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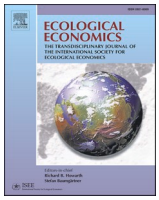

Analysis

Are wildfire risk mitigators more prepared to evacuate? Insights from communities in the Western United States☆

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ABSTRACT

As the realized experiences of wildfires threatening communities increase, the importance of proactive evacuation preparation and wildfire risk mitigation on private property to reduce the loss of lives and property is shaping wildfire policy and programs. To date, research has focused on pre-wildfire evacuation preparation and risk mitigation independently. This paper examines the substitutability or complementarity of these proactive risk-reducing actions. If mitigation and evacuation preparedness are substitutes, wildfire education programs may take a life-over-property approach. However, if proactive risk-reducing efforts are complements, wildfire education programs can confidently encourage residents to prepare for evacuation while also mitigating wildfire risk on their properties. This complementarity may also demonstrate that poorly mitigated households are less prepared to evacuate, compounding their risks. Using household survey data from 25 wildland-urban interface (WUI) communities across five Western states, we explore how wildfire risk mitigation actions affect evacuation preparedness. We find that improving household wildfire mitigation is associated with an improvement in wildfire evacuation preparedness. This complementary relationship between wildfire mitigation and evacuation preparedness actions highlights the potential benefits of a wildfire education approach that encourages residents to simultaneously prepare for evacuation and reduce wildfire risk on their properties before they are threatened by a wildfire.

1. Introduction

Wildfire risk in the United States has increased over the past few decades due to a warming climate, historical suppression of fire leading to the accumulation of fuels, and an expansion of communities in fire-prone areas (Abatzoglou and Williams, 2016; Mercer et al., 2008; Radeloff et al., 2018; Westerling et al., 2006). In recent years, rapid-moving wildfires, such as the 2025 Los Angeles Fires, 2023 Lahaina Fire, and the 2018 Camp Fire, have caused massive destruction of lives and properties.[1] These disasters not only result in fatalities but also

☆ The household surveys described in this report were organized and implemented by non-federal partners and were not conducted on behalf of the U.S. Geological Survey

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[1] The 2018 Camp Fire in Butte County, California, resulted in 85 fatalities and displaced over 50,000 people. The Lahaina Fire in Maui, Hawai'i, in 2023 resulted in 102 fatalities. As of the time of writing, news reports indicate the 2025 Los Angeles fires resulted in 29 fatalities and destroyed or damaged over 16,000 structures (**Shalvey et al.,** 2025).

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cause major economic losses by destroying homes and structures.[2] Proactive risk-reducing behaviors by wildland-urban interface (WUI) residents, such as evacuation preparation and property-level wildfire risk mitigation, reduce the catastrophic damages of these events (Cohen, 2000; Jolley, 2018; United States Department of Agriculture (USDA) Forest Service, 2022). Therefore, policymakers and community organizations aim to understand why individuals complete these proactive actions and how to encourage more of them (United States Department of Agriculture (USDA) Forest Service, 2024).

While most of the wildfire evacuation literature has focused on questions surrounding evacuation decision-making during a wildfire event (Ahmad et al., 2023; Kuligowski et al., 2020; Kuligowski, 2021; McCaffrey et al., 2018; McLennan et al., 2019; Zhao et al., 2022), this paper focuses on factors that lead to households completing recommended evacuation preparation actions prior to a wildfire event. For example, it is important to complete actions such as preparing a "go" bag or designating an emergency meeting location outside the fire hazard area before a wildfire occurs. These concrete actions are crucial to ensure quick and effective evacuation for residents while helping local firefighters by reducing congestion and allowing them to prioritize firefighting. Research has demonstrated that a lack of evacuation preparedness for hazards, such as wildfires and hurricanes, is a primary factor in the vulnerability of indigenous and elderly communities (Asfaw et al., 2019; Dostal, 2015).

Evacuation preparation is just one of many proactive wildfire risk-reducing actions a household can take to help reduce damages from wildfires. The hazards and disaster literature outlines preparedness and mitigation as pre-hazard phases of the disaster cycle (Alexander, 2002; Twigg, 2004). Mitigation is defined as "structural or non-structural measures undertaken to limit the adverse impact of hazards/threats"(Bosher et al., 2021). Preparedness is defined as "the knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters" (Bosher et al., 2021; UNDRR, 2020). While both stages occur before a wildfire event, the order in which a household implements these steps is ambiguous. Therefore, it is plausible that households' decisions about completing proactive mitigation and evacuation preparedness actions may be interconnected – whether they pursue one, both, or neither action.

Wildfire social science literature has commonly focused on understanding the determinants of wildfire mitigation (McCaffrey, 2015) and the evacuation intentions or behaviors during a wildfire event (Kuligowski, 2021). While understanding how certain factors may affect these actions independently, it is also critical to identify any relationship between mitigation and evacuation preparedness activities. To our knowledge, this article is the first to address the question of whether completing wildfire mitigation actions increases, decreases, or has no effect on the likelihood that a household is prepared to evacuate in the event of a wildfire. In other words, are wildfire risk mitigation actions and evacuation preparation complements or substitutes? In some localities, wildfire practitioners provide mitigation information, while other emergency management organizations distribute evacuation preparedness information. In contrast, in some areas wildfire practitioners promote both mitigation and evacuation preparedness activities together. If these activities are complements, this would suggest that households whose properties are poorly mitigated are also not prepared for evacuation, compounding their risks. However, encouraging households to complete mitigation actions could have positive spillovers on evacuation preparedness. The result of this inquiry makes an important contribution to the literature on proactive wildfire actions and can support policymakers and wildfire practitioners in developing policies and programs that incentivize better preparation for wildfires.

It is unclear from the wildfire literature whether we expect risk mitigation activities and evacuation preparedness to be complements or substitutes because the issue has not previously been examined. Although both types of actions are connected to wildfire disaster risk reduction, they reduce the risk of two different types of loss. Evacuation preparedness addresses risks to people, whereas mitigation primarily addresses risks to property. Much of the research on proactive activities has examined the relationship between insurance purchases and investment in private risk reduction activities (Hudson et al., 2017). In the case of flood and wind insurance, studies have shown a complementarity between insurance and risk-mitigating behaviors (Thieken et al., 2006; Carson et al., 2013; Petrolia et al., 2015; Hudson et al., 2017). On the other hand, Botzen et al. (2019) find that individuals with flood insurance perform fewer emergency preparedness measures when a disaster is imminent, demonstrating the potential substitutability of risk-reducing actions. This paper advances our understanding of the interactions between multiple proactive risk-reducing actions in the context of wildfires.

To identify the relationship between wildfire risk mitigation and evacuation preparedness, we use an instrumental variable approach leveraging a unique paired dataset of parcel-level rapid wildfire risk assessments and household surveys.[3] This methodology allows us to identify a causal relationship of how mitigation actions affect households' evacuation preparedness. We focus on this direction because evacuation preparation decisions are less studied in the literature and the disaster cycle often presents mitigation as the stage preceding preparedness (Alexander, 2002). Fig. 1 illustrates our simple conceptual model. As shown in previous literature, wildfire disaster risk reduction (consisting of both risk mitigation and evacuation preparedness) can be influenced by a variety of factors including demographics, risk perceptions, wildfire attitudes, previous experiences with wildfire, and wildfire community activities (Brenkert–Smith et al., 2006; Brenkert-Smith et al., 2013; Bayham et al., 2022; Kuligowski et al., 2020; McCaffrey et al., 2012; Whittaker et al., 2016). To empirically isolate the relationship between risk mitigation and evacuation preparedness, our empirical model controls for factors that may influence both mitigation and evacuation preparedness. We find that risk mitigation actions are complementary to evacuation preparedness. This suggests that unmitigated properties have unprepared residents, exposing these households to a greater risk of suffering harm. Conversely, one proactive risk-reducing action does not crowd out another. Therefore, wildfire practitioners can increase resilience by promoting actions that ensure safer properties and more prepared households.

The remainder of this paper is organized as follows. Section 2 discusses the background and recent literature related to wildfire evacuation and mitigation. Section 3 introduces descriptive statistics of the data used in our analysis. The instrumental variable methodology is described in Section 4. Results are presented in Section 5. Section 6 discusses the implications of the findings and Section 7 concludes.

2. Background

Due to the increased threat of wildfires, researchers have been interested in understanding households' decision-making regarding proactive wildfire preparedness actions. This article focuses on two

[2] Damages from wildfires totaled over $16 billion in the United States in 2020, with over 10,000 structures damaged or destroyed in California alone (NOAA, 2021).

[3] Parcel-level risk is defined as the combination of the local wildfire hazard posed to a residential parcel and the vulnerabilities of people and property to that hazard. Parcel-level risk illustrates intra-community heterogeneity in risk and includes not only structural characteristics but also broader-scale contexts that may influence wildfire risk to households, such as general social vulnerability or determinants of landscape-level hazards such as proximity to wildland vegetation (Meldrum et al., 2022).

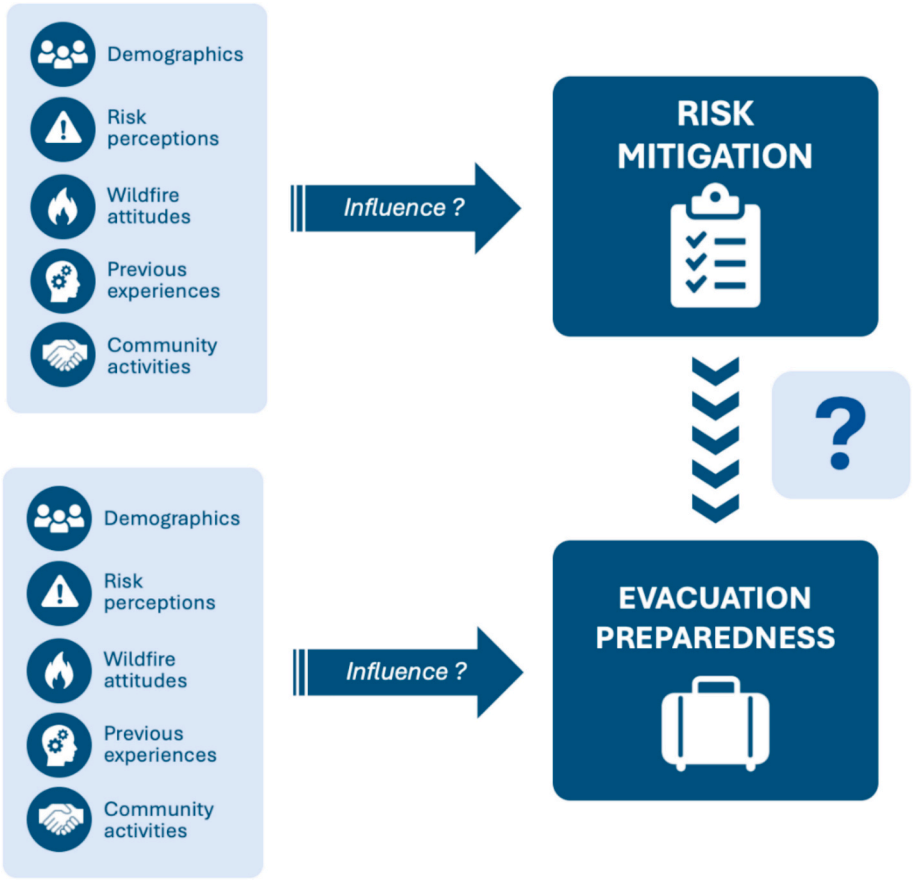

Fig. 1. Proposed conceptual model of the relationship between wildfire mitigation and evacuation preparedness, including potential types of factors hypothesized to influence each of them separately.

phases of the hazard cycle, defined in the disaster literature by Twigg (2004): mitigation and preparedness.[4] Mitigation refers to measures undertaken to limit the adverse impact of hazards/threats. Wildfire risk mitigation actions are meant to maximize the chances that a home will survive a wildfire. Preparedness in terms of evacuation refers to individuals' ability to effectively anticipate, respond to, and recover from the impacts of likely, imminent, or current disasters (Bosher et al., 2021). Pre-wildfire evacuation preparedness affects whether a household can ensure the safety of their family, pets, and valuable belongings during a rapid wildfire. For example, actions such as signing up for a wildfire evacuation notification system and identifying safe evacuation routes can give a household a better chance of surviving a wildfire.

2.1. Evacuation preparedness

During wildfires and other disasters, late evacuation decisions can lead to congested roadways, exposing individuals and first responders to more harm (Thompson et al., 2017). Therefore, most researchers have focused on how to improve evacuation decision-making during a wildfire event (Ahmad et al., 2023; Benight et al., 2004; Li, 2022; Sharma et al., 2024; McCaffrey and Winter, 2011). Past literature has shown that factors such as previous experience, risk salience, and receiving advice from neighbors, friends, and family can influence wildfire evacuation decisions (Mozumder et al., 2008; Strawderman et al., 2012; Toledo et al., 2018; Whittaker and Handmer, 2010; Whittaker et al., 2016). Kuligowski et al. (2020) demonstrate that simply having an evacuation plan can influence a household's decision to evacuate during a wildfire. While the literature has been primarily focused on evacuation decision making during a wildfire event, less focus has been on understanding what leads to evacuation preparedness before an event occurs.

While recent studies have provided insights into the decision-making processes surrounding evacuation during wildfires (Ahmad et al., 2023; Benight et al., 2004; Li, 2022; McCaffrey and Winter, 2011; Sharma et al., 2024), it is important to note that evacuation behavior can vary significantly across countries and communities. Approximately half of the wildfire preparedness research published since 2010 has been conducted outside the United States, with a strong focus on Australia and Canada (McCaffrey, 2015). A survey of Canadian WUI community members found that around 32–34 % of respondents reported that they were very/mostly prepared to evacuate (Wambura and Wong, 2024). On the other hand, the survey data we analyze below indicate between 64 % (Goolsby et al., 2022) and 79 % (Goolsby et al., 2023b) of the households within project areas located around the western United States have an evacuation plan. Given that social and institutional norms can strongly influence proactive risk-reduction behaviors (Brenkert–Smith et al., 2006; Howe et al., 2018; McCaffrey et al., 2012), findings from one country or region may not generalize to other contexts. This is especially important when trying to understand the evacuation preparation actions taken by households in countries with differing evacuation policies.

One significant difference between countries' evacuation policies stems from their attitudes toward stay-and-defend approaches. Starting in 2011, the United States adopted the "Ready, Set, Go!" approach to prepare for wildland fires, encouraging households to prepare to evacuate before a wildfire and to evacuate early when given notice (International Association of Fire Chiefs (IAFC), 2020; Wildland Fire

[4] An illustration of the phases of the disaster cycle can be found in Alexander (2002) "Principles of Emergency Planning and Management".

Action Guide, 2024). Yet, in Australia and historically in the United States, the strategy of households staying and defending their property during a wildfire was commonplace.[5] Therefore, some articles concerning wildfire evacuation behavior have focused on understanding why households intend to stay and defend their properties (Edgeley and Paveglio, 2019; McLennan et al., 2015; McNeill et al., 2015; Paveglio et al., 2015; Penman et al., 2013; Strahan et al., 2019). Although this paper does not investigate households' attitudes toward stay-and-defend, these attitudes may be pertinent to understanding the relationship between proactive mitigation and evacuation decisions. McCaffrey et al. (2018) point to differences in two classes of residents: those who believe in the effectiveness of evacuation as a risk mitigation strategy, and those who prefer to stay and defend their homes in the event of a wildfire as they believe they know best how to prepare their property for a wildfire. Paveglio et al. (2014) examine how individuals who plan to stay and defend their home differ in mitigation and fuel reduction activities on their property from households who plan to evacuate. They find that residents in Northern Montana who intend to stay and defend have completed higher rates of forest thinning on their properties. Stasiewicz and Paveglio (2021) further provide evidence that rural U.S. households often support staying and defending their homes and are more likely to complete more mitigation actions. These findings suggest that, in some contexts, households view these actions as related. This literature demonstrates a relationship between mitigation actions and evacuation intentions; however, no study has evaluated a causal relationship between mitigation and evacuation preparation actions. Our research evaluates how evacuation preparation actions, performed long before a disaster, are linked with other proactive measures implemented to reduce wildfire risk to residents in the western United States.

2.2. Wildfire risk mitigation

Fire scientists, with the help of experiments, fire models, and post-fire studies, have shown that the likelihood of a home igniting in a wildfire is determined by a variety of attributes of the structure and its surrounding area (Cohen, 2000; Maranghides et al., 2013; Penman et al., 2018). Improving defensible space, which consists of clearing vegetation and other flammable materials near the structure, is widely recognized as effective at reducing risk of structure damage or loss (Penman et al., 2018; Syphard et al., 2014). Other activities, such as structural hardening (i.e., improving the fire resistance of the home-building materials), are effective in reducing the probability of a home being destroyed in a wildfire (Syphard et al., 2017). Meldrum et al. (2022) demonstrate that even relatively small mitigation actions by residents before the 2020 East Troublesome Fire in the state of Colorado influenced the chance their home was destroyed by wildfire. Recognizing the benefits of these mitigation actions in reducing the catastrophic damage caused by wildfire, a rich literature has investigated the human dimensions of household risk mitigation behaviors (Brenkert–Smith et al., 2006; McCaffrey et al., 2012).

A comprehensive body of literature has shown how factors such as risk salience, risk perception, information, and social considerations are crucial in determining homeowners' wildfire mitigation behaviors (Bayham et al., 2022). Brenkert–Smith et al. (2006) develop insights into the complex social aspects of homeowners' wildfire mitigation decisions. They find that talking with other community members about fire and homeowners' perceptions of the topography near their residence are important factors in determining individuals' engagement in mitigation actions. Others find that both information from local community members regarding wildfire risk and the perceived effectiveness of mitigation are highly correlated with risk mitigation actions of households throughout the WUI (Brenkert-Smith et al., 2012; McFarlane et al., 2011). There is reason to believe that risk perceptions and mitigation actions may have a complex interconnected relationship; therefore, Champ et al. (2013) and Meldrum et al. (2019) use different approaches to model this joint determination of mitigation and risk perceptions. Using simultaneous models, Champ et al. (2013) find that perceived risk and wildfire risk-mitigating behaviors are jointly determined, while Meldrum et al. (2019) capture feedback and dual-directional interactions between mitigation actions and risk perceptions. Our research builds on the extensive literature around mitigation decisions to a relatively unknown area of how these decisions affect household evacuation preparedness.

3. Data sources and descriptive statistics

Our analysis leverages a unique dataset of household survey data paired with parcel-level rapid wildfire risk assessments conducted by a trained assessor. These data come from a series of projects implemented by the Wildfire Research (WiRē) Center[6] in partnership with wildfire education organizations (e.g., fire departments, regional wildfire councils, state forest services, non-governmental organizations) in select WUI communities in five Western U.S. states (Colorado, Utah, Washington, New Mexico, and Wyoming) between 2021 and 2023 (The Wildfire Research Center, 2024).[7] All projects followed a standardized data collection procedure involving a parcel-level wildfire risk assessment for all residential properties within a study community and a household survey delivered to the mailing address on record for all assessed properties (described in more detail in Champ et al., 2021). Study communities were selected to inform practitioner organizations' programmatic needs; all communities were considered as facing high wildfire risk, but they varied in many ways, including exposure to wildfire hazards, extent of existing wildfire education and outreach programs, and existing levels of property- or community-level mitigation efforts.[8]

3.1. WiRē parcel-level rapid wildfire risk assessment data

The parcel-level conditions are reflected in the WiRē rapid wildfire risk assessment. The rapid assessment is not a detailed on-site assessment of parcel-level wildfire risk. It is a quick assessment conducted from the road and includes critical location, property, and structure attributes that contribute to its overall wildfire risk.[9] The measure of household mitigation used in this study is based on a subset of the parcel-level characteristics collected in the WiRē rapid wildfire risk assessment. The attributes we include in the analyses here are those that residents can reasonably exert direct control over: proximity to close vegetation around a home, proximity to combustible materials (i.e. propane tanks or log piles), combustibility of attachments (i.e. decks or fences), siding material, and roof material. Each of these elements could feasibly be manipulated by homeowners to lower their homes' wildfire risk.

3.2. Household survey

WiRē developed the household survey in collaboration with partner

[5] Mandatory evacuation orders are now common in the United States; however, in other contexts, such as Australian bushfires, evacuation is not mandatory, and households often decide not to evacuate their residence and instead actively defend their homes against wildfires.

[6] https://wildfireresearchcenter.org/

[7] A map of these WiRē communities can be found in the Appendix Figure A1.

[8] We include only households that have both a parcel-level wildfire risk assessment and a household survey completed and are in a community with at least ten observations.

[9] These characteristics include aspects such as the topography of a parcel, distance to combustible materials, or the building materials of a home or structure.

organizations to provide insight into homeowners' wildfire preparedness actions, risk mitigation behaviors, and wildfire attitudes. The household surveys were administered by the practitioner organizations in each of the WUI communities using a modified Dillman approach involving four mailings: a letter introducing the project, a survey packet including a postage-paid return envelope, a reminder/thank you postcard, and a second survey packet (Dillman, 2011). The household survey includes questions about wildfire evacuation preparation, wildfire mitigation activities, characteristics of respondents' properties, and risk perceptions about wildfire. A summary of the WiRē household survey used can be found in the project specific data reports (Brenkert-Smith et al., 2023; Goolsby et al., 2022; Goolsby et al., 2023a; Goolsby et al., 2023b; Goolsby et al., 2024; Meldrum et al., 2024). The respondent's age, income, education, employment, tenure, previous experience with wildfire, previous experience with evacuation, and wildfire risk perceptions are also collected in the questionnaire. These survey responses are then paired with data collected from the rapid wildfire risk assessment.

Table 1 summarizes the measures of wildfire risk mitigation and evacuation preparedness. Panel A describes the household survey questionnaires and wildfire risk assessment mitigation attributes. We use these attributes to create two standardized indices for a household's mitigation: one based on the rapid assessment, and one based on the household survey. As shown by Meldrum et al. (2015), there may be a gap between wildfire risk perception reported by respondents in the household survey and those reported by a trained assessor conducting the wildfire risk assessment. In either measure, a higher mitigation score represents a household that has completed more mitigation.

Panel B describes the evacuation preparation household survey questions along with the standardized index for each. Evacuation preparedness may look different depending on where a person lives or the demographics of a household. For example, communicating with a neighbor and making a plan to protect pets or valuables may be extremely important to some. For others, signing up for notifications or identifying safe evacuation routes may be more significant. Therefore, using an index of all the evacuation preparedness variables can provide a broad picture of household preparedness for evaluating homeowners across many regions. A higher evacuation score represents a household that has completed more evacuation preparation actions. Table 2 provides descriptive statistics on resident characteristics, wildfire-related experiences and activities, and wildfire risk perceptions.

4. Methodology

As previously noted, when addressing wildfire risks, homeowners can complete a variety of proactive actions to protect themselves and their properties. In this paper, we develop a model to understand the substitutability or complementariness of these actions. As these proactive actions may not be independent, we use an instrumental variable approach to identify any causal relationship between mitigation actions and evacuation preparedness. This identification strategy allows us to estimate a causal relationship between wildfire risk mitigation and evacuation preparedness despite the data being cross-sectional.

Estimating the impacts of mitigation activities on a household's evacuation preparedness using a standard ordinary least squares (OLS) regression framework may provide biased estimates due to two possible

Table 1
Description of wildfire mitigation and preparedness attributes collected by the rapid assessment (RA) and household survey (HS).

Variable Name	Item Text	Attribute Level	Obs. RA	Obs. HS
Panel A: Wildfire Risk Mitigation				
Comb Attachment	Does your home have a combustible balcony, deck, porch, or fence attached to the structure?	No	337	631
		Yes	2122	1765
Close Combust	What is the closest distance from your home to combustible items other than vegetation such as lumber, firewood, a propane tank, hay bales, flammable outdoor furniture, or other materials that could easily ignite?	More than 30 ft	333	1050
		5–29 ft	599	787
		< 5 ft	1527	246
Close Veg	What is the closest distance from your home to overgrown, dense, or unmaintained vegetation?	More than 100 ft	72	733
		30–100 ft	360	824
		5–29 ft	1093	443
		< 5 ft	934	83
Roof type	Does your home have any of the following roofing materials?	Tile, metal, or asphalt	2334	2037
		Wood	125	46
Side type	Does your home have any of the following exterior siding materials?	Stucco, cement, brick, stone, or other non-combustible	664	708
		Log or heavy timber	122	175
		Wood, or vinyl siding	1673	1200
Mitigation Score	Standardized score home wildfire risk mitigation actions	Mean = 0, s.d. = 1	−2.14-3.48	−2.91-2.25
	Item Text	Attribute Level	Mean	s.d.
Panel B: Evacuation Preparedness				
Evacuation Plan	Do you have an evacuation plan for your household?	1 = yes 0 = no	0.74	0.43
Evacuation	Have you completed any of the following actions...			
Preparation	1. Identify how I will be notified about an evacuation	1 = yes 0 = no	0.60	0.50
Questions:	2. Sign up for a wildfire evacuation notification system	1 = yes 0 = no	0.61	0.29
	3. Identify safe evacuation routes (multiple, if possible)	1 = yes 0 = no	0.73	0.45
	4. Identify a location that my household will evacuate to	1 = yes 0 = no	0.53	0.50
	5. Identify what to take and what to leave behind during an evacuation	1 = yes 0 = no	0.59	0.50
	6. Discuss evacuation with my neighbors	1 = yes 0 = no	0.22	0.42
	7. Create a checklist for steps to take before evacuating	1 = yes 0 = no	0.25	0.43
	8. Identify a place to stay during a long-term evacuation (i.e., more than a few days)	1 = yes 0 = no	0.54	0.50
Evacuation Score	Standardized score of evacuation preparedness	−1.78 − 1.44	0	1

Notes: Data are from wildfire risk assessments and household surveys conducted by multiple partners and supported by the Wildfire Research Center (WiRē) in select communities across five western states from 2021 to 2023. Panel A describes the five mitigation attributes we study. Responses from the wildfire risk assessment (RA) and household survey (HS) are reported in the right columns. The mitigation score is created as a weighted index of these five attributes. Weights can be found in Table A5. Panel B describes the survey questions on evacuation preparedness and the standardized evacuation score (Rapid assessment n = 2459, Household Survey n = 2083, Evacuation n = 2459).

Table 2
Descriptive statistics.

Variable Name	Variable Description	Attribute Levels	Mean	s.d.	Obs.
Age	Age of respondent	22–98	64.8	12.2	2368
Male	Gender of respondent	1 = male 0 = female & other	0.62	0.49	2352
Income	Income brackets from 0 to $200,000+	0 = Less than 15,000 1 = 15,000-24,999 2 = 25,000-34,999 3 = 35,000-49,999 4 = 50,000-74,999 5 = 75,000-99,999 6 = 100,000-149,999 7 = 150,000-200,000 8=$200,000+	5.85	1.25	2086
College	College completion status of respondent	1 = yes 0 = no	0.81	0.40	2363
Employ	Employment status of respondent				2397
	Full-time	1 = yes 0 = no	0.34	0.47	
	Part-time	1 = yes 0 = no	0.10	0.30	
	Unemployed	1 = yes 0 = no	0.02	0.13	
	Retired	1 = yes 0 = no	0.54	0.50	
Talk Fire	Talked wildfire issues with neighbor	1 = yes 0 = no	0.63	0.48	2435
Evacuated	Previous evacuation experience	1 = yes 0 = no	0.30	0.46	2442
Fire	Previous experience with wildfire rear home				2455
	More than 10 miles away	1 = yes 0 = no	0.19	0.39	
	2–10 miles away	1 = yes 0 = no	0.45	0.50	
	< 2 miles away	1 = yes 0 = no	0.22	0.41	
	Fire on property	1 = yes 0 = no	0.02	0.15	
	Not sure	1 = yes 0 = no	0.12	0.32	
chance1	Over 50 % chance of wildfire on property within 12 months	1 = yes 0 = no	0.17	0.38	2402
chance2	If wildfire is on property, over 50 % chance wildfire destroys or severely damage home	1 = yes 0 = no	0.48	0.50	2405
Tenure	Years lived on the property	-1 - 80	15.70	13.13	2310
Occupy Full-time	Resident lives at the property for more than 9 months a year	1 = yes 0 = no	0.85	0.36	2429
Neighbor Actions	Neighbors actions influence wildfire risk	0 = All neighbors have taken action to 4 = No neighbors have taken action	1.25	0.76	2382
Source Useful	Use local sources for wildfire risk information	1 = not at all useful to 5 = extremely useful	3.87	0.88	1649
Activities6	Participated in a community wildfire preparedness activity	1 = yes 0 = no	0.32	0.47	2419
Activities9	Met with wildfire professional about property's risk	1 = yes 0 = no	0.31	0.46	2422
Mitigation Activities	Made my home more fire resistant (ex. replaced roofing, siding, added hardscaping)	1 = yes 0 = no	0.32	0.47	2398
Financial Barriers	Financial barriers prevent you from implementing actions to reduce risk of wildfire on property	1 = yes 0 = no	0.32	0.47	2381
Mitigation Beliefs	Belief physical characteristics of home contribute to wildfire risk	2 = alot, 1 = somewhat, 0 = not at all	0.83	0.67	2409

sources of endogeneity. First, there is potential omitted variable bias, in which we do not observe some characteristics about a household that are correlated with both mitigation and evacuation preparedness. Second, there is possible simultaneity in decisions about mitigation actions and evacuation preparation actions. Fig. 1 illustrates how a variety of demographic and social factors may influence both mitigation and evacuation preparedness at the same time. Similarly, wildfire education programs often advocate for households to complete both mitigation and evacuation preparation actions. Because our data are cross-sectional, we do not observe whether mitigation or evacuation preparedness actions were performed first. Therefore, a cross-sectional OLS regression would not provide causal estimates, as the regression coefficient may capture feedback on how evacuation preparedness might affect mitigation. However, using an instrumental variable approach removes concerns about endogeneity and is able to isolate a causal relationship between mitigation and evacuation preparedness.

To address this potential endogeneity, we include two instrumental variables for the mitigation model. In order for these instruments to be valid, they need to satisfy the relevance and excludability restrictions (Angrist and Pischke, 2009; Wooldridge, 2010). Our first instrument represents financial barriers to complete mitigation. This variable captures whether a household reported that financial costs were a factor preventing them from reducing wildfire risk on their property. Mitigation actions, such as changing the structure or materials of a home, removing vegetation, or removing other combustible materials, pose a significant financial cost to homeowners (Penman et al., 2016). Therefore, households who report financial barriers plausibly have not completed as many mitigation actions, ensuring our instrument is relevant to our endogenous variable mitigation. However, unlike mitigation actions, most evacuation preparation actions pose minimal financial costs.[10] Therefore, using household financial barriers as our main instrument should be plausibly exogenous to evacuation preparation actions.

The second instrumental variable measures whether a household believes the physical characteristics of their home contribute to their property's wildfire risk. This question is a proxy for a homeowner's belief in the efficacy of wildfire mitigation actions. If a homeowner does not believe the characteristics of their home impact their wildfire risk, it is plausible they would not implement mitigation actions to reduce their wildfire risk. These beliefs about mitigation efficacy should not affect a homeowner's beliefs about the efficacy of wildfire evacuation preparedness, however, these variables may be correlated with other unobserved characteristics of a homeowner's attitudes. We run the following specification using the first and both instruments.

Our two-stage least squares (2SLS) estimating equations are as follows:

First Stage:

$$Mitigation_{ic} = \beta_1 Z_{ic} + \beta_2 X_{ic} + \delta_c + \epsilon_{ic} \quad (1)$$

Second Stage:

[10] Consistent with this notion, appendix Table A3 demonstrates there is no significant difference in evacuation planning across income levels in our data.

$$Evac\ Score_{ic} = \gamma_1 \widehat{Mitigation}_{ic} + \gamma_2 X_{ic} + \delta_c + \upsilon_{ic} \quad (2)$$

In the first stage, we regress mitigation on the instruments, controls, and community fixed effects. Using the predicted values from our first stage, we estimate our second-stage equation. $Mitigation_{ic}$ represents the standardized mitigation score completed by a household i in a community c. $Evac\ Score_{ic}$ represents a standardized score of a household's evacuation preparedness. Table 1 demonstrates the construction of these standardized scores. Z_{ic} represents the instruments we use to predict wildfire risk mitigation. X_{ic} is a vector of controls that include factors we expect to impact mitigation or evacuation preparation decisions.[11] We include community-level fixed effects δ_c, and our error terms are ε_{ic} and ν_{ic}. $\widehat{Mitigation}$ represents the predicted values from our first stage estimates used in our second stage.

The parameter γ_1 is the coefficient of interest as it represents the local average treatment effect (LATE) of mitigation actions on evacuation preparedness. If $\gamma_1 > 0$, this represents that households that implement more mitigation are more likely to have completed more evacuation preparation actions. This indicates that mitigation actions are complements to evacuation preparedness. If $\gamma_1 < 0$, households that complete mitigation actions are less likely to complete evacuation preparation actions, indicating that households are willing to substitute these wildfire risk-reducing actions.

We estimate the model using the mitigation score created from the household survey responses and the mitigation score created from the wildfire risk assessment. As households have a vast number of choices for both mitigation and evacuation preparation actions, using these indices captures a wide picture of household behavior. However, it is plausible that specific mitigation actions may be more or less complementary to evacuation preparedness. Therefore, we apply a similar method to evaluate specific mitigation actions that are included in the overall mitigation score.[12] For these regressions, we focus solely on self-reported survey data to concentrate on the perceived mitigation characteristics of a homeowner. Using data reported by the individual gives us a better understanding of how the individual views their mitigation level on their property and how that potentially relates to their evacuation preparedness.

5. Results

5.1. Predictors of evacuation preparation

First, we examine some factors that may contribute to the evacuation preparedness of individuals in the WUI. Previous literature has shown that demographics, risk perceptions, and previous experiences with wildfire are predictive of household evacuation behaviors (Whittaker et al., 2016; Mozumder et al., 2008; Strawderman et al., 2012; Toledo et al., 2018; Kuligowski et al., 2020). Table 3 describes what percentage of respondents have an evacuation plan based on a variety of demographic or personal characteristics. Only 30 % of the households report previous evacuation experience yet 75 % of households report having an evacuation plan (Table 2). Households having direct experience with wildfires in the past are more likely to have an evacuation plan at the time of the survey (Table 3). Individuals who have evacuated in the past are 18 percentage points more likely to have an evacuation plan than those who have not evacuated in the past. Similarly, households that had a wildfire close to their property in the past are more likely to have an evacuation plan. Table 3 also demonstrates that risk perceptions are correlated with evacuation preparedness. Residents who believe there is a higher chance of a wildfire impacting their property in the next 12 months were more likely to have a plan to evacuate. Finally, we do not find any meaningful differences in evacuation planning related to demographics such as employment, income, or gender.[13]

Table 3
Percent of households with an evacuation plan by explanatory variables.

Variable	Responses	Have an Evacuation Plan	
		Percent	χ^2 p-value
Evacuated in the Past	No	68 %	$< 0.001^{***}$
	Yes	87 %	
Experience with Wildfire	Not Sure	60 %	
	More than 10 miles away	70 %	$< 0.001^{***}$
	2–10 miles away	75 %	
	< 2 miles away	82 %	
	Fire on Property	72 %	
Risk Perception (Chance of wildfire on property in next 12 months)	0–30 %	73 %	$< 0.05^{*}$
	40–60 %	79 %	
	70–100 %	82 %	

Notes: Table displays significant differences in households' evacuation planning by previous experience with wildfire and risk perceptions. ($^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$, $n = 2442$).

5.2. Instrumental variable results

Table 4 presents the results of our 2SLS and OLS regressions where Panel A and Panel B represent the first and second-stage regressions respectively. We run separate models using mitigation data from the wildfire risk assessment (columns 1–3) and the self-reported household survey responses (columns 4–6). In this table, we compare results when using one instrument (financial barriers; columns 1 and 4), using both instruments (financial barriers and mitigation efficacy; columns 2 and 5), and standard OLS framework (columns 3 and 6).

The OLS estimates from the model find a small but significant positive relationship between mitigation and evacuation preparedness. However, due to concerns about endogeneity of these OLS specifications, the estimates are likely to be biased. Interpreting the naive OLS estimates, we would conclude that there is a positive relationship between wildfire risk mitigation and evacuation preparedness; however, this relationship is substantively inconsequential. Although significant, the magnitude of the estimates provides no meaningful insights. When correcting this bias, our second-stage coefficients from our instrumental variable specifications provide evidence of a meaningful relationship between wildfire risk mitigation and evacuation preparedness. The preferred specifications include two instrumental variables (columns 2 and 5) as the inclusion of a second instrument increases the first stage F-statistics and reduces the biases from a weak instrument. The coefficient estimate of γ_1 0.56 (column 2) represents that a one standard deviation increase in a household's wildfire risk assessment mitigation score results in a 0.56 standard deviation increase in a household's evacuation preparation score. For example, the relative size of this coefficient represents that if a household were to change the distance to close vegetation around their home from 5 to 30 ft to over 100 ft, this would result in a household completing one more evacuation preparation action. This demonstrates the complementary nature of mitigation and evacuation

[11] These controls consist of age, gender, college, employment status, income, tenure, full time occupancy, previous experience with wildfire and evacuation, perceived wildfire risks, whether a household communicates with neighbors, whether a household has gone to community meetings, and if a household has met with a wildfire professional.

[12] The specific elements of wildfire risk mitigation we evaluate include distance to close vegetation, distance to combustible materials, combustibility of house attachments, and combustibility siding. These elements are detailed in Table 1, Panel A.

[13] These results are shown in Appendix Table 3 A. There is a small statistical difference between unemployed and employed individuals ($p = 0.02$). However, as shown in Table 2, these individuals make up only 2 % of our sample ($n = 44$) and are controlled for in our analysis.

Table 4
IV results from using wildfire risk assessment and household survey mitigation measures compared to ordinary least squares.

	Coef.					
	Wildfire Risk Assessment			Household Survey		
	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)
Panel A: First Stage (Dep = Mitigation Score)	(1)	(2)	(3)	(4)	(5)	(6)
Financial Barriers	−0.12*	−0.10*		−0.29***	−0.24***	
	(0.047)	(0.046)		(0.042)	(0.043)	
Mitigation Beliefs		−0.15**			−0.36***	
		(0.042)			(0.041)	
Controls and Community Fixed Effects	Yes	Yes		Yes	Yes	
Panel B: Second Stage	(Dep = Evacuation Score)					
Mitigation Score	0.82	0.56*	0.08*	0.35	0.23*	0.07*
	(0.514)	(0.242)	(0.031)	(0.268)	(0.093)	(0.026)
Controls and Community Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effect Groups	25	25	25	25	25	25
Observations	1538	1538	1538	1538	1538	1538
F Statistic	8.5***	16.1***	–	32.7***	71.2***	–

Notes: Table shows first and second-stage results of instrumental variable (IV) regression evaluating the impact of mitigation on evacuation preparedness. Controls include age, gender, employment status, college education, income, household tenure, whether a household is a full-time resident, whether a household has evacuated in the past, how close a previous fire has gotten to their property, the household's perceived chances of a fire on their property in the next 12 months, and if a wildfire reaches their property the chance their home would be destroyed, whether a household talks about wildfire with their neighbors, whether they have attended a wildfire community meeting, whether they have met with a wildfire professional, the perception of their neighbor's mitigation actions, as well as a professional assessment of whether their home has more than one road to evacuate on. Standard errors are clustered at the community level. *p<0.5; **p<0.01; ***p<0.001.

preparedness.

The second stage estimates for γ_1, when using the wildfire risk assessment mitigation data (column 2), are larger than the estimates using the self-reported mitigation data (column 5). Differences in these estimates may come from a variety of factors. As shown by Meldrum et al. (2015), self-reported and parcel-level rapid wildfire risk assessment mitigation data collected by a trained assessor do not perfectly align. Specifically, residents often report less risky parcel-level conditions than a trained assessor. The difference in our estimates could come from these differing perspectives of mitigation. Finally, the first stage F-statistics are much stronger when using self-reported mitigation scores, demonstrating that the instruments are more strongly correlated with their self-reported mitigation scores compared to the wildfire risk assessment mitigation scores.

First, we test Staiger and Stock's (1997) rule of thumb in which the F-statistic should be greater than 10 for an instrument to be sufficiently strong. The F-statistics range from 8.5 to 71.2. Although the first column F-statistic in Table 4 is lower than ten, we perform the Anderson-Ruben test for weak instruments and conclude our second stage estimates are statistically different from zero (Anderson and Rubin, 1949). Second, we estimate some alternative specifications related to the exclusion restriction assumption of the selected instrument. This assumption requires that the instrument does not directly affect the evacuation preparedness of households. This assumption cannot be directly tested using the data as we do not observe the correlation between our instruments and the error term υ_{ic}. We may be concerned that our instruments are correlated with overall pessimism about wildfire risk and therefore wildfire evacuation. Households could respond that they encountered some financial barriers to completing mitigation actions; however, they truly are demonstrating that they have not thought much about their wildfire risk. The survey also asks questions about other barriers that may prevent a household from completing some mitigation. One of these questions asks if mitigation is a "low priority to me". We run our specifications again excluding individuals who state that wildfire mitigation is a low priority to try to exclude households who may be pessimistic about all wildfire-related activities. The results do not differ from our preferred specification. Third, we test for over-identification using a Sargan test and fail to reject the null hypothesis that the instruments are valid at the 10 % significance level for all columns with multiple instruments (Sargan, 1958).

In the Appendix (Table A1), we present the coefficients of our controls within our first and second-stage estimates. These controls demonstrate what other characteristics are correlated with mitigation or evacuation preparedness. In the first stage, the perceived conditional probability of a home being destroyed in a wildfire (chance2) is statistically significant in predicting a home's self-reported mitigation score from the household survey. Additionally, having a college education, meeting with a wildfire professional, and mitigation activities of a neighbor are correlated with a household's mitigation score. This is consistent with the findings of Meldrum et al. (2019), which show mitigation and perceived wildfire risk are jointly determined. Along with household mitigation actions increasing a household's evacuation preparedness, we see that previous experience with an evacuation, college education, communication with your neighbors about wildfire, participation in community wildfire activities, and meeting with a wildfire professional are all significantly correlated with evacuation preparedness.

5.3. *Individual mitigation results*

Furthermore, we explore how each individual mitigation action may contribute to preparing households to evacuate. In Table 5, instead of using an overall score for mitigation measures from five different mitigation actions, we focus on each aspect of mitigation separately. The models in Table 5 only use mitigation data from the self-reported household survey. Similar specifications using the wildfire risk assessment mitigation attributes can be found in the Appendix (Table A2). Column (1) represents households creating defensible space around their property, Column (2) represents moving combustible materials farther away from their home, Column (3) represents whether a home has combustible attachments, and Column (4) represents whether a home has non-combustible siding.[14]

Financial barriers seem to be a major deterrent to risk mitigation

[14] We choose not to include the type of roof materials as an individual attribute of mitigation to examine. This is because having a combustible roof is relatively uncorrelated with the instruments we use across specifications, biasing our results.

Table 5
IV results from household survey individual mitigation attributes on evacuation preparedness.

	Dependent Variable			
Panel A: First Stage	Close Veg	Close Combustibles	Attached Combustibles	Combustible Siding
	(1)	(2)	(3)	(4)
Financial Barriers	−0.11**	−0.11*	−0.07**	−0.07**
	(0.031)	(0.033)	(0.021)	(0.015)
Mitigation Beliefs	−0.11**	−0.04	−0.11***	−0.17***
	(0.036)	(0.032)	(0.017)	(0.030)
Controls	Yes	Yes	Yes	Yes
Panel B: Second Stage	Dependent Variable: Evacuation Preparedness			
Mitigation Attribute	0.70*	1.01	0.76*	0.48*
	(0.295)	(0.648)	(0.276)	(0.213)
Controls	Yes	Yes	Yes	Yes
Fixed Effects	Community	Community	Community	Community
Fixed Effect Groups	25	25	25	25
Observations	1538	1538	1538	1538
F Statistic	9.9***	5.82	26.1***	64.3***

Notes: Controls include age, gender, employment status, college education, income, household tenure, whether a household is a full-time resident, whether a household has evacuated in the past, how close a previous fire has gotten to their property, the household's perceived chances of a fire on their property in the next 12 months, and if a wildfire reaches their property the chance their home would be destroyed, whether a household talks about wildfire with their neighbors, whether they have attended a wildfire community meeting, whether they have met with a wildfire professional, the perception of their neighbor's mitigation actions, as well as a professional assessment of whether their home has more than one road to evacuate on. Standard errors are clustered at the community level. *p<0.5; **p<0.01; ***p<0.001.

actions as reflected by the statistically significant first-stage coefficient estimates in all four columns of Table 5. Similarly, household beliefs on the efficacy of mitigation are relevant to whether a household has vegetation close to their house, whether their attachments are combustible, and whether their siding is combustible. In Columns 3 and 4, F statistics close to or well above the rule of thumb value of 10, demonstrate that our instruments are strongly correlated with whether a home's attachments and siding are combustible. However, the instruments seem to be less relevant to whether a household has vegetation or combustible materials close to their home (column 1 and 2). Results from Table 5 present a similar picture to those from Table 4. Three of the four individual mitigation actions are complementary to evacuation preparedness. This is consistent with the view that all else equal, individuals performing different types of mitigation actions are also better prepared for evacuation.

6. Discussion

This paper examined the relationship between households' wildfire mitigation efforts and their actions undertaken to prepare for evacuation. As our results show, residents are not substituting evacuation preparedness measures for mitigation measures; instead, household mitigation efforts complement their decisions to be more prepared to evacuate. While demonstrating the interconnected aspects of wildfire risk-reducing behaviors, this paper can provide some practical implications of our results for wildfire policy and practitioners. This relationship may validate those programs that have been effective in their joint messaging surrounding multiple proactive risk-reducing behaviors, encouraging households to both mitigate their properties and prepare for evacuation. Alternatively, organizations who typically work in their own respective area of wildfire mitigation or preparedness can benefit from reinforced messaging about other proactive risk-reducing behaviors.

While this complementary relationship may arise from wildfire practitioners jointly messaging about risk-reducing behavior, these results suggest the act itself of completing some risk-reducing behavior can help inspire a household to complete other risk-reducing actions. These results demonstrate a positive relationship, even when controlling for a variety of factors that have been shown to influence wildfire risk-reducing behavior (i.e., risk perceptions, previous experiences with wildfire, and engagement in community wildfire activities (Bayham et al., 2022; Brenkert–Smith et al., 2006; Kuligowski et al., 2020; McCaffrey et al., 2012; Whittaker et al., 2016)). Consistent with behavioral spillovers found in environmentally conscious behavior, completing one action can lead to households completing subsequent related actions (Carlsson et al., 2021; Goetz et al., 2024; Thøgersen and Crompton, 2009). We speculate that the act of completing risk-reducing activities may prompt positive behavioral spillovers into other proactive risk-reducing actions. Dolan and Galizzi (2015) suggest that information or action in one domain can have positive behavioral spillovers to another if these processes are linked by some underlying motive. In this context, it is plausible that mitigation and evacuation preparedness, which respectively reduce risk to property and risk to people, may be closely linked by some unobserved underlying motive to avoid damages from wildfire.

While this paper focuses on the directionality that mitigation behaviors affect evacuation preparedness, it is also plausible that there may be spillovers in the opposite direction. Due to the nature of our data, we do not have a strong enough instrument to test this hypothesis reliably. However, analyzing how increased evacuation preparedness could impact mitigation activities and their effects on risk aversion over time would be an excellent area of future research to validate the interconnectedness of these proactive decisions.

As with any study, the results are subject to some limitations imposed by the data and methodology used. While the dataset includes WUI communities across the western United States, the dataset is not representative of all western WUI communities. Further, the dataset only covers a three-year span in which experiences or salience of wildfire may have changed. Our specifications included fixed effects to capture cross-community variation. However, unobserved characteristics in these communities may make these findings less generalizable for all WUI communities in the western United States. Next, our instrumental variable methodology identifies only a local average treatment effect (LATE) (Imbens and Angrist, 1994). This effect can be interpreted as the marginal effect of individuals whose treatment outcome was changed by the variation in our instruments. Our estimates rely on barriers to or perceptions of wildfire mitigation actions; therefore, these estimates may not be generalizable to individuals with alternative barriers to complete mitigation or different populations. Finally, while the data we use describe mitigation characteristics of these parcels, we do not directly observe mitigation actions taken by the household. Our measures of mitigation from the household survey or rapid assessment could be consistent with well-performed mitigation actions by the household or a result of preexisting mitigation characteristics. For example, a household could be located far away from dense vegetation and originally built with a non-combustible roof. This would suggest that a household is very well mitigated against wildfire without any new mitigation actions taken by the household. This raises an important consideration when analyzing mitigation and evacuation preparedness tradeoffs. Do the existing conditions of a home's wildfire mitigation impact evacuation decisions? Or is it the act of completing mitigation actions themselves that affect evacuation preparedness? Further research would be beneficial in deciphering between these two rationales.

7. Conclusion

In conclusion, using an instrumental variable approach and a novel dataset, this paper investigates the relationship between mitigation efforts and evacuation preparedness among homeowners in the western United States. Due to the escalating threat of wildfires, a comprehensive strategy is needed to prepare and protect lives and property across WUI communities. This paper contributes to the rich literature on understanding decision-making surrounding proactive risk-reducing activities while being the first to demonstrate the complementary nature of these actions. We show how the completion of wildfire mitigation actions increases the likelihood of households undertaking more evacuation preparation measures. Understanding the determinants and interplay of evacuation and mitigation behaviors is imperative for guiding effective wildfire community outreach and policy interventions. These findings underscore the importance of integrated approaches that encourage both mitigation and preparedness to enhance community resilience to the growing threat of wildfires.

CRediT authorship contribution statement

Grant Webster: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Hannah Brenkert-Smith:** Writing – review & editing, Project administration, Funding acquisition, Data curation, Conceptualization. **Patricia A. Champ:** Writing – review & editing, Supervision, Project administration, Conceptualization. **James R. Meldrum:** Writing – review & editing, Supervision, Project administration, Conceptualization. **Kelly**

Wallace: Writing – review & editing. **Colleen Donovan:** Project administration, Data curation. **Carolyn Wagner:** Project administration, Data curation. **Christopher M. Barth:** Project administration, Data curation, Conceptualization. **Josh Kuehn:** Project administration, Data curation. **Suzanne Wittenbrink:** Data curation. **Christine Taniguchi:** Visualization.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Hannah Brenkert-Smith reports a relationship with Wildfire Research Center that includes: board membership. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Appendix

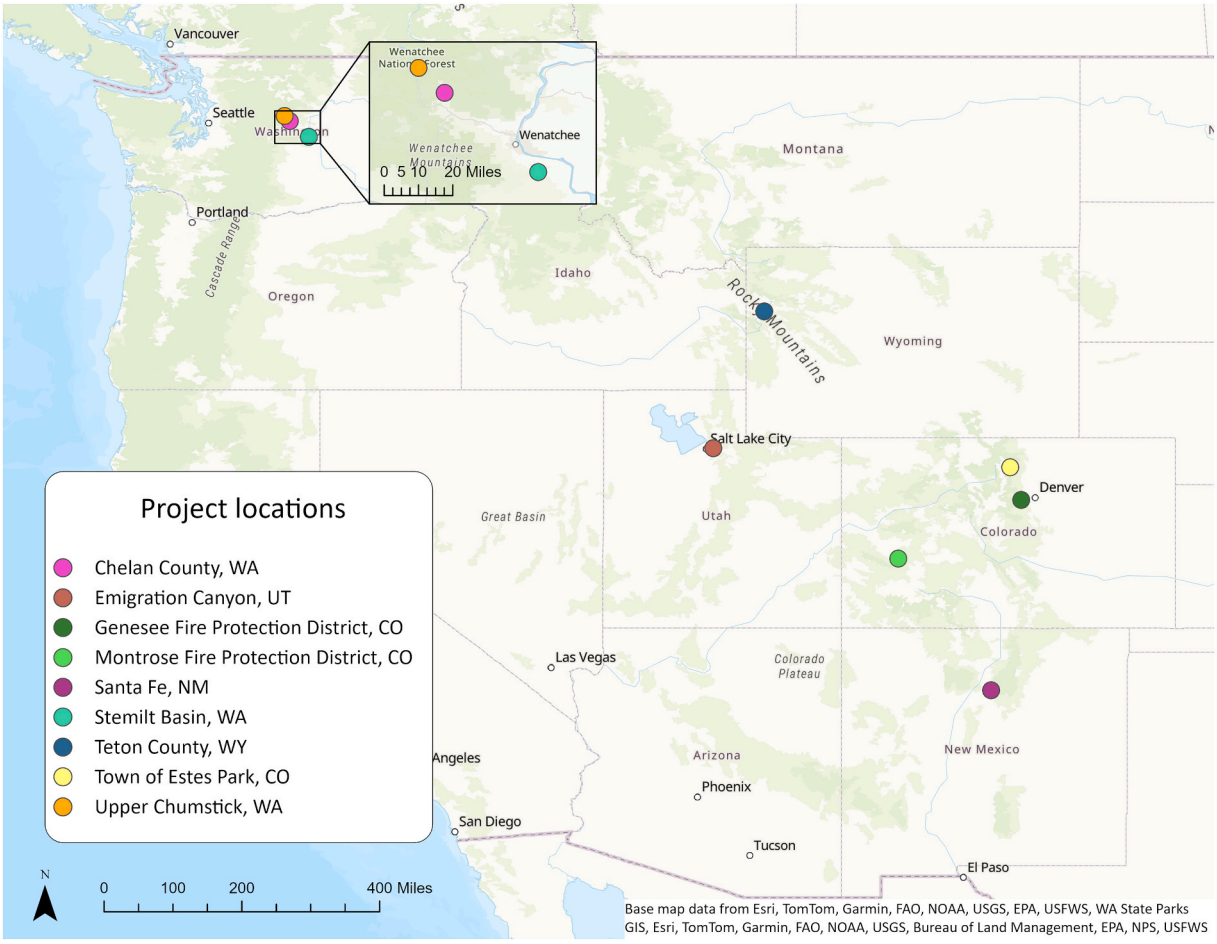

Fig. A1. Map showing points representative of Wildfire Research Center (WiRē) project locations in the Western United States. Inset map shows a zoom in on project locations in central Washington for clarity. Map image is the intellectual property of Esri and is used herein under license. Copyright © 2024 Esri and its licensors. All rights reserved. [color for online only].

Table A1 presents the full span of coefficients from our main estimation strategy in Table 4, Columns 2 and 5.

Table A1
Full IV results from using wildfire risk assessment and household survey mitigation measures on evacuation preparedness.

	Coef.	
	Wildfire Risk Assessment	Household Survey
Panel A: First Stage (Dep = Mitigation Score)		
Financial Barriers	−0.10*	−0.24***
	(0.046)	(0.043)
Mitigation Efficacy	−0.15**	−0.36***
	(0.042)	(0.041)
chance1	0.01	0.024
	(0.012)	(0.013)
chance2	−0.015	−0.054***
	(0.007)	(0.007)
Evacuated	0.026	−0.017
	(0.055)	(0.060)
Age	−0.005	0.038*
	(0.009)	(0.014)
Age^2	0.000	−0.0003*
	(0.000)	(0.0001)
College	0.10*	0.130**
	(0.047)	(0.044)
Male	0.067	0.022
	(0.051)	(0.041)
Income	0.009	0.038
	(0.020)	(0.025)
talkfire	0.015	−0.039
	(0.040)	(0.046)
Activities6	0.045	0.028
	(0.042)	(0.049)
Activities9	0.044	0.153**
	(0.039)	(0.050)
Neighbor Actions	0.079*	0.155***
	(0.037)	(0.038)
Tenure	0.004	−0.003
	(0.058)	(0.002)
Full-time	−0.005	0.26
	(0.050)	(0.078)
Panel B: Second Stage (Dep = Evacuation Score)		
Mitigation Score	0.56*	0.23*
	(0.242)	(0.093)
chance1	0.005	0.005
	(0.017)	(0.014)
chance2	0.003	0.007
	(0.010)	(0.009)
Evacuated	0.26***	0.276***
	(0.067)	(0.071)
Fire Distance: Not Sure	−0.27*	−0.258*
	(0.110)	(0.110)
Fire Distance: 2–10 miles away	0.005	−0.009
	(0.063)	(0.041)
Fire Distance: < 2 miles away	0.170*	0.140*
	(0.067)	(0.058)
Fire Distance: On property	−0.15	−0.188
	(0.129)	(0.100)
Age	0.009	−0.003
	(0.017)	(0.014)
Age^2	−0.0001	−0.000
	(0.0001)	(0.0001)
College	−0.210*	−0.183*
	(0.082)	(0.073)
Male	−0.059	−0.026
	(0.044)	(0.051)
Income	−0.015	−0.018
	(0.013)	(0.016)
talkfire	0.28***	0.300***
	(0.050)	(0.043)
Activities6	0.247*	0.266**
	(0.091)	(0.078)
Activities9	0.134*	0.124*
	(0.050)	(0.046)
Neighbor Actions	0.057	0.066
	(0.058)	(0.060)
Tenure	−0.000	−0.0002

(*continued on next page*)

Table A1 (*continued*)

	Coef.	
	Wildfire Risk Assessment	Household Survey
	(0.001)	(0.002)
Full-time	0.135	0.126
	(0.074)	(0.077)
Multiple Evacuation Roads	0.074	0.048
	(0.120)	(0.089)
Fixed Effects	Community	Community
Observations	1538	1538
F Statistic	16.1***	71.2***

Notes: Table shows extended first and second-stage results from Table 4 of IV regression evaluating the impact of mitigation on evacuation preparedness. Coefficients for employment status are in the regression but not included in the table because of insignificance. Coefficients on Fire distance are in reference to households who have not had a fire within 10 miles of their home. Standard errors are clustered at the community level. *p<0.5; **p<0.01; ***p<0.001.

Table A2
IV results from wildfire rapid assessment mitigation attributes on evacuation preparedness.

	Dependent Variable			
Panel A: First Stage	Close Veg	Close Combustibles	Attached Combustibles	Combustible Siding
	(1)	(2)	(3)	(4)
Financial Barriers	−0.06	−0.17	−0.04	−0.12*
	(0.042)	(0.033)	(0.033)	(0.025)
Mitigation Beliefs	−0.058	−0.009	−0.029	−0.20*
	(0.036)	(0.028)	(0.014)	(0.091)
Controls	Yes	Yes	Yes	Yes
Panel B: Second Stage	Dependent Variable: Evacuation Preparedness			
Mitigation Attribute	1.25*	6.15	2.75*	0.42
	(0.571)	(7.03)	(1.056)	(0.270)
Controls	Yes	Yes	Yes	Yes
Fixed Effects	Community	Community	Community	Community
Fixed Effect Groups	25	25	25	25
Observations	1538	1538	1538	1538
F Statistic	4.8	0.27	4.32	34.9***

Notes: Controls include age, gender, employment status, college education, income, household tenure, whether a household is a full-time resident, whether a household has evacuated in the past, how close a previous fire has gotten to their property, the household's perceived chances of a fire on their property in the next 12 months, and if a wildfire reaches their property the chance their home would be destroyed, whether a household talks about wildfire with their neighbors, whether they have attended a wildfire community meeting, whether they have met with a wildfire professional, the perception of their neighbor's mitigation actions, as well as a professional assessment of whether their home has more than one road to evacuate on. Standard errors are clustered at the community level. *p<0.5; **p<0.01; ***p<0.001.

Table A2 presents results from how individual wildfire rapid risk assessment mitigation attributes affect evacuation preparedness.

Table A3
Percent of households with an evacuation plan by income.

Variable	Responses	Have an Evacuation Plan	
		Percent	χ^2 *p*-value
Income	Less than $50 k	76.5 %	0.07
	$50-100 k	76.7 %	
	$100 k+	72.1 %	
Gender	Male	74.8 %	0.16
	Female	72.1 %	
Employment	Employed Full-Time	72.9 %	0.02*
	Employed Part-Time	72.9 %	
	Unemployed	54.5 %	
	Retired	75.7 %	

Notes: ($^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$).

Table A3 presents relationships between having an evacuation plan and other household characteristics.

Table A4
Correlations between mitigation and evacuation preparedness measures and other household characteristics.

Variable	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Mitigation Score	0	1	1	–	–	–	–	–	–	–	–
2. Evacuation Score	0	1	−0.05*	1	–	–	–	–	–	–	–
3. Age	64.8	12.2	0.02	−0.03	1	–	–	–	–	–	–
4. Male	0.62	0.49	−0.04	0.00	−0.08**	1	–	–	–	–	–
5. College	0.81	0.40	−0.04	−0.02	−0.06*	0.03	1	–	–	–	–
6. Risk Perception	0.17	0.38	−0.08***	0.06**	−0.09***	0.22***	−0.06**	1	–	–	–
7. Neighbor Mitigation	1.25	0.76	0.00	0.12***	−0.05*	0.01	0.03	−0.04	1	–	–
8. Evacuated	0.30	0.46	−0.11***	0.21***	0.12***	0.04	−0.06*	0.10***	0.01	1	–
9. Talk Fire with Neighbors	0.63	0.48	−0.01	0.21***	−0.02	−0.01	0.09***	0.12***	0.20***	0.07***	1

Notes: Table displays correlations between variables and significance levels using Spearman correlation coefficients. ($^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$). Note that results from more sophisticated analyses are strongly preferred over these. ($n = 1785$).

Table A4 presents correlation coefficients between the main dependent and control variables of our model.

Table A5
Weight of mitigation attributes used to create mitigation score variables.

Attribute	Level	Weight
Combustible Attachment	No	0
	Yes	100
Close Combustibles	More than 30 Feet	0
	5–29 Feet	40
	Less than 5 Feet	80
Close Vegetation	More than 100 ft	0
	30–100 Feet	50
	5–29 ft	75
	Less than 5 Feet	100
Roof Type	Tile, Metal, or Asphalt	0
	Wood	100
Siding Type	Stucco, Cement, Brick, Stone, or Other Non-combustible	0
	Log or Heavy Timber	35
	Wood or Vinyl siding	70
Maximum Total		450

Table A5 displays weights of survey attributes used to create the mitigation score variables.

Data availability

The data that support the findings of this study are protected by IRB data use standards and can only be used through a data sharing agreement with the WiRē Center.

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