable approach using social capital indicators in the wildfire (but not agriculture) context is Bihari and Ryan (2012), who operationalize social capital as a unified "community cohesion" factor. Using survey-based factor analysis, they combine indicators of trust, volunteering, local collaboration, and shared resource use—treating social capital both as an outcome of place attachment and wildfire experience, and as a predictor of preparedness behaviors such as vegetation clearing and emergency planning. While numerous indices have been developed to measure social capital more broadly, He et al. (2023) offer the only known attempt to create a Social Fabric Index specifically for disaster contexts. However, their model relies exclusively on demographic proxies and was not designed for agricultural communities or wildfire-related risks.

Given the absence of an index suited to wildfire-affected agricultural regions, the limitations of proxy-based models, and the relatively recent emergence of wildfire as a threat in agriculture, the literature on comparable indices in this context remains underdeveloped. Moreover, social capital measures must be context-sensitive (Engbers et al., 2017). Our intention, therefore, was not to utilize or generate a generalizable index, but to investigate the emergent and situated dynamics of adaptation to wildfire in agricultural communities in California. The *Social Fabric Index* we developed is thus necessarily inductive and grounded in 7 years of participatory fieldwork. e now turn to how the independent variable, the *Social Fabric Index*, was created and validated. To assess the multidimensional construct of social fabric within agricultural communities affected by wildfires, we developed a *Social Fabric Index*. This index is a composite measure designed to quantify the degree to which respondents were integrated within their local networks and the broader community and able to rely on them and/or support them during the wildfire. Although inherently multidimensional, we reduced this construct to a linear scale to facilitate statistical

TABLE 2 Independent variables tested and used in regression analysis.

Variable and group[†]	Description	Type[‡]	Q# ^
a. Operation characteristics			
Farm age	Farm age as of 2023.	Continuous	27
Total acres	Total acres managed (owned or leased).	Continuous	28
Farm diversity index	Number of crop and livestock types the farm focuses on. **	Interval	4
Gross farm sales	Gross farm sales in an average year. (1) Under $10 k; (2) $10–$25 k; (3) $25–$50 k; (4) $50 k–$100 k; (5) $100 k–$250 k; (6) $250–$500 k; (7) $500–$1 M; (8) Over $1 M	Ordinal	30
Gross farm sales less than $250 k	Annual Gross farm sales below $250,000.	Binary	30
Market diversity index	The number of market types used to sell most of the farm's agriculture products. Options include (1) Intermediate markets and third-party sellers; (2) Direct-to-consumers; (3) Retail markets; and (4) Institutions. **	Interval	29
Markets: direct to consumers	Sells most agricultural products in direct-to-consumer markets.	Binary	29
Markets: intermediate only	Sells most agricultural products in intermediate markets only, relying on no other market types.	Binary	29
Ecological	Organic or ecological practices (self-assessed).	Binary	34
b. Demographics			
Multi-generational	Belongs to a multi-generational farming family.	Binary	34
Years farming	Years of continuous farming experience in three groups: (1) under 10 years, (2) between 10 and 20 years, and (3) over 20 years.	Ordinal	34
Socially disadvantaged	Belong to a group that has been subject to prejudice or discrimination (self-assessed).	Binary	34
Immigrant	Is an Immigrant.	Binary	34
Over 65	Over 65 years old.	Binary	34
c. Socio economic context			
Safety net diversity	Has access to any of: (1) health insurance; (2) disability; (3) unemployment; (4) retirement money; or (5) generational wealth. **	Interval	33
Off-farm income	Household relies on off-farm income.	Binary	32
Off-farm income: core expenses	Household relies on off-farm income to cover farm costs or core household expenses.	Binary	32
Off-farm income: farm costs	Household relies on off-farm income to cover farm costs.	Binary	32
Off-farm income: accrue savings	Household relies on off-farm income to accrue savings	Binary	32
Landowner	Farmer owns any portion of the land they manage.	Binary	28
d. Foundational adaptive capacities			
Fire skills scale	Experience and comfort with fire, ranging from (1) worked as a firefighter; practiced; (2) prescribed burning, or (3) pile burning, or has (4) training in fire suppression. **	Interval	16
Social fabric index	Composite mean score of nine questions related to mutual aid and social networks including: support provided and received during the wildfire, people depended on, and increase in cooperation and networks (see Table 3).	Interval	-
Mutual aid: fire defense	Composite mean score of questions related to direct fire defense for neighbors or other farmers (see Table 3).	Interval	17, 18
Collective action	Composite mean score of questions related to participation in collective action (see Table 3).	Interval	21, 22
Support provided	Composite mean score of support provided to others during the wildfire (see Table 3).	Interval	18
Support received	Composite mean score of support received from others during the wildfire (see Table 3).	Interval	18, 8

(Continued)

TABLE 2 (Continued)

Variable and group[†]	Description	Type[‡]	Q# ^
Networks grew	Community networks grew in response to wildfire *	Ordinal	11
Cooperation	Wildfires had a positive effect on their cooperation and resource sharing with others*	Ordinal	7
Knowledge	Know how to deal with wildfire-related threats to the farm. *	Ordinal	11
Made changes	Have made significant changes to the farm as a response to wildfire.*	Ordinal	11
Mitigation scale	Range of risk management practices prioritized including: (1) grazing, (2) prescribed burning, (3) thinning, (4) annual fire breaks, (5) defensible space, (6) building hardiness, (7) evacuation comms. plan, (8) livestock evacuation plan, (9) employee fire response training (10) water storage/supply, (11) off-grid systems, (12) emergency warning systems, and (13) community prep. group. **	Interval	22
Bounceback	The farm can bounce back from the impacts of wildfire. *	Ordinal	11
e. Wildfire exposure			
Fire frequency	Frequency of wildfire occurrences on a scale from "Every 1–2 years" to "Only once," across four wildfire exposure types (direct, evacuation, smoke, power outages). Ordinal responses were averaged into a composite score, with higher values indicating more frequent exposure.	Interval	6
Fires before 2017	Experienced wildfires before 2017.	Binary	12
Fires before 2000	Experienced wildfires before 2000.	Binary	12
Neighboring fuel load	Defensible space around the farm is jeopardized by the fuel conditions of neighboring properties.	Binary	23
f. Wildfire impacts			
Total impact scale	The total impacts reported across all ordinal impact variables averaged into a composite score with a higher value indicating a higher impact. Variables are those listed within damage severity and personal impact scale below as well as: a measure of how wildfires affected respondents: (1) farm relationships; their ability to compensate; (2) themselves or (3) their workers; and (4) implementation of conservation practices. *	Interval	7 & 15a
Personal impact scale	Measure of how wildfires have affected respondents: (1) Physical health; (2) mental & emotional wellbeing; or (3) personal relationships.	Interval	7
Damage severity	Level of damage severity due to wildfire. Created from a composite mean score of six areas of damage or loss due to wildfire including: (1) operating income, (2) crops, livestock, or ag products; (3) dwellings; (4) farm buildings; (5) farm infrastructure; and (6) natural resources. Impact options were "Very little"; "Significant"; "Devastated."	Interval	15a
Considered quitting	Has considered stopping farming as a result of wildfire. *	Ordinal	11
Knows a farm that quit	Knows a farm or ranch that has shut down due to wildfires.	Binary	15
g. Wildfire recovery			
Financial recovery scale	Amount of total financial recovery of losses from "very little" to "nearly all" across each of nine possible financial sources accessed, averaged into a composite index.	Interval	25
	Financial Recovery Scale: Percentage of financial recovery coming from (1) farm insurance; (2) crop insurance; (3) USDA disaster assistance; or Govt-Ins; (4) conventional disaster relief.	Interval	25

[†]Unbolded and italicized variables are subsets of the variable above it and are generally used together in the same regression.
[‡]All binary questions are coded as yes = 1 and no = 0.
^ #Q: See Supplementary material for survey instrument and associated survey question.
*On a five-point Likert scale from strongly disagree (1) to strongly agree (5).
**Binary Select all that apply responses were averaged into a composite score. A higher value assigned to a higher number of items selected.

analysis and standardized measurement, making it easier to identify patterns, differences, or trends that might be obscured in a more complex, multidimensional representation. The index was constructed by calculating the average of 20 nominal variables from seven different survey questions selected based on their relevance to the dimensions of the social fabric (Table 3). These survey items were developed based on existing literature on wildfire adaptation and community resilience, as well as the first author's 7 years of field experience working with fire-affected agricultural communities. The index includes variables that measure cooperation and resource sharing; community integration as seen through the direct actions taken to support others during the wildfire(s) and support received from others; mutual aid provided in the form of fire defense; the growth of social networks; and engagement in collective action. Sources of financial recovery that rely on social networks were intentionally excluded from the index so they could be evaluated

TABLE 3 The composition of the social fabric index and sub-indices.

Sub indices and variables	Q #
Mutual aid—fire defense	
Cut fire lines or created firebreaks for neighbors or other farmers	18
Defended neighboring homes or property against fire	18
Received support defending property	19
Collective action	
Relied on informal farmer networks	21
Relied on a fire-safe council	21
Participates in community preparedness groups	22
Cooperation	
Wildfires had a positive effect on their cooperation and resource sharing with others*	7
Growth of Networks	
Community networks grew in response to wildfire*	11
Community integration	
Support provided	
Donated supplies to neighbors or other farmers	18
Shared their employees' time with other farmers	18
Helped market or distribute others' crops	18
Helped harvest other's crops	18
Helped relocate, or care for others' livestock	18
Helped evacuate other people	18
Support received	
Received support with harvest or evacuation	19
Relied on family or friends' labor	8
Relied on shared labor from other operations	8
Relied on neighbors	21
Relied on family and friends	21

All variables are binary (except those marked with an asterisk). Binary variables are coded yes = 1/no = 0.
*Binary variable with 2 = very positive or strongly agreed and 1 = positive or agreed.

separately. A higher value indicates that the respondent drew on more of the social fabric relationships described in the variables than those with a lower score.

To ensure the reliability and validity of the *Social Fabric Index* used in the analysis, we performed three robustness checks. First, the internal consistency of the index was assessed using Cronbach's alpha, a measure of scale reliability. A score of 0.74 indicates an acceptable level of internal consistency among the variables included in the index (Tavakol and Dennick, 2011). Next, we performed exploratory factor analysis to examine the underlying dimensions of the index. The analysis revealed three factors that together account for 99.7% of the total variance observed among the variables. The first factor, with an eigenvalue of 2.51, accounts for 57.4% of the variance and primarily captures the core themes of community integration and mutual aid, central to the conceptual framework of the index. This dominant factor supports the use of a single index since it encapsulates most of the critical elements of the *Social Fabric Index*. The additional factors primarily refine and extend the understanding imparted by the first factor, rather than introducing entirely distinct or unrelated dimensions (see Supplementary material for screepot and tables). Both analyses suggest that the index components are reasonably aligned with the underlying construct of the social fabric, lending credibility to its use as a single, summary measure.

Finally, to test the robustness of the index within the regression models, we performed a sensitivity analysis to explore whether any subset of the index components disproportionately influenced the model outcomes. We constructed sub-indices corresponding to themes identified by the literature and the factor analysis (Table 3). We then performed sensitivity analysis by substituting the index with the sub-indices. When any sub-indices showed greater statistical significance than others, they were expanded into a second model and reported in the results section below. By individually including these sub-indices in the models, we were able to ascertain which sub-index drove the results of the main index or had different outcomes.

2.3 Limitations

While this study distinguishes between foundational and realized adaptive capacities, some overlap exists in how these capacities are operationalized and measured. A key challenge is that certain variables, such as *Knowledge*, are used as both independent and dependent variables in different models. For instance, *Knowledge* is treated as an independent variable when examining its relationship to wildfire mitigation practices but as a dependent variable when assessing how wildfire exposure influences learning. This dual role reflects the complexity of adaptation, where knowledge can both drive adaptive actions and result from past wildfire experiences. However, using the same variable in both roles was necessary to capture the full feedback loop between learning and adaptation. Future research could address this by using longitudinal studies to better track how adaptive capacities evolve and interact over time.

Additionally, the heterogeneity of the sample, encompassing a broad range of crop and livestock types, was an analytical challenge. As it was not the focus of this study, we did not conduct a subgroup analysis based on production type, such as for ranchers, despite their critical role in wildfire risk management and response (Pinzón et al., 2025; Ratcliff et al., 2022; Schlickman and Milligan, 2022). Therefore, the distinct adaptive capacities of different production systems merit deeper examination in future studies.

Furthermore, although the construction of the Social Fabric Index was informed by theory and field-experience, its validation was limited to Cronbach's alpha and exploratory factor analysis. These are appropriate initial steps for index development, but do not confirm the underlying measurement model. Validation through confirmatory factor analysis, external scale analysis, or assessment of consequential validity would support the broader application of the index.

Finally, since the number and distribution of farmers who have directly experienced the impact of wildfire in California is unknown, we examined the spatial representativeness of the sample, which was mostly representative of the distribution of wildfires and farmers by region. More analysis could be conducted to refine the analysis of representativeness but it is beyond the scope of this paper. However, this statewide data set is, to our knowledge, the best currently available so we do not shy away from providing recommendations based upon it since the conditions spurring catastrophic wildfires continue to worsen and the stakes for wildfire-prone rural areas in California are extremely high.

3 Results and analysis

This section begins by describing the respondent characteristics, including their regional distribution. We then conduct an in-depth examination of four groups of regression models related to adaptive capacity. We conclude with an examination of correlations between farm characteristics, farmer demographics, the *Social Fabric Index*, and adaptive capacities.

3.1 Producer and operation characteristics

Of the 403 California farmers' responses used in the regression analysis—based on direct exposure to wildfires[7]—88% experienced a wildfire on or near their property and 35% experienced wildfire spreading directly onto their property. Respondents experienced wildfires an average of 2.7 out of the 6 years covered by the survey. Twenty-nine percent had also experienced wildfires before 2017 and 17% before 2000. Production systems varied, with 67% producing only crops, 15% producing only livestock, and 19% producing a mix of both. In total, 344 had crops and 134 had livestock. Primary crops grown included tree fruits and nuts (35%), grapes (43%), vegetables (25%), animal feed crops (15%), and flowers (14%). Primary livestock raised included cattle (non-dairy) (62%), small ruminant grazers (sheep and goats) (31%), poultry (28%), and bees (12%). In total, there were 105 ranchers, or producers with cattle, sheep, or goats. Figure 1 shows the regional distribution of respondents. Most of the respondents were experienced farmers with more than 10 years of continuous farming experience (75%), and more than half (53%) had at least 20 years of experience. The majority (67%) can also be classified as small farmers, generating less than $250,000 annually in an average year (Hoppe et al., 2010). The majority relied on off-farm income to cover their household expenses (50%), farm expenses (33%), or accrue savings (30%). Forty-six percent considered their practices to be organic or ecological, 42% were over 65 years old, 12% self-identified as limited-resource based on the USDA definition, and 9% identified as belonging to a group that has been historically subject to prejudice, henceforth referred to as socially disadvantaged. A detailed list of descriptive statistics of independent variables is provided in Supplementary material.

7 As noted above, respondents that *only* experienced prolonged exposure to smoke or ash were excluded from analysis.

3.2 Realized adaptive capacities

In this section, we present and analyze the results of the regression analyses examining the effects of various variables on farmers' realized adaptive capacities. These independent variables are grouped into five major categories: operation characteristics, demographics, socioeconomic context, foundational adaptive capacities, and wildfire exposure, impact, and recovery. Within these five groups, the variables are mostly grouped, ordered, and analyzed according to the strength and significance of their coefficients, allowing for a clear interpretation of their relative impacts on adaptive capacities. All independent variables from Table 2 were tested in each model following the purposeful variable selection approach detailed above. Only statistically significant variables and non-confounding variables are included in the models presented below, ensuring a focused analysis of explanatory variables.

3.2.1 Making changes

To examine what contributes to farmers' ability to adjust their practices to be more adapted to wildfires, the *Made Changes* models examine the factors that influence farmers' decisions to "make significant changes in response to wildfires" (Table 4). Model 1 examines the operational, demographic, socioeconomic, and adaptive characteristics that drive proactive adaptation to wildfire threats. Using the same variables, Model 2 filters the data by farmers at greater risk, identified by those who said that their "defensible space is jeopardized by fuel conditions of neighboring properties." This allows for a more nuanced analysis of how proximity to environmental hazards can shape farmers' motivations and capacity for change.

The regression analysis revealed that farmers who made significant changes in response to wildfires were those with greater wildfire-related knowledge, a stronger social fabric, and more frequent wildfire exposure. These farmers were also more likely to face fuel load risks, engage in ecological farming, and utilize direct-to-consumer markets. Additionally, they tended to maintain diverse market and production systems, have access to social safety nets, come from multigenerational farming families, and possess more years of farming experience.

Knowledge stands out as the variable with the strongest association with making significant changes in both models, both in terms of the size of the coefficient (and therefore the size of the effect) and the significance of the relationship. This may be closely related to *Fire Frequency* and *Neighboring Fuel Loads*, which also had a strong association. This suggests that farmers who have experienced wildfire exposure more frequently are more likely to seek out knowledge on how to address wildfires, have more experiential knowledge from previous wildfire exposure, and therefore more inclined to make changes to address these threats.

The *Social Fabric Index* was also amongst the strongest and most statistically significantly associated with both *Made Changes* models (Fifth largest in Model 1 and second largest in Model 2). Farmers whose networks grew, participated in collective actions such as community preparedness groups, and provided mutual aid in the form of fire defense were more likely to make significant changes. This might point to both the motivation and knowledge gained through

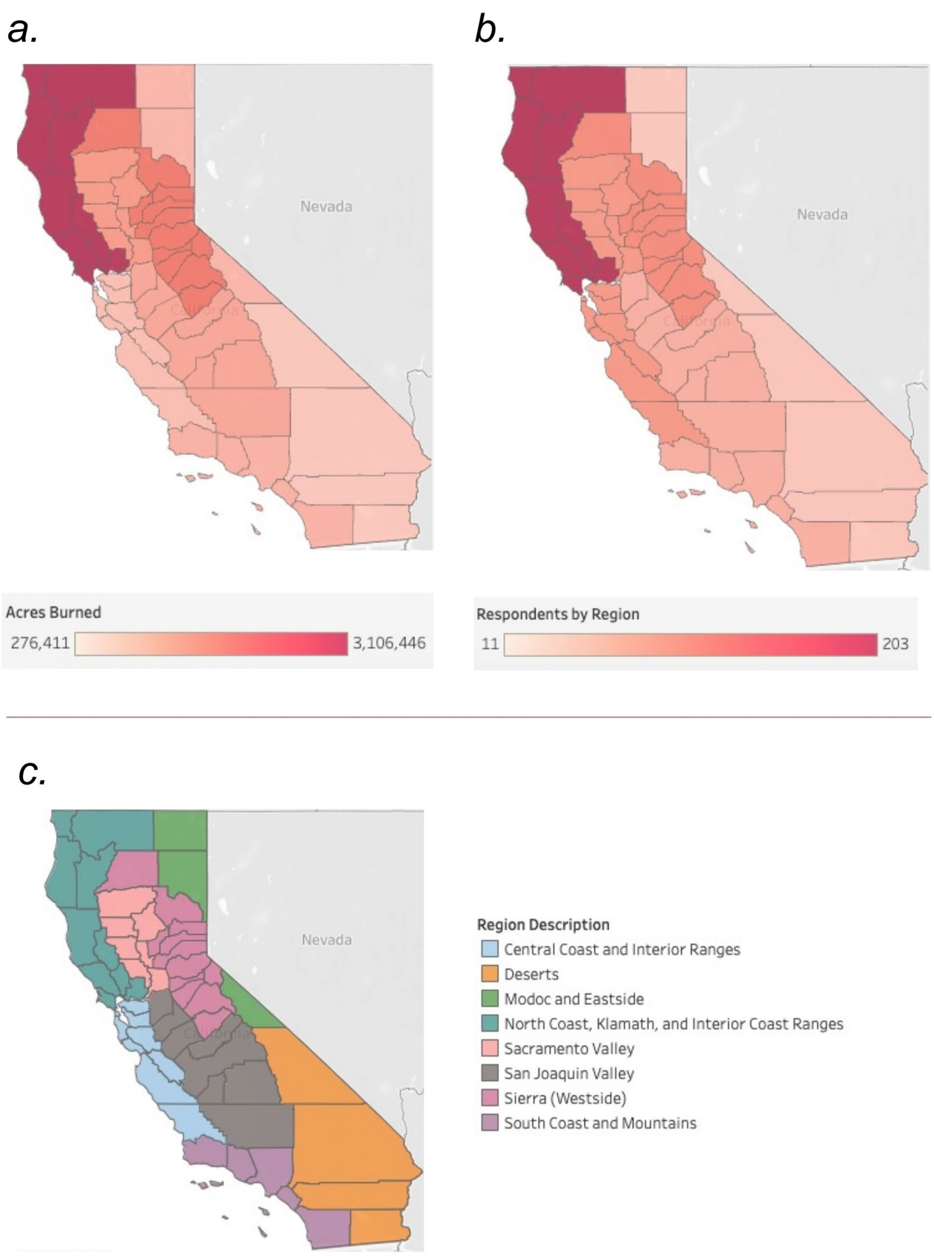

FIGURE 1
Maps of regional distribution of acres burned in California, survey respondents and California regions. **(a)** Acres burned in each region annually between 2017 and 2023. **(b)** Regions where survey respondents experienced wildfires between 2017 and 2023. **(c)** California regions.

mutual aid and collective action. The strength of social networks provides critical resources and support, improving farmers' adaptive capacities.

Ecological farming practices showed a strong association with making changes in high fire-risk contexts (Model 2), suggesting that an ecological mindset enhances adaptive responses. Additionally, farmers engaged in direct-to-consumer markets demonstrated a greater ability to adapt, likely due to the flexibility, diversity, and ecological orientation inherent in these systems (Carlisle, 2014; Esquivel et al., 2021). However, reliance on multiple market channels, such as intermediated ones, appeared to hinder making changes, possibly due to logistical constraints and reduced flexibility as found by Durant et al. (2023) in the context of the COVID-19 pandemic. Years of farming experience had a strong negative association with making changes, suggesting that established practices and market systems may limit flexibility, except in high-risk scenarios (Model 2) where immediate threats add urgency to adaptive responses. Meanwhile, being part of a multigenerational farming family positively influences the likelihood of making significant changes under these conditions. Multigenerational farms are likely to benefit from the accumulated local knowledge, networks, and resources to manage risks, supporting their ability to make changes.

Lastly, having access to a lower number of types of social safety net, such as unemployment benefits, disability benefits, retirement funds, and health insurance, was associated with making changes.

TABLE 4 OLS regression models of respondents based on the degree to which they have made significant changes in response to wildfires.

Dependent variable	Made significant changes in response to wildfires					
	Model (1)			Model (2)†		
	Coeff.	Std. Err.	*p*-Value	Coeff.	Std. Err.	*p*-Value
a. Operation characteristics						
Ecological	0.029	0.133	0.654	**0.203*****	0.157	0.006
Markets: direct to consumers	**0.144****	0.134	0.029	**0.148****	0.156	0.044
Market diversity index	**−0.119***	0.377	0.071	**−0.192*****	0.401	0.005
Farm diversity index	**0.096***	0.747	0.066	−0.060	0.733	0.301
Gross farm sales < $250 k	0.053	0.140	0.426	−0.087	0.188	0.279
Farm age	−0.055	0.005	0.480	−0.010	0.006	0.910
Total acres	−0.004	0.000	0.944	−0.050	0.000	0.557
b. Demographics						
Years farming	**−0.240*****	0.092	0.001	−0.129	0.105	0.110
Multi-generational	0.062	0.138	0.343	**0.159***	0.188	0.055
c. Socioeconomic context						
Safety net diversity	**−0.103***	0.240	0.073	**−0.110***	0.280	0.083
Landowner	−0.038	0.197	0.462	−0.021	0.248	0.693
Off-farm income	−0.083	0.134	0.167	−0.030	0.156	0.649
d. Foundational adaptive capacities^						
Knowledge	**0.194****	0.086	0.020	**0.307*****	0.078	0.000
Social fabric index	**0.147****	0.375	0.030	**0.293*****	0.369	0.000
e. Wildfire exposure, impact, recovery						
Fire frequency	**0.125***	0.070	0.064	**0.196****	0.078	0.013
Damage severity	0.027	0.131	0.691	−0.018	0.148	0.824
Neighboring fuel load	**0.189*****	0.126	0.002	—	—	—
Observations		242			166	
Pseudo R^2		0.2997			0.4171	
Variance Inflation Factor (VIF)—max		1.82			1.93	
Shapiro–Wilk's W Test		0.9805			0.9887	
White's Test	chi2	*p*-value		chi2	*p*-value	
	167.69	0.1886		133.26	0.6214	

The asterisk and bolding indicate statistical significance at or below the 10% level; * is <0.1; ** is <0.05, and *** is <0.01.
†Filtered by respondents who are surrounded by neighboring fuel loads.
^Mitigation Scale was excluded due to the potential for multicollinearity.

While marginally significant, this suggests that farmers with fewer safety net resources may feel a greater urgency to adapt their operations. In contrast, those with access to more types of safety nets may have the financial flexibility to absorb losses or delay action, reducing the need for adjustments. This dynamic aligns with resilience literature, which suggests that households with fewer buffers innovate and take risks to maintain their livelihoods (Antwi-Agyei et al., 2013; Berardi et al., 2021). However, such adaptation can come at the cost of increased financial and emotional strain, potentially leading to burnout (Berardi et al., 2021). This is explored further in the *Considered Quitting* models presented later in this section.

Finally, when controlling for other operation and demographic characteristics, farm size as measured by either gross farm sales or total acres did not significantly affect farmers' ability to make changes. This finding indicates that the inclination to make significant changes is not necessarily dependent on the scale and resources of the farming operation but rather on other factors such as knowledge, social fabric, market and ecological orientation, production diversity, fire history, years and generations of farming, and access to safety nets.

3.2.2 Mitigation scale

The *Mitigation Scale* models investigate the implementation of wildfire risk management practices among farmers, focusing exclusively on respondents with neighboring fuel loads that jeopardize their defensible space (Table 5). To examine the *Social Fabric Index* in detail, Model 2 replaced this general index with *Networks Grew*, the sub-index most significantly associated with the *Mitigation Scale*.

The regression analysis revealed that farmers who adopted a greater number of wildfire risk management practices were those with a stronger social fabric, greater wildfire-related knowledge, and more frequent wildfire exposure. These farmers were also more likely to engage in ecological farming, maintain diverse crop and livestock operations, utilize direct-to-consumer markets, and come from multigenerational farming backgrounds. Additionally, they were more likely to rely on off-farm income to build savings, own their land, and have access to a broader range of social safety nets.

The *Social Fabric Index* emerged as the variable with the strongest and most statistically significant association with implementing wildfire risk mitigation practices. This was further refined in Model 2 which shows that the growth of social networks (a sub-index of the *Social Fabric Index*) had the greatest influence on the model. This corresponds to the literature that the expansion of social networks, often as a result of experiencing wildfires (Bihari and Ryan, 2012), provides critical resources, shared knowledge, motivation, and collective action, which are essential for effective wildfire risk management (Lambrou et al., 2023; McCaffrey, 2015; Paveglio et al., 2019). Knowledge, a prerequisite to implementing risk management practices (Darnhofer et al., 2010; Thacker et al., 2023), is also positively associated with the mitigation scale. Relatedly, *Fire Frequency* was another crucial factor, as frequent wildfire exposure likely increases knowledge, awareness, and urgency, prompting proactivity (Bihari and Ryan, 2012; Paveglio et al., 2015a, 2015b).

TABLE 5 OLS regression models of respondents' implementation of wildfire risk mitigation practices.

Dependent variable	Mitigation scale					
	Model (1)†			Model (2)†		
	Coeff.	Std. Err.	*p*-Value	Coeff.	Std. Err.	*p*-Value
a. Operation characteristics						
Ecological	**0.165****	0.025	0.010	**0.230*****	0.027	0.001
Markets: direct to consumers	**0.112***	0.027	0.094	**0.161****	0.028	0.018
Market diversity index	−0.103	0.079	0.150	−0.062	0.073	0.351
Farm diversity index	**0.137*****	0.121	0.007	**0.166*****	0.131	0.003
Farm age	−0.085	0.001	0.111	−0.083	0.001	0.143
Total acres	−0.086	0.000	0.171	−0.049	0.000	0.335
b. Demographics						
Multi-generational	**0.148****	0.028	0.024	**0.171****	0.029	0.011
c. Socioeconomic context						
Safety net diversity	**0.097***	0.048	0.099	0.048	0.048	0.407
Landowner	**0.120****	0.050	0.033	**0.125***	0.065	0.088
Off-farm income: accrue savings	**0.126****	0.025	0.033	**0.158****	0.027	0.014
d. Foundational adaptive capacities^						
Knowledge	**0.220*****	0.011	0.000	**0.271*****	0.012	0.000
Social fabric index	**0.357*****	0.068	0.000	—	—	—
Networks grew	—	—	—	**0.275*****	0.011	0.000
e. Wildfire exposure, impact, recovery						
Fire frequency	**0.210*****	0.011	0.001	**0.175*****	0.012	0.009
Observations		169			166	
Pseudo R^2		0.5509			0.5360	
Variance Inflation Factor (VIF) - max		1.42			1.40	
Shapiro–Wilk's W Test		0.9947			0.9890	
White's Test	chi2	*p*-value		chi2	*p*-value	
	100.87	0.3207		109.20	0.1514	

The asterisk and bolding indicate statistical significance at or below the 10% level; * is <0.1; ** is <0.05, and *** is <0.01.
†Filtered by respondents who are surrounded by neighboring fuel loads.
^Made Changes was excluded due to the potential for multicollinearity.

As with the *Made Changes* models, farmers with an ecological orientation, those managing a greater diversity of crops or livestock, and those selling through direct-to-consumer markets consistently show a positive association with mitigation practices. However, unlike in *Made Changes, Multi-Generational* had a consistently strong positive association and *Safety Net Diversity* was positively associated with the implementation of mitigation practices. Therefore the more social safety nets farmers had access to, the more mitigation practices they implemented. Additionally, landowners and those with off-farm income also show a positive association with implementing risk management. This finding aligns with the wildfire literature, which indicates that renters are less likely to manage fuel loads (Collins, 2008), and the broader agriculture literature, which consistently identifies land ownership as a key factor for investing in long-term conservation and adaptation practices (Adusumilli and Wang, 2019; Calo, 2020; Sklenicka et al., 2015). Nonetheless, it is important to note that farmers who rent their land are still making changes in response to wildfires, as demonstrated in the *Made Changes* models. Importantly, having off-farm income to accrue savings, rather than to cover farm or household expenses, is strongly associated with implementing risk management practices. Overall, these socioeconomic findings suggest that land ownership, financial resources, and a financial buffer facilitate adaptation by enabling investment in long-term risk strategies.

3.2.3 Knowledge

The *Knowledge* models explore the determinants of farmers' self-assessed knowledge for managing wildfire-related threats (Table 6). As with the previous analysis, Model 2 replaces the *Social Fabric Index* with its sub-indices most significantly associated with *Knowledge*.

Farmers who reported greater knowledge of how to manage wildfire threats were more likely to believe in their ability to recover

TABLE 6 OLS regression models of respondents based on their confidence in knowing how to deal with fire-related threats.

Dependent variable	Knows how to deal with wildfire-related threats					
	Model (1)			Model (2)		
	Coeff.	Std. Err.	*p*-Value	Coeff.	Std. Err.	*p*-Value
a. Operation characteristics						
Gross farm sales < $250 k	**0.141*****	0.114	0.009	**0.144*****	0.114	0.008
Total acres	−0.058	0.000	0.130	−0.052	0.000	0.191
b. Demographics						
Years farming	**0.152*****	0.065	0.004	**0.138*****	0.066	0.009
c. Socioeconomic context						
Off farm income: core expenses	**−0.187*****	0.113	0.001	**−0.168*****	0.112	0.002
Socially disadvantaged	**−0.114****	0.171	0.025	**−0.109****	0.168	0.029
d. Foundational adaptive capacities						
Bounceback	**0.253*****	0.052	0.000	**0.264*****	0.053	0.000
Made changes	**0.214*****	0.065	0.002	**0.214*****	0.063	0.001
Fire skills scale	**0.145*****	0.193	0.004	**0.122****	0.194	0.015
Social fabric index	**0.111****	0.269	0.025	—	—	—
Mutual aid: fire defense				**0.150*****	0.143	0.002
Cooperation				**0.081***	0.057	0.096
e. Wildfire exposure, impact, recovery						
Fire frequency	**0.207*****	0.063	0.001	**0.210*****	0.060	0.000
Total impact scale	**−0.183*****	0.150	0.003	**−0.164*****	0.149	0.007
Fires before 2017	**0.094***	0.118	0.082	**0.108****	0.115	0.040
Financial recovery scale	0.026	0.113	0.635	0.019	0.110	0.719
Observations		274			272	
Pseudo R^2		0.3354			0.3618	
Variance Inflation Factor (VIF) - max		1.45			1.48	
Shapiro–Wilk's W Test		0.9676			0.9705	
White's Test	chi2	*p*-value		chi2	*p*-value	
	96.13	0.5908		107.79	0.6705	

The asterisk and bolding indicate statistical significance at or below the 10% level; * is <0.1; ** is <0.05, and *** is <0.01.

effectively from disruptions, have made significant operational changes, and possess a longer history of wildfire experience. They also tended to have a stronger social fabric, greater fire-related skills, more farming experience, and lower wildfire impact. Additionally, these farmers were more likely to report annual farm sales below $250,000 and rely less on off-farm income.

Unsurprisingly, farmers who believed that their farms could recover from previous wildfire disruptions (*Bounceback*) were more knowledgeable about how to handle wildfire-related threats. Similarly, farmers who experienced wildfires more frequently and before 2017 were more likely to know how to deal with wildfire threats. The act of making changes also showed a significant positive association with *Knowledge*. Farmers who had already implemented significant changes in response to wildfires likely developed adaptive strategies, boosting their confidence in managing wildfire threats. Regular exposure to wildfires likely increases motivation to change (Paveglio et al., 2015b), increases social capital (Bihari and Ryan, 2012), provides practical knowledge and skills, and increases confidence from successful recovery strategies, reinforcing their ability to manage future risks effectively. However, the scale of the impact experienced was negatively and significantly associated with *Knowledge*. This suggests that there might be a threshold at which a significant or devastating wildfire exceeds a farmer's ability to effectively manage it with their current knowledge, and might shake their confidence.

As with the previous models, the *Social Fabric Index* was strongly and statistically significantly associated with *Knowledge*. Specifically, Model 2 shows that mutual aid through direct fire defense and increased cooperation and resource sharing emerged as the most important components of the *Social Fabric Index*. This is further explained by the significant and positive association with having fire skills such as firefighting, prescribed burning, and fire suppression. These skills empower farmers to not only protect their properties but also contribute to community-wide efforts in managing fires, further strengthening their social fabric (Bihari and Ryan, 2012). The positive association between fire skills and knowledge also suggests that experiential learning and comfort with fire are powerful drivers of confidence and competence when farming in a wildfire ecology.

Years Farming was also positively correlated with knowledge. More experienced farmers likely had accumulated more experience and skills over the years, increasing their knowledge and confidence, but not necessarily their motivation to make changes, as demonstrated by its negative association in the *Made Changes* model.

Among the most statistically significant associations with having *Knowledge* were being a small farmer (gross sales < $250,000) and not depending on off-farm income to cover farm or household expenses. This suggests that farmers who focus solely on their operations may have more knowledge, as their livelihood depends entirely on the success of their farm. For small farmers, their scale and flexibility seem to facilitate having deeper knowledge, perhaps due to being more personally connected to the day-to-day management of their farm. However, socially disadvantaged farmers were less likely to have this knowledge, perhaps due to limited access to financial, institutional, and community resources and support (NYFC, 2023).

3.2.4 Considering quitting

The *Considered Quitting* models examine the factors that lead farmers to contemplate leaving their farming careers due to the risks posed by wildfires (Table 7). As the *Social Fabric Index* was not statistically significant in this analysis, significant subindices were included instead. We again use nested modeling, this time to illustrate how the inclusion of the *Knowing a Farmer Who Quit* variable in the second model impacts the main explanatory variables from the first model and the overall results.

The regression analysis revealed that farmers who considered leaving farming due to wildfires were more likely to perceive a lower ability to recover from the disruption, experience greater damage severity, and make significant operational changes. They also tended to report lower gross farm income, manage newer operations, have more diversified markets, and be younger. Additionally, these farmers were more likely to know another farmer who had quit, report less growth in their social networks, and provide less mutual aid support, particularly in the form of fire defense.

As expected, farmers with less severe wildfire damage and those who believed in the ability of their farms to recover were less likely to contemplate leaving farming. Importantly, when accounting for other variables, the personal impact scale was *not* significant. However, when either the *Financial Recovery Scale* or the *Bounceback* variables were excluded from the model (not shown), personal impacts from wildfires, such as effects on health, wellbeing, and relationships, became more significant predictors of quitting. This suggests that financial recovery can mitigate personal impacts, as seen in previous models. In the case of *Bounceback*, one possible explanation is that the immediate personal toll of wildfires, such as injury or post-traumatic stress (Papanikolaou et al., 2012), may play a role in the decision to leave farming when the extent of the farm's recoverability (*Bounceback*) is not yet known. Such a temporal relationship, where personal impacts are felt more acutely in the immediate aftermath of a wildfire while the farm's recovery is assessed later, warrants further exploration through qualitative or mixed methods research. Interestingly, wildfire exposure frequency did not show a significant association with the decision to quit when other factors were accounted for, which also merits further investigation.

Counterintuitively, those who invested heavily in adapting to wildfire risks (*Made Changes*) were more likely to consider quitting farming. The substantial effort, pressure and resources required to adapt may lead some farmers to question the sustainability of continuing farming under the constant threat of wildfires. However, when *Made Changes* was replaced by *Mitigation Scale*, this relationship disappeared, suggesting that it's not conventional wildfire risk management practices (e.g., fuel load management, emergency preparations) driving this association. Instead, it may be related to broader changes in agricultural production or operational management. Qualitative or mixed methods research is needed to better understand these dynamics as well.

Consistent with the literature, small, diverse, young, and first-generation farmers and those with newer operations were found to be most at risk of leaving farming as a career (Carlisle et al., 2019; NYFC, 2023). However, except for gross farm sales, these variables lost significance when *Knows a Farmer Who Quit* was introduced in Model 2, suggesting that farmers with these characteristics are also more likely to know peers who have left farming, as reflected by the moderate correlations between these variables and 'Knows a Farmer Who Quit' (Pearson's $r = 0.14–0.20$).

One of the most striking findings is the strong positive association in Model 2 between considering leaving farming as a profession and knowing another farmer who stopped farming due to wildfires. This social influence was even stronger than the impact of damage

TABLE 7 OLS regression models of respondents who have considered stopping farming.

Dependent variable	Has considered stopping farming as a result of wildfires					
	Model (1)			Model (2)		
	Coeff.	Std. Err.	*p*-Value	Coeff.	Std. Err.	*p*-Value
a. Operation characteristics						
Gross farm sales	**−0.122****	0.036	0.029	**−0.149****	0.039	0.015
Market diversity index	**0.087***	0.403	0.089	0.063	0.518	0.296
Farm age	**−0.108***	0.005	0.080	−0.085	0.006	0.232
Total acres	0.010	0.000	0.792	−0.009	0.000	0.814
b. Demographics						
Multi-generational	**−0.107***	0.181	0.085	−0.056	0.199	0.406
Over 65	**−0.160*****	0.156	0.004	−0.087	0.167	0.140
c. Socioeconomic context						
Off-farm income: farm costs	−0.020	0.168	0.725	−0.040	0.197	0.536
d. Foundational adaptive capacities						
Bounceback	**−0.266*****	0.072	0.000	**−0.267*****	0.084	0.000
Made changes	**0.127****	0.074	0.023	**0.154*****	0.076	0.008
Social fabric index	--	--	--	--	--	--
Networks grew	**−0.108****	0.074	0.047	**−0.113***	0.085	0.067
Mutual aid: fire defense	**−0.098***	0.225	0.071	−0.061	0.272	0.339
e. Wildfire exposure, impact, recovery						
Knows a farmer who quit				**0.277*****	0.195	0.000
Damage severity	**0.228*****	0.163	0.000	**0.140****	0.169	0.045
Personal impact scale	0.078	0.146	0.163	0.031	0.162	0.620
Financial recovery scale	0.025	0.160	0.647	0.034	0.185	0.592
Observations		263			199	
Pseudo R^2		0.3726			0.4550	
Variance Inflation Factor (VIF) - max		1.64			1.80	
Shapiro–Wilk's W Test		0.9900			0.9886	
White's Test	chi2	p-value		chi2	p-value	
	136.07	0.0982		146.64	0.1657	

The asterisk and bolding indicate statistical significance at or below the 10% level; * is <0.1; ** is <0.05, and *** is <0.01.

severity, indicating the powerful effect of peer experiences on farmers' decisions. Knowing a farmer who stopped farming might arguably serve as a valuable proxy for considering quitting oneself, especially since farmers may be reluctant to admit they are contemplating leaving the profession but might more openly share that their peers are quitting. Interestingly, while the *Social Fabric Index* was not directly associated with considering quitting, two sub-indices showed significant associations. Providing mutual aid in the form of direct fire defense and growth in social networks due to wildfires were negatively associated with considering quitting in Model 1, highlighting the resilience-enhancing effects of these activities. However, in Model 2, providing mutual aid became non-significant, and the significance of network growth declined. This suggests that the introduction of the variable *Knows a Farmer Who Quit* partially explained these relationships, likely reflecting the powerful influence of peer decisions on farmers' considerations. All of these variables indicate the importance of social networks, community support, and collective action in farm continuity amid threats of disasters, while also revealing the complex ways peer behaviors can mediate or alter the protective effects of these social factors, while also demonstrating the multifaceted and sometimes conflicting influences of social factors on farmers' considerations.

3.3 Correlations between farmer characteristics and social fabric

To examine the relationships between farm characteristics, farmer demographics, adaptive capacities, and the strength of the social fabric, we calculated Pearson's correlations among these variables, the

Social Fabric Index, and the four measures of realized adaptive capacity (Table 8).

The results in Table 8 reveal key relationships. Farmers with a strong social fabric demonstrate a clear alignment with higher levels of adaptive capacities, emphasizing the critical role of social connections in fostering resilience. Additionally, ecological farming, production diversity, market diversity, and direct-to-consumer markets show the strongest positive correlation with the *Social Fabric Index*, *Made Changes*, and *Mitigation Scale*. This suggests that farms employing diverse, locally-embedded, and sustainable practices significantly contribute to stronger social networks and realized adaptive actions.

4 Discussion

The adaptive capacities of wildfire-affected farmers in California revolve around three interrelated dynamics: knowledge, adaptation, and the social fabric. These elements work together to build resilience but are also constrained by systemic and resource-based vulnerabilities.

4.1 Central dynamics: knowledge, adaptation, and the social fabric

The iterative process of adaptation among wildfire-affected farmers is evident in the analysis. Initially, the experience of wildfires leads to learning about the potential impacts of farming in a fire-prone ecology, prompting farmers to gain skills and make changes in response to these threats. These adaptations, in turn, lead to a further increase in knowledge and the implementation of risk mitigation practices. Knowledge—representing both confidence and the capacity to deal with wildfire threats—consistently emerged as a central driver of adaptive behaviors across the analysis. Farmers with greater knowledge and experience in dealing with wildfires were better equipped to make significant changes, implement mitigation strategies, and bounce back from wildfires. With each subsequent wildfire, farmers' knowledge grows, allowing them to better prepare and respond. A cumulative effect where initial adaptations pave the way for further risk management strategies creates a reinforcing cycle of resilience-building behaviors.

However, if threats from wildfires become too severe, the damage may exceed what is feasible to recover. In such cases, the farm may not bounce back if previous wildfires have already crippled the system to an unrecoverable extent, or if the current damage exceeds the farmer's knowledge or resources for recovery. The ongoing threat of wildfire thus has a dual effect: While frequent exposure increases knowledge and motivation in managing threats, it can also threaten the farming system beyond repair and thus the capacity to continue farming.

Our analysis also reveals that adaptation, while increasing preparedness, can contribute to potential burnout and considerations of quitting. It is plausible that the continual use of resources for adaptation; when profits margins from farming are small to begin with, can deplete even well-resourced farmers. Ultimately, while adaptation can be empowering, the substantial effort and resources required to adapt may lead some farmers to question the sustainability of continuing farming under the constant threat of wildfire.

TABLE 8 Correlation matrix of operation characteristics and farmer demographics with adaptive capacities and social fabric†.

Variable	Social fabric	Made changes	Mitigation scale	Knowledge	Considered quitting
Social fabric		0.34	0.46	0.22	0.05
Ecological	0.18	0.16	0.25	0.01	0.18
Diversity scale	0.18	0.18	0.27	0.00	0.04
Market diversity	0.20	0.08	0.11	0.01	0.17
Markets: direct to consumers	0.17	0.16	0.25	−0.01	0.13
Markets: intermediate only	−0.17	−0.16	−0.23	0.03	−0.23
Small farmers (Gross sales < $250 k)	0.08	0.13	0.08	0.04	0.07
Gross farm sales > $500 k	−0.08	−0.09	−0.07	0.01	−0.07
Farm age	0.01	−0.08	−0.07	0.06	−0.24
Years farming	−0.03	−0.09	−0.05	0.13	−0.22
Multi-generational	0.04	0.01	0.00	0.09	−0.24
First generation	0.04	0.02	0.07	−0.07	0.19
Non-landowner	0.04	−0.07	−0.20	−0.05	0.02
Immigrant	−0.10	−0.10	−0.05	−0.15	−0.02
Socially disadvantaged	0.06	−0.02	0.09	−0.17	0.14

†Color coding of the correlation coefficients is by Quartile.

4.2 Weaving the social fabric that sustains wildfire resilience

Building wildfire resilience depends on critical social elements—community cohesion, collective action, local knowledge, place attachment, and diverse land use—that are widely documented in wildfire social science literature (Bihari and Ryan, 2012; Lambrou et al., 2023; Paveglio et al., 2019, 2015a, 2015b; Thacker et al., 2023). Although not specific to agriculture, these elements are particularly relevant to farming communities, where social fabric plays a pivotal role in fostering adaptation and resilience.

The social fabric is woven throughout the wildfire adaptation process as both a protective and motivational force, linking individual resilience to community-wide strength. Evidence from the analysis demonstrates that it facilitates the growth of experiential knowledge, the implementation of risk management practices, the transformation of farming systems, and protection against burnout—ultimately sustaining farm continuity. This transformation occurs at multiple scales. At the individual farming system level, the results show that the social fabric directly supports the adoption of wildfire mitigation strategies, enabling farmers to make significant operational changes and improve their knowledge of how to address wildfire threats. For example, farmers embedded in strong social networks have reported sharing resources, knowledge, skills, and labor (Pinzón et al., 2025), which enabled practical changes that reduced vulnerability to wildfires.

This social fabric does more than just support individual farmers; it knits together entire communities, with the potential to mend the social fragmentation that has exacerbated catastrophic wildfires. At the landscape scale, the social fabric creates a ripple effect, fostering broader systemic change. Peer influences, supported by cooperative networks and mutual aid during and after disasters, encourage other farmers and rural residents in the region to adopt similar practices, potentially transforming the collective landscape into a more fire-resilient mosaic. While this ripple effect is inferred from existing patterns and prior research (Paveglio et al., 2015b; Thacker et al., 2023; Roos et al., 2016; Paveglio et al., 2019; Bihari and Ryan, 2012), it posits the potential of agrarian community engagement to drive large-scale wildfire resilience.

Unlike other rural residents and urban-to-rural migrants, farmers—including newcomers—can more readily integrate into their rural community's social fabric. Wildfire social science literature often emphasizes the challenges newcomers face in integrating into communities, which can limit the cohesion needed for landscape-level resilience (Paveglio et al., 2019; Paveglio et al., 2015a; Uyttewaal et al., 2023). However, farmers are different. The very nature of their work necessitates quicker integration, as they depend on their local communities for resources, labor, and markets. Through their roles in land stewardship, community food systems, and local economies, farmers serve as both contributors to and beneficiaries of community cohesion.

4.2.1 Strengthening the social fabric with local and diversified farmers

Local, diversified ecological farms are particularly well-suited to foster wildfire resilience. These farms benefit from local ecological knowledge, strong place attachment, environmental consciousness, and generational ties to the land, enabling them to interpret and respond to environmental change fluidly (Esquivel et al., 2021; Hintz and College, 2015; Mullendore et al., 2015). By managing agroecosystems that build local food systems, these farmers foster social cohesion and social embeddedness (Ajates, 2021; Brinkley, 2018; Flora, 2004; Glowacki-Dudka et al., 2013) that facilitate disaster resilience. The diversity inherent in small and diversified farms also creates a heterogeneous landscape that acts as a buffer against fire spread and aids recovery efforts (Aquilué et al., 2020; Carmo et al., 2011; Thacker et al., 2023).

These farms further contribute to wildfire resilience through their integration into local economies, which strengthens ties between farms and their communities. By building direct market relationships and cultivating regional and diversified food systems, these farmers can weave a tapestry of resilience that extends beyond their farms. Farmers who sell through food hubs, CSAs, local food cooperatives, and farmers markets are not just selling food; they are creating interdependencies that fortify community wildfire resilience. The relationships they forge—through direct market interactions and regional food systems underpinned by circular economic principles—enhance their adaptability and response capacity during crises and disasters (Durant et al., 2023; McDaniel et al., 2021; Souza and Caldas, 2018; Flora, 2004). These practices align with a socio-ecological approach that emphasizes accepting fire presence while minimizing its impacts through effective management and collaboration. At the heart of effective disaster management lies a robust social fabric, woven most powerfully by ecologically oriented and socially embedded farmers.

4.2.2 Holding together as the social fabric frays

While the social fabric supports individual farmers and fosters community-wide resilience, it is not impervious to disruption. Farmers at the heart of these networks are themselves vulnerable, and when they leave agriculture—whether due to financial strain, burnout, or disaster impacts—the social fabric is destabilized. Each loss weakens the network and leaves remaining members more exposed and at greater risk of exiting themselves. The resilience of the social fabric ultimately depends on the retention and support of its members.

These dynamics reflect insights from political ecologist Paul Robbins' degradation and marginalization thesis (Robbins, 2012), which emphasizes how structural inequities—such as insecure land tenure and limited access to financial resources—create feedback loops that perpetuate vulnerability and environmental degradation. Our findings demonstrate that farmers without secure land ownership or sufficient social safety nets are significantly less likely to invest in long-term wildfire risk mitigation strategies, leaving their systems increasingly susceptible to further shocks. This susceptibility exacerbates marginalization, increasing the likelihood of farm closures and further weakening the social networks critical to community resilience.

Agroecological farmers, often embedded within strong social networks and diverse farming systems, are particularly well-positioned to lead the transformation needed for greater fire resilience. However, their ability to sustain these efforts hinges on addressing the systemic vulnerabilities identified by political ecology. Expanding access to financial safety nets, secure land tenure, and community resources is critical for breaking these cycles of vulnerability and ensuring that the social fabric remains strong. By addressing these structural inequities, policymakers can reinforce the resilience of both individual farms and the broader agrarian communities that sustain them. Without such measures, the social fabric risks fraying further, jeopardizing not only individual farms but also the collective resilience of wildfire-affected regions.

4.3 Future research

The findings of this study provide a foundation for understanding the adaptive capacities of farmers in the face of wildfire threats, but there remain several avenues for future research that could further illuminate the complexities of agrarian wildfire resilience.

Regional social fabric case studies: To gain a deeper understanding of how social fabric and fire resilience are interwoven, qualitative research in regions with a strong history of wildfires and established farming communities, such as Marin or Yolo County, is needed. Such studies could document the historical relationship between fire and agricultural actors, as well as how social networks are formed, sustained, and leveraged during wildfire events. This would provide insights into the effectiveness of agrarian-based fire preparedness groups and identify gaps that need to be addressed for future disaster preparedness.

Adaptation, quitting, and mental health: The positive and statistically significant association between considering quitting and making changes in response to wildfire impacts raises important questions. Understanding whether this is due to the stress, effort, or resources required for adaptation—or broader changes in agricultural operations—could clarify this relationship. Qualitative research could explore the decision-making processes of farmers who contemplate quitting after disasters, examining what facilitates or hinders their continuity. This line of inquiry could also investigate the mental health impacts of wildfires on farmers and whether financial recovery or safety nets can alleviate the psychological toll.

Multigenerational farming: The advantages of multigenerational farming families in adapting to wildfire threats warrant closer examination. Research could explore the processes of intergenerational knowledge and resource transfer, the strength of their social fabric, and the role of accumulated local knowledge in sustaining resilience across generations. Additionally, investigating what is lost when multigenerational farms are destroyed by wildfires could highlight the broader impacts on community adaptation. Understanding these dynamics could also inform strategies to support new-entry farmers in their resilience.

5 Conclusion

The importance of social fabric—manifested through strong community networks and mutual aid—is evident in our results, showing that these social ties are integral to fostering adaptive capacity and preventing farmer attrition in the face of wildfire threats.

In light of these findings, we offer public and private sector decision-makers recommendations for enhancing wildfire resilience through agriculture:

a. Strengthen farmer networks: Support cooperative models, such as fire-safe councils and farmer-led preparedness groups, that foster mutual aid and resource-sharing during disasters. Programs should prioritize funding for community-based initiatives that expand social fabric and local capacity.
b. Incentivize sustainable practices: Encourage agroecological and mosaic landscapes. These landscapes not only buffer wildfire impacts but also promote biodiversity.
c. Integrate farmers in governance: Institutionalize the role of farmers in wildfire management by including them in regional planning efforts. This ensures their experiential knowledge informs policies, while also fostering equity in decision-making processes. Their on-the-ground experience and knowledge are invaluable for creating effective and practical strategies to manage wildfire risks.
d. Build local food systems: Strengthen community networks essential during disasters by incentivizing direct market channels and alternative food networks (food hubs, farmers markets, grower cooperatives, etc.) which have been shown to increase economic viability, productive flexibility, and social embeddedness.
e. Equip farmers as first responders: Provide farmers with adequate fire response training, as they are often directly involved in defending their and their neighbors' properties during wildfires. Allocate funding for shared resources like water storage systems and defensible space equipment. Support and resource fire response groups that include agricultural communities among their networks such as Rangeland Fire Protection Associations (Abrams et al., 2017; McCormick et al., 2016).

By centering farmers as pivotal agents in wildfire resilience, this study bridges the gap between understanding the social dimensions of wildfire adaptation and the practical strategies that leverage farmers' unique knowledge, networks, and practices. We discover that the strength of the social fabric—built through mutual aid, local knowledge, and collective action—is a cornerstone of adaptive capacity in agricultural communities. However, the resilience of this fabric hinges on sustained investment in these communities. Agriculture, we propose, represents an underexplored but critical facet of broader wildfire resilience. Without integrated support, the networks that sustain food system resilience risk unraveling under the pressures of increasing wildfire threats and climate variability. Policymakers, institutions, and communities must collaborate in strengthening these connections, ensuring that agriculture remains both a livelihood and a linchpin in our collective response to evolving environmental challenges.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: http://dx.doi.org/10.13140/RG.2.2.24004.03201.

Ethics statement

The studies involving humans were approved by the UC Davis Institutional Review Board (IRB) ID 1764124-1. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

NP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. RG: Conceptualization, Supervision, Writing – review & editing, Validation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that Gen AI was used in the creation of this manuscript. The first author used GPT-4o (https://chat.openai.com) alongside the prompts listed in Supplementary material to assist in drafting earlier versions of the manuscript and editing its content. The second author subsequently provided developmental edits, with basic editing and structural assistance from GPT-4o. All AI-assisted text was carefully reviewed and validated by the authors to ensure accuracy and originality.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1564080/full#supplementary-material

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