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Social science to advance wildfire adaptation in the southwestern United States: a review and future research directions

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ABSTRACT

Background. Social science that seeks to advance wildfire adaptation in the southwestern US states of Arizona and New Mexico remains underdeveloped in comparison with other regions in the USA. **Aim.** To identify key themes in the existing social science literature on wildfire in the Southwest and to determine future research needs that can inform more strategic adaptation across scales and contexts. **Methods.** This article presents an in-depth literature review, organising findings using the Fire Adapted Communities Framework. **Key results.** Research on social aspects of wildfire in the southwestern USA has continued to diversify and broaden in scope over time, but some foundational lines of inquiry (such as public support for prescribed fire) have become outdated while other areas of study (such as fire prevention) have not been explored at all. **Conclusions.** Opportunities to advance wildfire social science efforts in the Southwest are abundant and well positioned to inform social understandings in other regions and countries. **Implications.** Researchers wishing to conduct social science research related to wildfire in the Southwest should seek to update and diversify knowledge in this field both through strategic selection of study sites and populations and via intentional, rigorous research design that acknowledges and elevates the nuances of social interactions with wildfire.

Keywords: adaptation, Arizona, communities, human dimensions of wildfire, literature review, New Mexico, social science, southwestern USA, wildfire.

Introduction

The centrality of social contexts and processes to broader wildfire adaptation efforts has been emphasised consistently over the course of several decades of international research across diverse scales, populations, and environments (Daniel *et al.* 2007; Toman *et al.* 2013; Tedim *et al.* 2016). An emergent focus on elevating social components of wildfire adaptation in management practices has introduced renewed calls from social scientists to better integrate social considerations through public involvement, community interactions, and organisational collaboration among other approaches (Carroll *et al.* 2007; Paveglio 2021; Eriksen 2022). The southwestern US states of Arizona and New Mexico have experienced a recent influx of high profile wildfires that caused socially and ecologically impactful outcomes and generated public and political concern, motivating review and examination of changes in national policy. These include the 1990 Dude Fire and 2013 Yarnell Fires that drove improvements in fire fighter safety, the destructive 2002 Rodeo–Chediski Fire that helped motivate the 2003 *Healthy Forests Restoration Act* (HFRA), and the 2000 Cerro Grande and 2022 Hermits Peak-Calf Canyon Fires that renewed discussions and challenges around prescribed fire use, each underscoring the continued need for integration of social considerations across the region (Finco *et al.* 2012; Abrams *et al.* 2015; Colavito *et al.* 2021). Impacts associated with these and other fire events emphasise the importance of understanding social conditions in the Southwest; however, the Southwest lags behind some regions of the USA in terms of social science research that can inform wildfire adaptation (Collins *et al.* 2022).

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The southwestern USA encompasses a complex web of social and ecological conditions that have influenced the emergence of localised conditions for wildfire adaptation, response, and recovery. Both Arizona and New Mexico exhibit similar trends to other regions of the USA, such as increases in wildfire events bolstered by climate change, rapid development and land use change, and difficulty reducing fuel on landscapes at the scale and scope needed to support fire adaptation (Hjerpe *et al.* 2009; Radeloff *et al.* 2018; Mueller *et al.* 2020). However, there are also more unique phenomena and processes that set the Southwest apart and make it worthy of further study. This includes an eclectic mix of social considerations, such as complex land use histories such as Spanish land grants awarded to New Mexico communities and Pueblos, Indigenous use of fire since time immemorial, and distinctive culturally significant infrastructure such as acequias (community-operated irrigation systems) (Raish *et al.* 2005; Dunbar-Ortiz 2007; Cox 2014; Fulé *et al.* 2021; Roos *et al.* 2021). The Southwest is also home to varied ecosystems such as the Sky Island bioregion, Sonoran Desert, and the largest contiguous ponderosa pine forest in the world (Schubert 1974; Arizpe *et al.* 2020; Aslan *et al.* 2021). This ecological diversity fostered the establishment of numerous forest restoration concepts and early development of associated management practices and techniques (Covington *et al.* 1997). Additionally, this region has a history of innovative management approaches to address wildfire risk, ranging from early and extensive use of natural ignitions to achieve management objectives (Hunter *et al.* 2014; Stoddard *et al.* 2020) to the adoption of novel policy mechanisms to fund forest restoration and watershed health (Steelman and Kunkel 2004; Miller *et al.* 2017). Together, these environments have created complex management challenges related to wildfire, including the prevalence of post-fire flooding caused by monsoon rains falling over hydrophobic burn scars (Fraser *et al.* 2022). Social science research can provide meaningful insights into wildfire management and adaptation across these conditions as people and the landscapes they live in continue to evolve across the region (Colavito 2017).

Numerous reviews related to social components of fire focus on specific topics (e.g. Christianson 2015; McCaffrey 2015; Hesseln 2018), or more broadly on the status of this field (Toman *et al.* 2013; McCaffrey *et al.* 2013*a*).; this review focuses instead on research conducted specifically within the Southwest. This geographic focus is applied with the intent to (1) identify unique regional, sub-regional, and local contexts that influence human relationships with wildfire in the Southwest, and (2) determine which research topics and contexts are underrepresented in studies published about the Southwest to elevate their inclusion in research for more cohesive wildfire adaptation. This article presents a comprehensive literature review of the existing social science literature for both southwestern states, with the aim of identifying overarching themes and notable research gaps that merit further exploration. These findings can provide a roadmap for future social research in this region to encourage actionable science that can make a meaningful impact for communities, managers, and ecosystems moving forward.

Approach

Literature reviews are well suited for characterising past research and assessing future needs due to their comprehensive nature (Booth *et al.* 2012; Gough *et al.* 2012). They necessitate the methodical collection, screening, and analysis of literature around a specific topic, allowing the elucidation of key topics or themes to produce new observations about a given field (Littell *et al.* 2008). Several core online databases, including CAB abstracts, Web of Science, Google Scholar, and Treesearch, formed the basis for this review. Broad search strings such as 'U.S. southwest OR Arizona OR New Mexico,' 'wildfire OR wildland fire OR brush fire OR forest fire,' and 'social OR human' were combined using advanced search tools in each database to gather candidate publications for review. This process resulted in the identification of 302 unique publications. The following five criteria, modified from Toman *et al.* (2013) and McCaffrey *et al.* (2013*a*) to allow comparison with broader wildfire social science trends being observed in the USA, were used to screen these candidate publications to determine their suitability for inclusion in this study: (1) The publication must be focused entirely, or in large part, on the examination of social components of wildfire and its management; (2) The publication must include primary data collected and analysed using a social science research method such as interviews, focus groups, or surveys. This focus best captures rich detail about the populations and contexts studied in ways that secondary data cannot. Economic studies were excluded because of significant differences in methodologies and data. Studies focused exclusively on document analyses or literature reviews and syntheses were also excluded to avoid repeated inclusion of the same findings; (3) The publication must use social data gathered fully or partially in southwestern USA. Geographic delineations of what constitutes the 'Southwest' varies significantly; this term is used here to refer to the states of Arizona and New Mexico exclusively. In publications where this term was used to describe the Southwest as a broader geography including other states, focus was placed on analysis of findings and implications for these two states. Studies that presented data collected in multiple states and/or countries and included a southwestern site were kept in this review to ensure comprehensive documentation of existing data; (4) The publication must be a peer or editorially reviewed journal article or book chapter. White papers, reports, and other grey literature are not included here given that quality can vary significantly and that there are few maintained databases

Fig. 1. The Fire Adapted Communities Framework, developed by the Fire Adapted Communities Learning Network (FAC Net 2021). The Framework presents 10 components that contribute to community wildfire adaptation and provides related examples of potential actions. Importantly, this does not present a one-size-fits-all approach but a starting place for discussion and action around local wildfire adaptation.

containing these materials across organisations and agencies, making it difficult to comprehensively assess these kinds of publications; and (5) The publication must be published or in press by June 2023. No parameters were specified regarding how old a publication should be for inclusion given the scarcity of such work in the Southwest. Additional publications identified for consideration were determined via searches conducted in common forestry- or fire-focused journals, on prominent researchers, and through review of works cited in initial materials identified through the screening process above.

In total, 65 publications produced between 1984 and 2023 were included in this review.[1] These publications generally focused on using social science methods to understand wildfire adaptation across different scales and contexts, with important implications for the establishment and continuity of fire adapted communities – groups of residents, land management, government, and fire professionals who collaborate effectively to plan for, respond to, and recover from wildfire (Paveglio and Edgeley 2020). Therefore, the author read each article and categorised key findings under the 10 considerations presented in the Fire Adapted Communities Framework (also sometimes referred to as the FAC wheel) (Fig. 1), before coding thematically within each consideration by hand. Existing research emphasises the benefits of focusing adaptation at the community level (Paveglio *et al.* 2018), and numerous efforts across the Southwest such as the New Mexico Fire Adapted Communities Learning Network, Yavapai Firewise, and the Arizona Wildfire Initiative seek to foster or support fire adapted communities, underscoring the practical benefits of exploring existing literature through this framework. The Fire Adapted Communities Framework was developed by the Fire Adapted Communities Learning Network to help communities explore pathways to wildfire adaptation and provide examples of activities associated with each consideration. Importantly, the concept of a fire adapted community is not a one-size-fits-all framework, meaning that the recommendations provided around the outer circle of Fig. 1 are not prescriptive, but instead illustrative of the range of potential actions that communities might explore (Paveglio and Edgeley 2020; FAC Net 2021). Publications often had findings, implications, or research needs that aligned with several of the 10 Fire Adapted Communities Framework considerations, and therefore may appear multiple times in different sections below.

[1]A full list of publications included in this study can be found in the supplementary materials for this article.

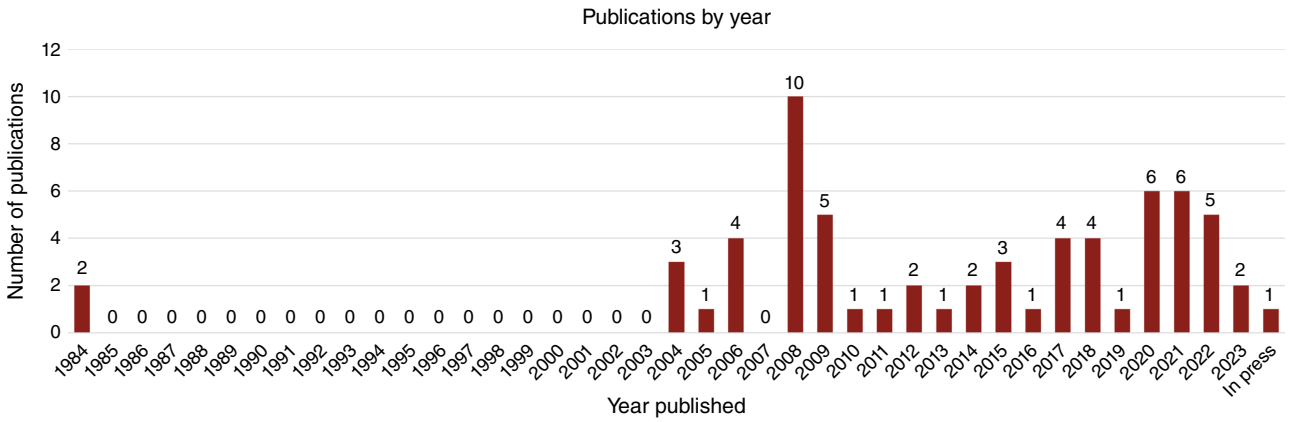

Fig. 2. Number of publications produced annually containing social science research on wildfire in the Southwest.

Emergent themes across findings are summarised below, using the 10 Framework considerations to identify gaps in knowledge about social fire adaptation in the Southwest. Each section concludes with a list of suggested future research directions for social scientists studying the Southwest to consider as research on humans and wildfire continues to grow. These research needs were determined using a three-phased approach: first, any recommendations made in publications included in this review were identified and grouped where suggestions were similar; second, the author compared this list of needs with the current state of the science on that topic using existing literature reviews and syntheses wherever possible (e.g. Toman *et al.* 2014; Christianson 2015; McCaffrey 2015; Hesseln 2018); and finally, the author compared these research needs with the Fire Adapted Communities Framework to identify other possible considerations that may be missing, still recognising that Fig. 1 is not exhaustive but can indicate common kinds of activities that social science research can support or explore. It was not always clear whether recommendations made by publication authors were specific to the Southwest or were intended to be more generalisable; therefore, the author organised research needs in each section below from most to least specific to the Southwest where possible, to indicate which needs are more relevant to this region.

Findings

Earlier social research on wildfire in the Southwest focused on public acceptance of varied management approaches such as prescribed fire (e.g. Cortner *et al.* 1984; Taylor and Daniels 1984; Brunson and Shindler 2004), a trend that reflected policy changes within the federal land management agencies in the late 1970s and 1980s. These efforts often sought to 'test' residents' knowledge via survey instruments to examine the extent to which ecological and management understandings influenced support or opposition. A shift began in the mid- to late 2000s as research increasingly focused on the engagement and integration of residents and communities into adaptation efforts, rather than studying them merely as external supporters or opposers of land management (Collins 2008*b*, 2009; Winter *et al.* 2009). This transition was likely influenced by wildfire social science research funding made available through the 2000 National Fire Plan (Steelman *et al.* 2004; McCaffrey and Kumagai 2007). Related research also began to emerge around public experiences with fires, examining risk perceptions, communication, and evacuation. The latest wave of research from around 2010 onward situates social science about wildfire within larger geographic scales and across broader lines of inquiry associated with forest health and landscape level fuels management. This aligns with growing interest in partnerships, collaboration, and cross-boundary management of public lands, driven in part by agency missions related to stewardship and partnerships. Fig. 2 shows the number of publications produced annually and included in this review, with several influxes in publishing that appear to align with these three waves. Two Fire Adapted Communities Framework considerations – 'prevention' and 'infrastructure and business' – have received little to no attention in the Southwest to date.

Far more research was published using data collected in Arizona (39 articles) than New Mexico (11 articles), although a modest number used or compared data from both states (15 articles). Some populations or areas were studied frequently over time – most notably, Flagstaff, AZ (e.g. McCaffrey 2008; Steelman 2008; McCaffrey *et al.* 2013*b*; Urgenson *et al.* 2017; Colavito *et al.* 2020; Edgeley and Colavito 2022; Hjerpe *et al.* 2023) – or shared insights from the same dataset across multiple studies, particularly in the White Mountain region of Arizona (Carroll *et al.* 2005, 2006; Cohn *et al.* 2006, 2008; Collins 2008*a*, 2008*b*, 2009; Collins and Bolin 2009). The vast majority of studies used

interview (40) or survey (28) methodologies to collect data. Focus group research (5) on wildfire has not been published using data from the Southwest since 2009 (Ryan and Hamin 2009; Winter *et al.* 2009). Few studies explicitly identified a social theory used to develop or advance understandings or inform study design; where this information was present, researchers typically used Ajzen and Fishbein's (1980) Theory of Reasoned Action (e.g. Muleady-Mecham *et al.* 2004; Winter *et al.* 2009) or Giddens' (1984) Structuration Theory (e.g. Carroll *et al.* 2005, 2011). The following sections explore these topical and methodological evolutions with specific attention to emergent themes and related research needs organised under each area of the Fire Adapted Communities Framework. It is critical to note that studies including data from one community, population, or state presented here is not generalisable to the entire Southwest, but the collection of such data over time and in different locations and contexts can help inform a deeper understanding of social variation related to wildfire adaptation in the region.

Safety and evacuation

Evacuation studies conducted in the Southwest have focused primarily on resident behaviours and information needs during fire. Although mass evacuation was the favoured approach to ensuring public safety across all studies, alternatives to evacuation have been explored in Santa Fe, NM, highlighting opportunities to leverage public interest in 'stay and defend' approaches to encourage residents to conduct property mitigation actions (McCaffrey *et al.* 2015). Prior events such as the Cerro Grande and Rodeo–Chediski fires were motivators for exploring improved evacuation approaches and communication strategies, such as reverse 911 systems (Cohn *et al.* 2006; McCaffrey *et al.* 2015). However, study populations had different information preferences during fires compared with others, both within the Southwest and in other areas of the USA, signalling the importance of tailoring evacuation planning and implementation to local populations (McCaffrey *et al.* 2013*b*). This is significant because experiences with evacuation have been found to influence varied support for future fuels management strategies in some instances (Edgeley and Colavito 2022). Information accessed prior to fire events is also influential: Arizona survey respondents who engaged in higher levels of planning during 2020 were more confident that external factors such as the COVID-19 pandemic and related 'stay at home' orders would not affect their evacuation decision-making during a fire (Edgeley and Burnett 2020). Consistency in study sites for evacuation-related studies allowed some localised trends to emerge; for example, Flagstaff residents repeatedly exhibited high trust in government information sources during fire compared with other study locations (McCaffrey *et al.* 2013*b*; Steelman *et al.* 2015; Edgeley and Colavito 2022).

Future studies should expand on existing understandings of evacuation and safety in greater detail, with particular attention to efforts that:

- Document evacuation decision-making processes related to secondary hazards such as post-fire flooding or debris flows;
- Explore efforts to address limited community ingress and egress in southwestern contexts;
- Examine planning and implementation of different public safety efforts during wildfire across scales and agencies and the extent to which this informs subsequent experiences, particularly as they relate to evacuation alternatives such as stay and defend, shelter in place, and use of safety zones;
- Understand how the public interpret and act on specific evacuation messaging and communication strategies such as text alert systems and *Ready, Set, Go!*; and
- Characterise social and environmental influences on evacuation decision-making at the household level.

Wildfire response

Existing Southwestern studies examining wildfire response focus on two broad topics: public support or opposition for wildfire response and exploration of professional perspectives about operational approaches.

Higher levels of local ecological knowledge and perceived ecological need for fire appear to influence acceptance of specific fire management strategies in both Arizona and New Mexico (Diaz *et al.* 2016). Resident disapproval of fire management strategies has been found to foster long-lasting conflict and distrust in federal agencies after fire, often stemming from perceived oversight of local knowledge and values as was documented following the Rodeo Chediski Fire (Carroll *et al.* 2005, 2006, 2011). A survey of Southwestern residents conducted by Winter and Cvetkovich (2008) also found ethnicity and race to be a substantial driver of trust of, and support for, US Forest Service wildfire management.

More recent research focuses on operational perspectives, highlighting the Southwest's jurisdictional complexity across a spectrum from coordination to co-management during wildfire response (Nowell and Steelman 2015; Davis *et al.* 2022; Nowell *et al.* 2022). These studies found that successful coordination of response was driven by pre-fire planning that allowed the establishment of relationships and communication channels (Owen *et al.* 2012; Nowell and Steelman 2015). The use of decision support systems (DSS) to navigate operational decision-making in the Southwest is increasingly documented by social scientists, revealing specific benefits for oversight of natural ignitions to achieve management objectives when using the Wildland Fire Decision Support System (WFDSS) (Fillmore and Paveglio 2023) and capacity for refocusing on long-term land

management strategies when using Potential Operational Delineations (PODs) (Greiner *et al.* 2021).

Further wildfire response research should seek to better capture the full suite of actions beyond wildfire management and suppression tactics. The Southwest can benefit from efforts to:

- Examine responses beyond wildfire management, including actions and involvement of law enforcement, local government, and non-governmental organisations;
- Identify current and future workforce needs related to wildfire response in the Southwest;
- Understand when and how different decision support systems are used and the outcomes they achieve for Southwestern environments and communities, including trust in or use of DSS outputs;
- Explore how public support for fire management varies among fire events, ecosystems, and social contexts; and
- Investigate Incident Management Team (IMT) dynamics during wildfires in Southwestern conditions, which may include study of operational considerations such as transition periods between IMTs, how the public interacts with IMTs, and the impact that interaction may have on resident decision-making, trust, and support over time.

Resident mitigation

The establishment and perpetuation of social norms around mitigation has been documented in the Southwest for centuries, originating among tribes (Roos *et al.* 2021). Southwestern studies published in the late 2000s predominantly explored barriers and opportunities for resident mitigation, much of which aligns with national research trends on this topic. Perceived and experienced wildfire risk and place attachment were consistent motivators, informing how residents chose which property to purchase, their level of investment in mitigation activities, and their engagement in community-level discussions and actions (McCaffrey 2008; Collins 2008*a*, 2008*b*; Collins and Bolin 2009; Plecki *et al.* 2021). Commonly reported barriers included cost and resources associated with mitigation activities, which was determined to exacerbate vulnerability in socially varied landscapes (Collins and Bolin 2009). Purchase of insurance was considered an adequate alternative to property mitigation by some Arizona residents (Collins and Bolin 2009). The role of fire events in motivating subsequent mitigation activities was noted in studies conducted after the Rodeo–Chediski, Wallow, and Monument fires. These efforts found that the novelty of destructive fire more readily produced policy and behavioural change in landscapes where fire was infrequent compared with landscapes where fire was commonplace (Cohn *et al.* 2008; Mockrin *et al.* 2018). Few studies explore resident engagement in mitigation following cascading hazards such as low air quality caused by smoke and post-fire flooding, although initial research into the latter suggests connectivity between individual and collective actions can be leveraged to increase engagement (Burnett and Edgeley 2023).

Institutional roles in resident mitigation have been increasingly documented, including the influence of real estate and planning professionals on resident risk perceptions, the presence and absence of homeowners' associations or other community organisational structures like Firewise committees and WUI groups, and use of ordinances or regulations (Steelman 2008; Collins 2008*a*; Bihari *et al.* 2012; Steffey *et al.* 2020). Inclusion of local values, consideration of feasibility, and aesthetic impacts were also noted as critical considerations for ensuring compliance for the latter (Winter *et al.* 2009). Many of these studies describe concern about shifting perceptions of responsibility related to the institutionalisation of mitigation and the sustainability of formalised approaches to wildfire risk reduction, in some instances indicating that successful fire adaptation requires both formal and informal approaches to be truly comprehensive in the Southwest.

The majority of research on resident mitigation in the Southwest focuses on Ruidoso, NM, Flagstaff, AZ, and Arizona's White Mountains region. These studies were published predominantly between 2008 and 2012, indicating that future research must capture regional social diversity beyond these locations and assess any shifts in mitigation behaviours and activities. Social scientists should seek to:

- Identify tools and resources that can address disparities in social vulnerability across cultures and contexts through mitigation and assess their implementation or use;
- Examine the effectiveness of different messaging language and delivery on engagement in mitigation from wildfire and associated threats in southwestern contexts;
- Understand how communities leverage formal and informal approaches to engage residents in mitigation activities, and the extent to which those approaches are sustainable and effective over time;
- Examine how communities might incorporate long-term planning into use of funds such as Community Wildfire Defense Grants to ensure sustained risk reduction; and
- Assess uptake of mitigation actions on private property and the role of potentially influential factors such as resident turnover using longitudinal or repeat study designs.

Partnerships and community engagement

Southwestern research examining partnerships explores collaboration and co-management through both formal and informal channels to address risk and impacts before, during, and after wildfire events (e.g. Russell *et al.* 2021; Nowell *et al.* 2022). Inclusion of diverse individuals and organisations, clarity regarding each player's role, and unification of shared values, priorities, and terminology were

consistently identified as critical factors influencing the success of collaborative efforts (Urgenson *et al.* 2017; Davis *et al.* 2022; Huber-Stearns *et al.* 2022). These conditions advanced social acceptance of management strategies among both the public and professionals, supported progressive identification of scientific needs, and allowed strategic prioritisation of treatments across landscapes among other benefits (Colavito 2017; Urgenson *et al.* 2018; Davis *et al.* 2022). Exploration of policy-driven initiatives for partnership, collaboration, or co-management was a common framing for Southwestern case studies; this included the Sitgreaves Community Wildfire Protection Plan (Fleeger 2008), the Flagstaff Watershed Protection Project (Miller *et al.* 2017), the White Mountain Stewardship Project (Mottek Lucas *et al.* 2017), Collaborative Forest Landscape Restoration Program (CFLRP) sites (Urgenson *et al.* 2017, 2018; Bradshaw 2019), the Reserved Treat Rights Land Program (Russell *et al.* 2021), and the Rio Grande Water Fund (Huber-Stearns *et al.* 2022). These cases underscore the value of knowledge co-production and scientific inquiry to advance wildfire adaptation in southwestern landscapes (Colavito 2017; Grimm *et al.* 2022).

Community engagement was an emergent theme across several considerations within the Fire Adapted Communities Framework (for examples, see sections on *Regulations, policy, and plans* and *Recovery* in this article). Centering community values and needs in engagement and partnership efforts is critical for effective communication, collaboration, and trust building in both Arizona and New Mexico (Toman *et al.* 2006; Fleeger 2008; Morehouse *et al.* 2010; Bradshaw 2019). Engagement across different formats, such as public meetings and art exhibitions, allowed a deeper public understanding of forest and fire management in the region to emerge (Fleeger 2008; Morehouse *et al.* 2010; Colavito *et al.* 2020). Level of engagement often hinged on a complex web of influences, including availability of grant funding, alignment of policy or practices with local culture, and experience with recent wildfires (Steelman and Kunkel 2004; Steffey *et al.* 2020).

Research that builds from the existing partnerships and community engagement literature should:

- Explore collaborative dynamics, strategies, and considerations that can help maintain partnerships and community engagement over extended periods of time. Insights can be drawn from both existing efforts, such as the Four Forest Restoration Initiative (4FRI), and emerging projects, such as the US Forest Service's Wildfire Crisis Strategy landscapes, which make greater efforts to include tribal lands and partners (e.g. San Carlos Apache Tribal Forest Protection Project landscape);
- Investigate the establishment and implementation of partnerships to address risk, impacts, and recovery in post-fire environments, particularly in contexts that involve marginalised and historically underrepresented communities;
- Identify how policy-driven partnerships and collaboration can become more equitable and inclusive, particularly regarding tribal engagement;
- Expand understandings of community-driven engagement efforts, particularly among rural or underserved populations; and
- Understand how communities characterise and engage (or do not engage) in collective action across different scales and contexts.

Landscape treatments

Social perceptions of fuels treatments constitutes one of the more studied aspects of human adaptation to fire in the Southwest, documenting consistently high social acceptance and support for various approaches over almost four decades. Earlier research examined support for prescribed fire, identifying knowledge of fire ecology, level of education, and impact to scenic beauty as influential factors (Cortner *et al.* 1984; Taylor and Daniel 1984; Muleady-Mecham *et al.* 2004). Arizona respondents in a multi-state survey were least likely to express concerns about prescribed fire (Brunson and Shindler 2004), and support for this approach remained high six years later in a resurvey effort (Toman *et al.* 2014). Other techniques like livestock grazing, use of natural ignitions to achieve management objectives (sometimes referred to as 'managed fire'), and mechanical and non-mechanical thinning also shared high public acceptance in survey research (Cortner *et al.* 1984; Brunson and Shindler 2004; Muleady-Mecham *et al.* 2004; Ostergren *et al.* 2008; Toman *et al.* 2014). Experiences with recent wildfires also appeared to influence support for post-fire fuels management techniques like salvage logging (Cohn *et al.* 2008; Ryan and Hamin 2008, 2009). Across these resident-focused studies, beliefs and values related to landscape conditions and trust in land management agencies conducting fuels treatments consistently influenced acceptance or support (Cohn *et al.* 2008; Ostergren *et al.* 2006, 2008; Morehouse *et al.* 2010).

More recent research on landscape treatments focuses on manager perspectives regarding planning and implementation, seeking to understand how wildfire and related risk mitigation fit into broader conversations about ecological resilience and restoration (e.g. Miller *et al.* 2017; Aslan *et al.* 2021). Many of these studies also emphasise the importance of Indigenous histories, knowledge, partnerships, and inclusion in determining appropriate and effective fuels management approaches for southwestern landscapes, underscoring the consequences of forced exclusion of cultural fire use (e.g. Tarancón *et al.* 2020; Abrams *et al.* 2021; Roos *et al.* 2021; Russell *et al.* 2021). Federal structures for promoting large-scale and cross-jurisdictional strategies for enhancing ecological resilience through fuels treatments (e.g. CFLRP) consistently reveal the importance of building shared responsibility for ecosystem health as it relates to fire

(Mottek Lucas *et al.* 2017; Urgenson *et al.* 2017; Davis *et al.* 2022; Huber-Stearns *et al.* 2022). Such efforts accelerated faster in the presence of broadly agreed upon interpretations of core concepts such as 'resilience,' 'forest restoration,' and 'best available science' (Colavito 2017; Urgenson *et al.* 2018; Greiner *et al.* 2020). However, discussions of where social resilience fits into fire adaptation efforts were scarce among managers tasked with the implementation of these programs (Greiner *et al.* 2020).

Recent Southwestern studies of manager perspectives on landscape treatments primarily use qualitative methods like semi-structured interviews, but studies of the public have exclusively used quantitative survey methods. Future studies of public relationships to fuels treatments can benefit greatly from use of qualitative approaches that can provide greater depth and reasonings behind support (or lack thereof) that cannot be fully understood using survey measures alone (Paveglio and Edgeley 2023). Significant social, ecological, and management shifts have occurred across many southwestern landscapes since the most recent study of public perspectives on fuels treatment (Toman *et al.* 2014), emphasising the importance of future research to:

- Characterise the factors and conditions driving public understanding and support or opposition for use of natural ignitions to achieve management objectives., Ideally, this should be paired with solution-driven social investigations of barriers to use of this technique given its increasing application in the Southwest;
- Explore social aspects of fuels management in ecosystems that until recently experienced infrequent fires (e.g. Sonoran Desert) and in areas where fuels treatments have been excluded (e.g. federally designated wilderness areas);
- Examine manager perspectives on monitoring and metrics associated with fuels treatments at different scales and across different ecological conditions;
- Develop a contemporary understanding of public perspectives on fuels management techniques and landscape treatments that go beyond quantitative methodologies, including exploration of conflict or cohesion around treatments in different social and ecological contexts; and
- Establish clearer understandings of the transition from planning to implementation of landscape-scale projects, including prioritisation processes, partnerships (particularly with tribes and other historically underserved groups), and perceived effectiveness or impact of that work over time relative to project objectives.

Public health

Existing research on public health in the Southwest is largely focused on mental health and wellbeing as it relates to ecosystem impacts and place attachment after specific fires. The emotional healing of community members in areas affected by fire can benefit greatly from engagement in landscape rehabilitation and recovery through activities such as reforestation and trail repair (Burns *et al.* 2008; Ryan and Hamin 2008), particularly after large or socially impactful events like the Rodeo-Chediski, Aspen, and Cerro Grande fires. Eisenman *et al.*'s (2015) survey following the 2011 Wallow Fire expanded this subfield by examining distress or 'solastalgia' caused by fire's impacts on the landscape, uncovering varied psychological impacts among respondents.

Other research has explored how health outcomes affect decision-making in different contexts. Williams and Ishak (2018) examined the impacts of the Yarnell Hill Fire tragedy on firefighter mental health, finding that participants adapted their behaviours to accommodate mental health impacts and stress in the weeks following, while Edgeley and Burnett (2020) documented changes in mitigation efforts and evacuation planning driven by the COVID-19 pandemic during the 2020 fire season in Arizona.

Together, these studies indicate that mental health effects of fire are long-lasting and closely tied to landscape recovery in southwestern ecosystems. A more comprehensive understanding of public health related to wildfire in the Southwest is urgently needed; for example, research related to smoke impacts in this region focuses exclusively on economic assessments of smoke impacts (e.g. Jones *et al.* 2016). Future research should:

- Establish a foundational understanding of social impacts and adaptation related to smoke from wildfire and forest management efforts;
- Characterise connections between wellbeing and wildfire events over time in southwestern ecosystems with greater nuance;
- Explore how members of the public manage their health relative to wildfire, including whether these efforts vary among different populations and contexts, identification of resources communities use or need in order to protect their health, and the effectiveness of programs and techniques for mitigating health risks among vulnerable populations (e.g. air filter programs, use of clean air spaces);
- Seek to understand how mental health support can influence community recovery following fires; and
- Develop a foundational knowledge of the role that disabilities and pre-existing physical and mental health conditions play in varied aspects of social adaptation to fire.

Prevention

Social science research related to fire prevention in the Southwest is scarce; no publications included in this review focused exclusively on this topic, despite an increase in large human-caused wildfires and management efforts to address them in this region (Nagy *et al.* 2018). Studies included in this review that did briefly touch on prevention note that it

has garnered less consideration among Southwestern land managers compared with fire suppression when discussing local land management planning (Aslan *et al.* 2021), and that public support for total suppression as a fire prevention technique has historically been influenced by demographic variables (Muleady-Mecham *et al.* 2004). A survey of Yavapai County, AZ residents found that 67% of respondents agreed 'humans cause most of the wildfires in this state' (Brunson and Shindler 2004: p670). Existing research on ignition prevention beyond this review's selection criteria typically has been published as grey literature (e.g. Kohler and Evans 2021), but it indicates an urgent need to understand the dynamics surrounding both human behaviour and management strategies. The absence of regional prevention research reflects broader oversight and lack of scientific progression regarding human behaviour and ignition prevention in the wildfire literature (Hesseln 2018).

Underdevelopment of social science research related to fire prevention in the Southwest and recent shifts in recreation and public land use, population change, and ecosystem health regionally indicate that more comprehensive risk management efforts may emerge via research designed to:

- Characterise the relationship between recreation and human-caused wildfire ignitions in and around southwestern communities;
- Understand public support or opposition for both regulatory and non-regulatory prevention strategies, such as forest closures, fire bans, and public education campaigns, and the role of land management agencies and other entities in oversight of these approaches;
- Evaluate the impacts of fire prevention on community functioning and local livelihoods, including examination of the impacts of wildfire for southwestern economies, with particular attention to non-market values and ecosystem services;
- Assess the effectiveness of various intervention strategies on reducing unwanted wildfire ignitions across different social and ecological contexts; and
- Explore behavioural influences on spatial and temporal patterns of human-caused ignition occurrence.

Regulations, policy, and plans

Examination of regulations, policy, and plans in existing research has spanned multiple scales in the Southwest. At the local level, community-based policies and regulations implemented by homeowners' associations often face resistance but can be effective at influencing uptake of mitigation actions on private properties (Winter *et al.* 2009; Steffey *et al.* 2020). Fleeger (2008) examined the establishment of the Sitgreaves Community Wildfire Protection Plan in Arizona, noting that existing collaborations were critical to successful plan creation and that agencies could empower communities to proactively mitigate risk by providing technical expertise. This latter point was also noted by Bihari *et al.* (2012) while studying a different population: planners based in Ruidoso, NM, who described having a duty to incorporate education into planning efforts. Insurance companies were identified as a key player in motivating local on-the-ground change through policy design in both NM and AZ (Collins 2009; Bihari *et al.* 2012). Post-fire land use planning and regulation was explored in a series of articles that included case studies of two Arizona wildfires, emphasising the need for incorporation of local social diversity into such efforts while highlighting varied support for regulatory approaches to wildfire adaptation (Mockrin *et al.* 2018, 2020).

Translation of national policy to southwestern landscapes was a common area of study, although many of these publications explored the role of fire within the broader context of forest resilience rather than as a focal topic (e.g. Greiner *et al.* 2020; Abrams *et al.* 2021). These efforts emphasised the importance of flexibility in policy and planning processes to better accommodate diverse southwestern contexts. Study of specific policies and planning oriented projects such as the White Mountain Stewardship Project (Mottek Lucas *et al.* 2017), Southwestern CFLRP landscapes (Urgenson *et al.* 2017), HFRA (Steelman and DuMond 2009), and use of PODs for fire planning (Greiner *et al.* 2020) reveal challenges surrounding large-scale efforts to manage wildfire risk relative to forest health in the Southwest. These included difficulties associated with engagement and decision making among diverse stakeholders, particularly environmental groups who leveraged formal processes to advocate for specific values (Steelman and DuMond 2009). Tribal perspectives were rarely engaged in research relative to this sub-area, although one article (Russell *et al.* 2021) presented a case study of prescribed burning in Pacheco Canyon, NM, with support from the Reserved Treaty Rights Land Program, highlighting the limitations that Bureau of Indian Affairs partners face under this funding structure.

Regualtions, policy, and plans remain one of the more developed bodies of social science research in the Southwest; however, federal, state, and local guidance, strategies, and legislation about fire are rapidly changing. Additional studies can help provide greater context and opportunities for comparison to other regions while keeping pace with the introduction and implementation of evolving programs and structures. These efforts could:

- Document the implementation and impacts of state-level policies such as the Arizona Healthy Forest Initiative or New Mexico's 2021 *Prescribed Burning Act* (HB 57);
- Explore the role that regulation, policy, and/or planning can play in motivating cross-boundary management on Southwestern landscapes, particularly those that include private lands;
- Understand the extent to which current planning efforts are effectively nested or coordinated across scales (e.g. use

of Community Wildfire Defense Grants, Community Wildfire Protection Plans, or Hazard Mitigation Plans);
- Characterise the long-term outcomes of policies, plans, and regulations, and the extent to which they achieved their goals; and
- Assess the sustainability of grant funds, cost shares, and other financial mechanisms for producing long-term improvements to wildfire adaptation at different scales.

Infrastructure and business

No studies were identified that focused exclusively on infrastructure and business, which may in part be due to the exclusion of economic methodologies in this review. Although new studies are emerging to quantify the economic costs of wildfire response in its entirety in the Southwest, some of which use surveys as one tool for more comprehensive representation of impacts (e.g. Hjerpe *et al.* 2023), little to no research engages qualitative methods for understanding these components. Given the absence of research on this topic, foundational research to fill this gap may benefit from efforts to:

- Determine what different organisations, groups, and populations consider 'critical infrastructure' in the Southwest and the approaches through which they should be prioritised and protected;
- Characterise the impacts of fire on urban areas or the Southwest given the proximity of recent fire events to large cities such as Phoenix and Albuquerque, including the effects of changes in air quality or water quality and availability;
- Advance social understandings of infrastructure and economic considerations related to residual materials produced by fuels treatments (e.g. biomass utilisation, the Wood For Life program which donates residual materials to Indigenous communities for firewood, or sustainability of the Southwestern wood products industry relative to wildfire);
- Understand how businesses and critical infrastructure, such as hospitals, are planning for wildfire events and related impacts and, where fires have occurred, the extent to which that planning was adequate;
- Examine planning, management, and recovery efforts related to critical utilities threatened by wildfire such as water, sewer systems, gas, and electricity (e.g. public safety power shutoff events), and related impacts for Southwestern populations; and
- Explore business and infrastructure representatives' roles in collaborative management.

Recovery

The Cerro Grande and Rodeo–Chediski fires drew early attention to both social and ecological recovery research in the Southwest. Initial social science focused on conflict and cohesion after the Rodeo–Chediski Fire, revealing long-lasting local legacies of galvanisation and fragmentation driven by pre-existing and emergent social interactions (Carroll *et al.* 2005, 2006, 2011). A second wave of post-fire research explored place attachment and its role in resident recovery, demonstrating a clear and continued interest in public engagement in post-fire restoration and ecological recovery after multiple fires that highlights the importance of including community members in land management planning and rehabilitation where it is safe and efficient to do so (Burns *et al.* 2008; Ryan and Hamin 2008; Eisenman *et al.* 2015). That interest extended to specific post-fire rehabilitation techniques such as salvage logging, which revealed recreation and economic benefit as drivers of local support (Ryan and Hamin 2009). Recent research has shifted to explore adaptation efforts that emerge during the recovery process. These include exploration of land use planning and development policies as a tool for post-fire adaptation, which uncovered significant variation in support and perceived feasibility among Southwestern study fires (Mockrin *et al.* 2018, 2020), and examination of property-level efforts to address post-fire flood risk that found connections between engagement in individual and collective actions (Burnett and Edgeley 2023).

Many recent impactful, record-breaking Southwestern wildfires have received little attention in the social science literature. New research is needed to:

- Characterise recovery processes after secondary hazards like debris flows and flooding related to wildfire events, and the extent to which they differ from recovery after wildfire and other hazard events;
- Explore social aspects of vegetation recovery after fires, including perspectives on reforestation, work conducted by Burned Area Emergency Response (BAER) teams, and the role that landscape recovery plays in social recovery;
- Document how affected households, communities, and governments navigate long-term wildfire impacts;
- Investigate processes for recovery planning and evaluation of their implementation, including the role of FEMA and state recovery entities in post-fire recovery;
- Understand both grassroots and top-down recovery response efforts in affected communities, tribes, and landscapes across a spectrum of impacts; and
- Examine the role that insurance coverage (or lack thereof) plays in recovery following both wildfires and secondary events such as post-fire flooding.

Discussion

Social science research related to wildfire in the Southwest has evolved significantly over the past four decades, making fundamental contributions to national and international

understandings of key topics such as resident mitigation and support for landscape treatments. However, some considerations for fire adaptation remain chronically understudied in Arizona and New Mexico relative to other states (e.g. California and Colorado). For example, research on public acceptance of prescribed fire has become outdated, whereas other areas such as fire prevention and smoke adaptation remain unexplored, limiting the development of a comprehensive picture of the unique regional, state, and local contexts that affect human–wildfire interactions. Advancing social science related to wildfire is increasingly urgent as investment in efforts to reduce risk and accelerate adaptative actions continue to intensify (most recently with the addition of new US Forest Service Wildfire Crisis Strategy landscapes in Arizona and New Mexico), but prioritisation, funding, and implementation of adaptation activities often remain driven by spatial and secondary data (such as census data) or property characteristics gathered by tax assessors (such as property size, value, and year structures were built) (Ager *et al.* 2019; USDA Forest Service 2022). Thus, this review presents a potential roadmap for critical social science research in the Southwest over the coming years to ensure that efforts to adapt to wildfire incorporate local contexts that maximise public and professional health and safety while minimising social and ecological impacts.

This review documents two core areas where disparities in social science research related to wildfire in the Southwest are emerging that should be considered by social scientists seeking to expand this field: study locations and study populations. Far more research draws from data collected in Arizona than New Mexico, and existing research in both states has historically focused on several key populations, including Flagstaff and the White Mountains region of AZ, and Santa Fe and Ruidoso, NM[2]. The Rodeo–Chediski and Cerro Grande fires have been focusing events in social science research for their respective states, acting as benchmarks for regional attitudes and approaches for several decades now (Moscovici 1988; Birkland 1997). However, there is a scarcity of studies exploring some of the Southwest's more recent impactful fire events (e.g. the 2012 Little Bear Fire, NM, or the 2021 Telegraph and Mescal fires, AZ), meaning that more contemporary understandings of experiences with wildfire are lacking. Much of the existing research across the Southwest also focuses on forested ecosystems; as wildfire expands into ecosystems that historically have not experienced frequent fire, the need to study human–fire interactions in other environments will become greater. A very limited number of studies explore underrepresented perspectives on fire adaptation, including Indigenous and Hispanic experiences and insights (Winter and Cvetkovich 2008; Roos *et al.* 2021; Russell *et al.* 2021). Taken together, this review is an invitation for social scientists to consider the study of new places and populations to elevate social and ecological diversity in conversations about fire adaptation in the Southwest. Such studies can advance discussion and action related to environmental justice and equity and better situate Southwestern insights in broader conversations about fire adaptation as it relates to climate change, drought, and other risks (Ojerio *et al.* 2011; Smith *et al.* 2016; Wilder *et al.* 2016). However, this suggestion also comes with a call for scientists to engage these communities and populations in meaningful and ethical ways that respect local culture and knowledge, being mindful of participant capacity and relationships as partnerships, collaborations, and knowledge co-production become increasingly sought after (Wilmer *et al.* 2021).

This review also provides key insights related to study design for social scientists wishing to study wildfire in the Southwest. First, there may be value in greater methodological diversity in future research, where appropriate, to access novel findings that current studies do not, perhaps most readily through the reintroduction of focus groups as a data collection technique. Other more specialised or interdisciplinary approaches, such as Q-methodology or participatory mapping, are scarcely used and may offer opportunities to expand and deepen nuanced understandings, particularly related to decision-making processes around wildfire in both operational wildfire management and land management contexts and to understand behaviours enacted by residents or communities. Second, social scientists should explore opportunities to embed Southwestern research within broader discussions and advancement of theory development to support fire adaptation moving forward. The growing absence of the use and acceleration of social theory in the Southwest is of concern because one of the most foundational purposes of social science research is theoretical advancement (Flyvbjerg 2001; McCaffrey and Kumagai 2007). Inclusion of theoretical thinking in wildfire research across this region will ensure that Southwestern conditions and considerations inform theory development, which may be particularly valuable if such research also includes understudied or localised populations and places.

Broadening scales and scopes related to lines of inquiry in social science research for wildfire over the past decade have resulted in a gradual shift from studies that engage communities or engage in public-facing research to manager-oriented studies that investigate social perspectives on ecological adaptation at the landscape and regional scales. Study of managers is of great importance and future efforts should endeavour to explore more specific management challenges and approaches; however, many studies of this nature exclude community voices or rely on assumptions that managers accurately perceive and understand community dynamics and can serve as a proxy for these populations, limiting more holistic and representative understandings of social dynamics around wildfire. As efforts to advance landscape

[2]See Supplemental Materials for a comprehensive list of study locations in publications included in this review.

level adaptation progress, continued inclusion of resident and community perspectives that complement and extend studies of managers and other professionals will be essential for cohesive and strategic advancement (Paveglio *et al.* 2018). Without continued study at the community level, the Southwest risks falling behind other regions in terms of capacity to incorporate social nuance into adaptation strategies because the depth of social understandings available in other states may no longer exist; therefore, there is a need to protect and maintain intentional inclusion of community members through place-based, primary data collection among social scientists studying the Southwest.

Widespread challenges regarding the process of conducting social research that yields high-quality datasets are reflected in studies conducted in the Southwest. For example, survey studies in this review conducted in the 2000s had response rates above 40% (e.g. Brunson and Shindler 2004; Ostergren *et al.* 2006), whereas those conducted since 2010 tend to be below 25% (e.g. Diaz *et al.* 2016; Zanocco *et al.* 2018; Edgeley and Colavito 2022), aligning with documented national declines in study participation over time (Stedman *et al.* 2019). As the conditions for social science research evolve, two common limitations of research exploring the social aspects of wildfire have emerged more frequently in recent publications. First, there is an increase in studies that draw from small datasets without discussion or action regarding approaches to determine data quality (e.g. theoretical saturation or non-response bias). Second, research efforts focused solely on secondary data such as GIS analyses or investigations of census data as a proxy for social conditions have emerged in greater numbers. Such studies were identified but removed from this review in earlier database searches because although they may have the capacity to make broad inferences about human populations, they are generally unable to capture the complexities and nuances that local social systems exhibit because of their inability to document non-quantifiable factors in the same way that wildfire social science can. Wildfire social science can explore social interactions with the landscape through many lenses, ranging from experiences with a specific event to relationships and resources that influence actions related to risk, but must go further than studies reliant on secondary data to embrace emergent insights while remaining grounded in direct connections to the people and places being studied.

Some ambiguity has emerged about what constitutes wildfire social science in recent years. Drawing on insights from the Southwestern research examined above, this article posits that rigorous wildfire social science has several key characteristics that set it aside from other related fields: (1) it is primarily concerned with the role that wildfire plays in social relationships to the landscape over time, with particular attention to continuity and change in both landscapes and the people that inhabit them (Williams and Stewart 1998; Paveglio *et al.* 2009); (2) it is grounded in place-based data collection that necessitates interaction with the study population at hand to gather primary data using foundational social science research methods. These approaches are best suited to capture social processes related to fire and the land by drawing on the past and present to anticipate how relationships between people and place might evolve in the future, as demonstrated by the depth and breadth of much of the research in this review; (3) it contributes to the establishment or expansion of social theory (McCaffrey and Kumagai 2007; Paveglio 2023); and (4) it results in the generation of *actionable* outcomes for people living and working in fire-prone landscapes (Champ *et al.* 2022). Importantly, wildfire social science recognises that not everything can (or should) be quantified; much of the value imbued in social science approaches lies in its ability to elucidate intricate nuances in social systems, and oversimplification of these social processes can result in ineffective or misaligned policies and management strategies that become catalysts for unintentional or unwanted outcomes over time. Opportunities to conduct rigorous wildfire social science both in the Southwest and beyond are abundant and can build from the foundational research presented in this review.

Conclusion

Social science is becoming a more integrated component of wildfire adaptation discussions and actions in the Southwestern USA. This review finds that there is a small but growing body of research dedicated to social aspects of wildland fire in Arizona and New Mexico, but the need for social science research related to wildfire in these states persists as people and place continue to evolve. A shift from community-oriented research towards manager-focused studies over the past decade has limited regional capacity to document and theorise about the nuances at the local level that must be incorporated to progress wildfire adaptation. This article provides a roadmap of focal areas to expand wildfire social science in the Southwest, ensuring that conditions in Arizona and New Mexico are included and elevated in national and international conversations about wildfire adaptation. The Southwest is well positioned to become a national and international leader in key areas of wildfire social science such as management of and response to post-fire flooding, and support and use of natural ignitions to achieve land management objectives. Strategic hiring and investment in wildfire social science within the Southwest can further support this, particularly within agencies like the US Forest Service that have hired researchers with similar expertise in other regions of the USA. A growing wildfire social science workforce in Arizona and New Mexico can benefit greatly from hiring practices that are inclusive of the Southwest's rich diversity of ethnicities, races, cultures, languages, and histories. Many of the research needs identified here are likely present across

other US states, regions, and countries; therefore, similar geographically focused literature reviews elsewhere will be beneficial for developing a comprehensive constellation of wildfire social science understandings, needs, and disparities at the national level. Wildfire social science continues to play a critical role in adaptation planning and action, but increased investment in, and inclusion of, this research is critical to ensure that ecological and social adaptation are effectively integrated at local, landscape, and regional scales.

Supplementary material

Supplementary material is available online.

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