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Exploring relationships between perceived suppression capabilities and resident performance of wildfire mitigations

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ABSTRACT

Increased wildfire activity has led to renewed interest in enhancing local capacity to reduce wildfire risk in residential areas. Local fire departments (LFDs) are often the first responders to rural wildfires. However, LFDs may also struggle to address service demands in the growing wildland urban interface, including increasing numbers of wildfire incidents and changes in area socio-demographics (e.g., aging populations) or culture (e.g., decreasing volunteerism, new residents). We used a mixed-mode survey (n = 770) to explore rural perceptions of various fire service organizations (FSOs), including LFDs, in wildfire-prone areas of northeastern Washington State, USA. We also explore relationships between perceptions of LFD capabilities or capacity (e.g., personnel, LFD ability to respond to private property during a wildfire event) and resident performance of eleven wildfire risk mitigation activities that contribute to home defense (e.g., development of a water supply, installing sprinklers). We found that study participants have relatively high levels of trust in LFD's to respond to a wildfire event on their properties. This trust is also slightly higher than the amount of trust placed in other FSOs (e.g., state, federal, private contractors). Respondents also largely understand that LFDs do not have sufficient capacity or capability to respond when wildfire events impact multiple private properties in their area. Trust in LFDs was significantly and negatively correlated with resident installation of fire-resistant siding, installation of sprinklers on their home, and placing firewood or lumber more than 30 feet (~9 m) from their dwelling. Similarly, respondents' perceptions of LFD capacity and capabilities was significantly and negatively correlated with purchasing a generator and stacking firewood more than 30 feet (~9 m) from their home. Our results suggest that perceptions of FSOs have the potential associations with resident performance of select wildfire mitigation actions (e.g., firewood placement, installation of non-flammable siding). However, they also were not significantly related to many other mitigations suggested for residents to complete as part of broader wildfire management strategies (e.g., driveway clearance, water supply establishment, safe zone creation).

1. Introduction

Fire service organizations (FSOs) such as local fire departments (LFDs) are important components of strategic wildfire risk reduction and suppression activities in the wildland urban interface (WUI)—areas characterized by the intermingling of residential development and fire-prone wildland vegetation. LFDs are typically responsible for protecting structures during wildfire events in the United States, while state and federal resources are mandated to respond to and appropriately manage wildland fire events (Madsen et al., 2018). LFDs can be important partners in promoting local adaptation to wildfire risk and often fill the role(s) of liaisons, initiators, and influencers in fire-prone communities through a number of initiatives, including: (1) campaigning for the adoption of the international WUI fire code; (2) establishing Firewise or FireSmart communities; and (3) providing education programs, information, or home risk assessments to property owners (Monroe et al., 2006; Jakes et al., 2011; Madsen et al., 2018; Mockrin et al., 2018). While LFDs are typically the first entities to engage in wildfire suppression in or near residential areas, few research efforts explore the complex ways that people perceive of LFD response capabilities in wildfire or bushfire management (McCaffrey et al., 2013; Stasiewicz and Paveglio, 2017, 2018; O'Halloran and Davies, 2020). LFD response capacities can be affected by documented decreases in volunteerism, emigration, and aging rural demographics (NFPA Journal, 2017; Evarts

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and Stein, 2019) in fire prone landscapes. LFDs also are faced with increasingly challenging fire conditions and a burgeoning demand for fire protection services as more people move into fire-prone areas (Martinuzzi et al., 2015; Radeloff et al., 2018). The extent to which WUI homeowners understand the trends in local fire response capabilities mentioned above, and how resident perceptions of LFD capabilities relate to their own mitigation efforts, may be important components of understanding wildfire adaptation in the WUI.

The actions residents take (or lack thereof) before a fire event have documented links to the risks and wildfire circumstances first responders encounter during wildfire response (Evans et al., 2015; Braziunas et al., 2020). For instance, some residents may expect their LFD to send resources to defend their property from a wildfire event regardless of whether the resident has fully prepared their property to be safely defended (McFarlane et al., 2011). This demonstrates a potential detachment between what residents expect from FSOs and their own personal responsibility for preparing their property for wildfire. Instances where residents and firefighters have divergent perceptions about what constitutes acceptable risk during wildfire response have led to conflict between fire professionals and residents surrounding firefighter response to properties (e.g., refusing to respond to a property due to firefighter safety concerns). These situations can impact local capacity to deal with wildfire risk by influencing ongoing trust or willingness to work with firefighting personnel during fire preparation, response, or post-fire recovery (Carroll et al., 2005; Cortner and Gale, 1990).

Complicating local wildfire management further are variable perceptions of LFDs and FSOs. Some studies suggest that LFDs can be perceived of as more of a "social club" than an actual fire department, which hints both at the legacy of fire departments serving as a hub of culture in rural U.S. communities and the potential stresses that occur when influxes of new residents bring different expectations about professional fire services to an area (Carroll et al., 2006; Rasch and McCaffrey, 2019). Residents and other fire professionals may view volunteer-based and/or rural fire departments as less specialized or well-trained when compared to their state, federal, or city-based counterparts (Evarts and Stein, 2019; MNP Consulting, 2017). High rates of success among fire suppression organizations in the United States has led some to worry about a "dampening effect," whereby residents believe that past suppression successes are indicative of future successes by firefighting organizations. This "dampening effect" may cause some residents to believe that FSOs will protect their property during a wildfire event regardless of whether they have performed personal mitigations on their property that make firefighter safety and success possible (Collins, 2005, 2008; McFarlane et al., 2012). Similarly, WUI LFDs are nested in a system of fire response that can be somewhat reliant on outside assistance from state and federal agencies to successfully manage a WUI wildfire. For instance, LFDs may lack the equipment, training, or personnel needed to respond to larger fire events. The demand for suppression resources during high-activity fire years in the United States can mean that state and federal assets are scarce (Stonesifer et al., 2017; Belval et al., 2020). Rural areas may be less likely to receive assets than more populated areas during times of high-fire activity and low-resource availability because population density is often implicit in the ways that fire agencies quantify risk and prioritize resource allocation (Abrams et al., 2017; Masarie, 2018).

Promoting private property mitigations within the home ignition zone (HIZ) is a major focus of national- and state-level directorates for addressing wildfire risk in the North American WUI (WFEC, 2014; FACC, 2019). Mitigations in the HIZ have been a predominant focus of social science research on resident adoption of wildfire adaptation practices. In the North American context and for the purposes of this study, the HIZ is the 100–200 foot (~30–61 m) area around a home where wildfire mitigations (e.g., defensible space, structure modifications, active firefighting) have a large influence on home ignition potential and subsequent damages (Cohen, 2000; Duerksen et al., 2011). The HIZ is often divided into three zones: (1) 0–30 feet (0–9.1 m), (2) 30–100 feet (~9–30 m), and (3) 100–200 feet (~30–61 m) from the exterior of the home. More recently, additional emphasis has been given to what many call HIZ 0: the 0–5 foot (0–1.5 m) area surrounding a structure. HIZ 0 is where wildfire transmission to structural assets often occurs, including ember-ignited fire damage to homes (NFPA, 2020). Consequently, HIZ 0 is increasingly associated with particularly strict prescriptions related to vegetation management and the construction materials of structures (e.g., siding, vents, decks, propane tank placement). Varying mitigation strategies are prescribed in each zone of the HIZ to help reduce both the risk posed by an approaching flame front (e.g., radiant heat, direct ignition between wildland vegetation and a home) and by firebrands—embers that can travel significant distances from a fire and cause further ignitions among a variety of fuels (e.g. homes, wildland vegetation). HIZ mitigations are designed to increase the likelihood that a home will survive a wildfire event and enhance the success of suppression efforts on private property (Cohen, 2000; Martin et al., 2009; Brenkert-Smith et al., 2012). In addition to fuel reduction and home hardening (i.e., making residences more resistant to ignition), resident performance of actions that facilitate active property defense by residents or firefighters during a fire event (e.g. installing sprinklers, establishing a water supply) also warrant increased attention from the research community (Proudley, 2008; Carroll et al., 2011; Penman et al., 2013, 2015; McCaffrey et al., 2015, 2018). Increased interest in actions that facilitate property defense come in response to increasing wildfire risk and the scarcity of water sources in many portions of the U.S. West (Stasiewicz and Paveglio, 2018).

Existing literature exploring resident mitigations in the HIZ suggests that the relationships between resident or property characteristics and individual behavior are not consistent across all populations. This trend is corroborated by studies exploring the heterogeneous nature of human populations in the WUI, and highlighting differential approaches to wildfire mitigation that reflect smaller-scale community patterns and local context (Paveglio et al., 2015, 2018a). Several factors from the broader hazards literature (e.g., age, residency status, income, previous experiences with wildfire risk, and wildfire insurance coverage) are often implicated when examining resident performance of wildfire mitigations (Collins, 2008; Martin et al., 2009; Brenkert-Smith et al., 2012; Fischer et al., 2014; Dickinson et al., 2015; Paveglio et al., 2016, 2018b; Olsen et al., 2017). Yet formal examination of residents' perceptions about LFD capacity in relation to resident performance of wildfire risk reduction activities is relatively scarce. For instance, Hall and Slothower (2009) found that most of their respondents from four small communities in the coast range of Oregon, USA, agreed that "creating defensible space would make firefighters' jobs easier." Price et al., (2016) found that higher levels of trust in firefighters to protect property among property owners near Cypress Hills Interprovincial Park in Canada was associated with the performance of higher levels of structural mitigation on private property. Existing findings that resident perceptions of firefighting entities often relate to their performance of structure-related wildfire mitigations makes it particularly important to explore trust in local firefighters as researchers have often noted that structure characteristics are a consistently important factor in home survival (Syphard and Keeley, 2019).

The research presented in this manuscript explores and expands key components of wildfire risk mitigation in the WUI by employing an approach that investigates the multiple dimensions of resident perceptions of their LFDs. It uses a mixed-mode survey of residential property owners in Pend Oreille County in northeastern Washington, USA, to better explore the relationships between perceptions of FSOs and the wildfire mitigation actions WUI residents performed on private properties. We pay special attention to actions that managers in fire-prone regions of North America recommend in HIZ 0 or those that are important for structure defense. The goal of our research effort is to illuminate areas where LFDs and communities can potentially partner to address their collective wildfire risk and provide additional nuance to the large body of research exploring relationships resident adoption of

wildfire risk mitigations. The following research questions guide our effort:

(1) How do study area residents perceive local fire department capabilities?
(2) What level of trust do area residents have in fire service organizations with respect to wildfire risk mitigation?
(3) What are the relationships among respondent perceptions of LFD capabilities, trust in FSOs, resident characteristics (e.g., age, income, residency status), property characteristics and homeowner performance of preparations for property defense?

2. Methods

2.1. Site selection and sample frame

We selected Pend Oreille County, Washington, USA (a wildfire-prone region) as our study area (see Fig. 1). Selection of Pend Oreille builds off previous focus group research engaging residents, fire professionals, and emergency managers that indicated there was varying support for and adoption of wildfire risk mitigation strategies across diverse populations in the county (Paveglio et al., 2019a). Paveglio et al., (2019a) noted how residency and proximity to the many lakes in the county may influence the emergence of diverse populations who would approach wildfire risk reduction in different ways and have varying relationships with fire service organizations. Those authors also suggested that support for various approaches to wildfire management likely varied across a continuum of development ranging from densely-packed lakefront homes to more dispersed rural properties. For example, focus group participants and managers expressed that densely-packed lakefront property owners were often more supportive of instituting regulatory approaches to mitigating fire risk on private property (e.g., installing sprinklers on homes, home inspections) than nearby individuals in more residentially dispersed areas (Paveglio et al., 2019a). Thus, research in Pend Oreille County provided the opportunity to study varied perceptions of LFD capabilities, trust in LFDs or extra-local suppression organizations, and the relationship between those perceptions and resident adoption of private property wildfire mitigations. Pend Oreille County covers 1425 square miles, has 13,001 residents, and includes 57,936 housing units according to the most recent census information (US Census Bureau, 2010). The region is characterized by a high proportion of public lands and a long history of resource extraction and utilization (i.e., timber and agriculture), hosts a variety of recreational opportunities that provide year-round tourism, and was also experiencing ongoing amenity migration at the time of this study. The region was impacted by the 2015 Kanisku Complex fires that burned approximately 26,124 acres of predominately national forest (i.e., US Forest Service) land, and threatened 25 residences and 10 structures; the fires were managed by an Alaska Type 2 and later a Type 3 Incident Management Team and cost more than $26.3 million USD to suppress (Northwest Interagency Coordination Center, 2015).

The sample frame for this research consisted of three distinct geographic zones extending from four lakes (see Fig. 1c) identified in previous literature as representative of diverse development patterns in the county (Paveglio et al., 2019a). Sampling across these three distinct geographic zones permitted us to capture potential geographic variation across populations and a range of conditions spanning from dense lakeside development to larger and more rural properties. We identified the zones and potential respondents using GIS parcel (i.e., property) data acquired from the Pend Oreille County Assessor's Office and water body shapefiles acquire from the Washington National Hydrography Dataset Area or NHD Waterbody Layers (Washington State Department of Ecology, 2020). Zone 1 included any properties with residential dwellings (e.g., homes, cabins, mobile homes) with a centroid within 500 feet (~152 m) of any of the four lake edges; this buffer represented individuals with the highest levels of lake access who would potentially share the lake as a common backyard or water resource of concern. Zone 2 included all properties with a home or dwelling with their centroid within 1.5 miles (~2.4 km) of the outer edge of Zone 1. Zone 3 consisted of all residential properties with their centroid within 1.5 miles of the outer edge of Zone 2. The 1.5-mile buffer distance represents a commonly used threshold for the distance a firebrand could travel from

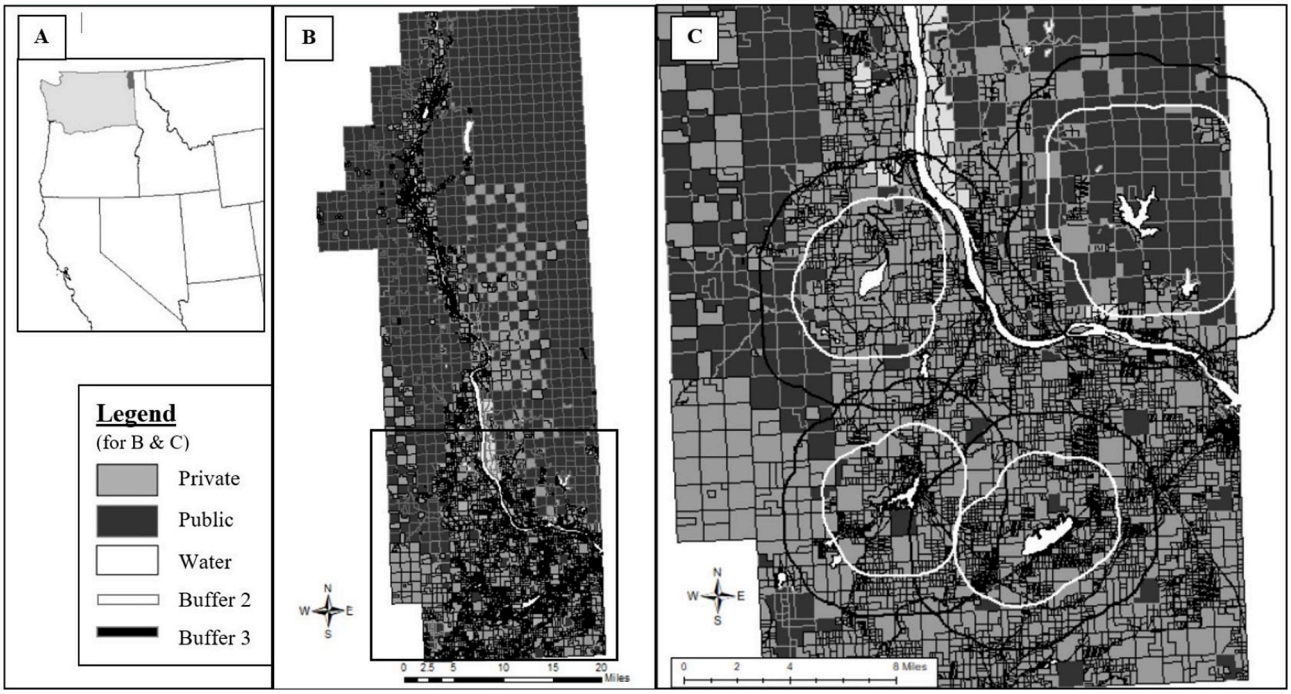

Fig. 1. Map of study area. (A) Location of the study county in Washington State, in the Pacific Northwest of the United States. (B) Public-private landownership classifications for Pend Oreille County, Washington, USA. (C) The 1.5-mile (2.4 km) (white) and 3-mile (4.8 km) (black) buffers delineating the preliminary sample frame.

a forest fire and ignite a spot fire or structure (Radeloff et al., 2005) and mirrors the sampling methods utilized in other studies exploring private landowner mitigation actions across residential gradients (Paveglio et al., 2018b, 2021; Edgeley and Paveglio, 2019). The approximately 3-mile (~3.8 km) buffer extending from the lakes, and which comprised the full sample frame, also permitted the inclusion of properties adjacent or in close proximity to public lands or private timberlands, which introduces the potential for residential interactions with FSOs other than the LFD (e.g., state, federal). Properties affiliated with a land trust, business or commercial use, apartments, or condominiums were removed from the sample frame to ensure that those recruited would have the ability to make and implement decisions about wildfire risk mitigation performance on the property. Surveys were only delivered to the primary tax mailing address of owners, thus ensuring that residents with multiple properties in the study area received only one survey and that their primary residence was the focus of the study.

The research team began survey administration in August 2018 using a mixed-mode approach. All residential property owners in the sample frame received a survey via one of two modes based on their residency type: (1) second homeowners received a mailed survey utilizing procedures suggested by Dillman and others (2014) (i.e., the "Tailored Design Method") and (2) primary homeowners received a survey via a drop-off, pick-up approach where members of the research team visited primary residences in-person to administer the survey. We used the GIS parcel and tax data to discern whether each residence in the sample was a primary or secondary residence and assigned each residential property to the appropriate administration method. A team of five trained researchers visited primary residences in the sample frame (n = 600) over 15 days to hand-deliver surveys and inform residents about the purpose of the research using a common protocol (i.e., drop-off, pick-up method). Researchers arranged to collect completed surveys within 24 hours and continued to revisit properties in a systematic fashion to ensure adequate opportunities to contact participants or collect completed surveys. Drop-off, pick-up survey approaches can procure higher response rates than mail surveys in rural locations, especially when implemented in geographically discrete areas (Steele et al., 2001; Trentelman et al., 2016), which was important for our rural study location. We elected to focus our drop-off, pick-up efforts on two of the lakes with the highest populations to maximize opportunities for response and to permit the small research team to make multiple trips back to initial participants who requested more time with the survey. Mail administration was extended to populations across all four lakes to compensate for potential lower survey response rates from second homeowners due to contacting them via mail.

The research team administered a mail version of the survey instrument to all 957 homeowners in the initial four-lake sample frame. Mail administration took place in August 2018 alongside the drop-off, pick-up effort and featured successive mailings adapted from Dillman et al., (2014): (1) an introductory letter, (2) a paper copy of the survey and a prepaid return envelope; (3) a thank you/reminder postcard with the option complete the survey online using Qualtrics and a property-specific access code; and (4) a final reminder letter with a second invitation to complete the survey online. Each of the four mailings was sent seven-to-ten days apart.

We administered surveys to 1557 residential landowners in the sample frame. The research team received or collected 770 completed surveys for an overall response rate of 49.5%. The response rate for the drop-off, pick-up effort was noticeably higher (470 completed surveys, 78.3% response rate) than the mail/online effort (300 completed surveys, 31.3% response rate).

2.2. Survey measures

The survey instrument for this research adapts and expands questionnaires used to study wildfire mitigation efforts in McCall, Idaho, and Flathead County, Montana. (e.g., Paveglio et al., 2014, 2016, 2018b). The 16-page survey included questions relating to performance of property-level wildfire mitigation actions, new or expanded questions about resident perspectives of LFDs and FSOs involved in wildfire risk mitigation and suppression, and sociodemographic characteristics of property owners. The first author pilot tested the survey instrument in May 2018 among 27 property-owners near Moscow, Idaho to evaluate new questions and further refine existing measures.

We used three 5-point Likert scale, agree-disagree statements (Bryman, 2012) to gauge respondent perceptions of LFD capacity and capabilities. Statements included in the survey implicated perceptions about the number of local firefighters associated with the LFD and the ability of LFDs to manage wildfire events in the study area. Additional 5-point Likert scale, agree-disagree statements implicated the capability of state agencies, federal fire management agencies, and privately contracted fire crews to put out fires on residents' private property. The full list of LFD and FSO statements are provided in Table 1. We also included demographic questions frequently used in social science research and focused on mitigation performance, including full-time or part-time residency, age, previous experience living in areas with wildfire risk, and level of wildfire insurance coverage. Sociodemographic questions permitted researchers to embed this particular analysis within the larger literature and compare results with studies where a single prompt was used to represent trust in LFDs or firefighters. For experience living with fire risk, participants were asked to select whether they (1) had lived an area or multiple areas with high wildfire risk, (2) had not lived in an area with high wildfire risk, or (3) did not know if they had lived in an area with high wildfire risk. Respondents were asked whether they had (1) full or partial or (2) no wildfire insurance coverage for their home or dwelling. We used geographic data to code whether a property was directly adjacent to a lake (i.e., lakefront property). We also asked residents a four-option fixed-choice question about the proximity of neighboring property lines to their residence to explore the relationship between property characteristics and our select mitigation actions (see Table 2 for the full list).

We used a set of 11 yes/no questions to examine resident

Table 1
Measures related to resident perceptions of FSO capacities and capabilities. Respondents were asked to select their response on a 5-point Likert scale ranging from −2 to +2 where: −2 = Strongly disagree; −1 = Disagree; 0 = Neither agree or disagree; 1 = Agree; 2 = Strongly agree.

Prompt	Composite measures	n	Mean (SD)
	Mean (SD)		
My local fire department has enough **personnel** to protect private properties at risk from wildfire in this area	***LFD capacity and capabilities***α = 0.714−**0.81** (0.85)	706	**−0.69** (1.03)
My local fire department could protect **private property** owners in this area during large wildfire events		705	**−0.72** (1.14)
My local fire department is capable of putting out wildfires in this area **without the assistance** of state or federal resources		704	**−1.01** (1.02)
I trust the **local fire department** to put out fires on my property	***Trust in LFD***	725	**0.92** (1.06)
I trust **state agencies** (e.g. Washington Department of Natural Resources) to put out fires on my property	***Trust in extra-local FSOs***α = 0.852**0.42** (1.02)	725	**0.58** (1.14)
I trust **federal agencies** (e.g., USFS) to put out fires on my property		725	**0.38** (1.22)
I trust **privately contracted firefighters** to put out fires on my property		715	**0.31** (1.13)

SD = standard deviation.
α = Cronbach's alpha.

Table 2
Resident and property characteristics for the Pend Oreille study population.

Variable name	n	Measures	Range and response frequency	Mean (SD)
Residency	755	1 = Full-time 0 = Part-time	1 = 63.7% 0 = 36.3%	0.64 (0.48)
Age	683		20–90	62.67 (12.59)
Previous experience with wildfire risk	756	0 = I don't know if I have lived in an area with high wildfire risk 1 = I have not lived in an area with high wildfire risk 2 = I have lived in an area or multiple areas with high wildfire risk	0 = 13.0% 1 = 44.2% 2 = 42.9%	1.30 (0.69)
Household income after taxes (2017)	615	1 = less than $20,000 2 = $20,000-$39,000 3 = $40,000-$59,000 4 = $60,000-$79,000 5 = $80,000-$99,999 6 = $100,000-$149,000 7 = $150,000-$199,999 8 = $200,000-$249,999 9 = $250,000 or more	1 = 8.6% 2 = 15.3% 3 = 16.4% 4 = 19.0% 5 = 12.7% 6 = 14.0% 7 = 6.2% 8 = 2.6% 9 = 5.2%	4.23 (2.11)
Wildfire insurance	707	1 = partial or full coverage 0 = no coverage	1 = 88.3% 0 = 11.7%	0.88 (0.32)
Lakefront	770	1 = Yes, touching lake 0 = No, not touching lake	1 = 33.8% 0 = 66.2%	0.34 (0.47)
Nearest neighbor	752	1 = Equal to or less than 30 ft (~9 m) 2 = Between 30 ft and 100 ft (~9–30 m) 3 = Between 100 ft and 200 ft (~30–61 m) 4 = More than 200 ft away (>61 m)	1 = 41.7% 2 = 21.2% 3 = 12.0% 4 = 25.1%	2.20 (1.23)

Table 3
Study participant performance (yes/no) of wildfire risk mitigation actions.

HIZ 0 actions	n	Percent performed
Regularly removed the accumulation of **needles and leaves** from roofs, gutters, or decks	747	87.1%
Removed any **flammable materials** or vegetation within 5 feet of your home	743	76.6%
Stacked **firewood/lumber** at least 30 feet [~9 m] from your residence	731	68.4%
Used nonflammable **siding** materials such as tile, slate, brick, heavy timber or stone	725	30.8%
Planted **fire-resistant plants** around your residence	713	19.5%
Home-defense actions	**n**	**Percent performed**
Ensured that **driveway access** meets access requirements for emergency vehicles	715	74.1%
Established a **water supply** for firefighting	724	49.9%
Purchased a **generator** to help power water pumps or provide electricity during a wildfire event	730	46.3%
Designated a **safe zone** on my property (e.g. structure, pool, bare ground) where people could safely shelter as a fire passed	724	39.8%
Installed external (outdoor) **sprinklers on my home**	718	23.5%
Installed external **sprinklers that can reach up to 50 ft** [~15.2 m] away from my house	716	21.1%

performance of mitigation actions in the HIZ on their private property (see Table 3). The mitigations we selected for inclusion in this study reflect common wildfire preparation check-lists for preparing homes for wildfire or bushfire risk in national standards (NFPA, 2020; CFA, 2020) and our review of prior studies focused on individual wildfire preparation (e.g., Nelson et al., 2005; Kanclerz and DeChano-Cook, 2013; McNeill et al., 2013; Whittaker et al., 2013; Koksal et al., 2019). Mitigation questions focused on actions related to structure ignition risk such as removing needles and leaves from gutters, use of non-flammable building materials, and using fire resistant plants in landscaping. Additional questions focused on actions that could enhance passive or active home defense (e.g., installation of sprinklers, establishing a water source, purchasing a generator) and firefighter safety (e.g., establishing a safe zone, maintaining your driveway for safe emergency vehicle access).

3. Analysis

All data analysis used the quantitative software package IBM SPSS Statistics 26 (IBM, NY). Data were entered by trained coders using an identical key, with the first author performing periodic accuracy checks. Researchers coded 5-point Likert-scale items from −2 to 2 (with 0 for neutral) for ease of interpretation. We conducted a principal components analysis with oblique rotation to explore the potential for composite measures associated with perceptions of LFDs and trust in extra-local FSOs. Oblique rotation is appropriate when question statements share conceptual features or are designed to serve as composite measures (e.g., capacity, capability, trust) (Stevens, 2009). Three measures related to resident perceptions of LFDs loaded as a distinct component. The Kaiser-Meyer-Olkin (KMO) measures associated with each principle were greater than 0.614, which is well above the acceptable limit of 0.5 (Field, 2013). Three measures related to perceptions of LFD capacities and capabilities to deal with a wildfire event had a Chronbach's α of 0.714, which reflects a high level of internal consistency (Kline, 2005). Trust in the LFD to respond to fire on private property did not load into the aforementioned factor. Thus, we treated data relating to that measure as a separate component of the analysis. The three statements related to extra-local FSOs emerged as one component featuring a Chronbach's α of 0.852 (see Table 1).

We conducted a series of binary logistic regressions to explore the relationships between our dichotomous dependent variables (i.e., yes/no performance of various mitigation actions) and our continuous, categorical, or dichotomous independent variables (see Tables 1 and 2). A binary logistic regression is useful for exploring the odds (i.e., odds ratio; e^B) of a dichotomous event (i.e., a mitigation action) occurring given different levels of the input (i.e., independent) variable(s) (Field, 2013). We utilized binary logistic regression to examine how changes in the predictor values are associated with changes in the probability of mitigation action performance.

4. Results

Descriptive statistics for individual prompts and composite measures related to LFD or FSO variables are presented in Table 1. There was a moderate level of disagreement that LFDs had enough personnel to protect private property at risk from wildfire in their area (M = −0.69, SD = 1.03). There was also moderate disagreement that the LFD could protect private property owners in the area during a large wildfire event (M = −0.73, SD = 1.14) or that LFDs would be able to put out a wildfire in their area without extra-local assistance (M = −1.01, SD = 1.02).

Respondents reported a relatively high level of trust that their LFD would respond to fires on their property (M = 0.92, SD = 1.06). There was a more moderate level of trust in state agencies to put out a fire on their property (M = 0.58, SD = 1.14) and in federal agencies (M = 0.37, SD = 1.22) to put out a fire on their property. There was less agreement among respondents that they would trust privately contracted fire crews

would put out a fire on their property (M = 0.30, SD = 1.13).

Performance of reported mitigations in HIZ 0 varied across activities included in the survey (Table 3). Approximately 87% of respondents reported regularly removing the accumulation of needles and leaves from roofs, gutters, or decks. Nearly 77% reported removing any flammable materials or vegetation within 5 feet (~1.5 m) of their home, while 68.4% of respondents indicated that they had stacked firewood and lumber at least 30 feet (~9 m) from their residence. Approximately 31% of respondents had utilized nonflammable siding materials in their building construction, and 19.5% had incorporated fire-resistant plants into their landscaping.

Performance of reported home defense actions also varied across the study population. Approximately 74% of respondents reported keeping their driveway clear for emergency vehicles and about 50% reported establishing a water supply for firefighting. Approximately 46% of respondents indicated they had purchased a generator to support firefighting efforts, while nearly 40% of respondents reported establishing a safe zone on their property where firefighters or others could safely shelter as a fire passed. Approximately 23% of respondents had installed external sprinklers on their home, and 21% reported installing external sprinklers that could reach up to 50 feet (~15.2 m) from their home.

Respondents consisted of 63.7% full-time residents and 36.3% part-time residents. Respondent age ranged from 20 to 96 years old, with a mean age of 63. Approximately 43% of the respondent population noted that they had lived in an area with high wildfire risk, 44.2% reported that they had not lived in an area with high fire risk, and 13% did not know. Nearly 89% of the surveyed population reported having some form of wildfire insurance coverage and 11% reported not having any wildfire insurance coverage. The average annual household income was between $60,000 and $100,000 USD. Approximately 34% of respondents owned property that touched a lake (i.e., categorized as lakefront). Nearly 42% of the population reported that the nearest property line was equal to or less than 30 ft (~9 m) from their home (within HIZ 1), with an additional 21% indicating that the nearest property line was between 30 and 100 ft (~9–30 m) (HIZ 2) of their home. Approximately 12% of respondents indicated that the nearest property line was between 100 and 200 ft (~30–61 m) (HIZ 3) of their home, and approximately 25% reported the nearest property line as more than 200 ft (>61 m) away (beyond HIZ 3) from their home (Table 2).

Results from the binary logistic regressions for home defense actions are presented in Table 4. Residency (B = 1.020; e^B = 2.772, p < .001), wildfire insurance coverage (B = 1.070, e^B = 2.915, p = .001) and age (B = 0.025, e^B = 1.026, p = .008) were all positively and significantly related to ensuring that driveway access meets access requirements for emergency vehicles. That is, full time residents and those with higher levels of insurance coverage were more likely to have established driveway access. Full-time residency also was significantly related to establishing a water supply for firefighting (B = 0.709; e^B = 2.031, p = .002), as was lakefront property ownership (B = 0.770, e^B = 1.769, p = .001). The latter result suggests that lakefront property owners were more likely to have access to a water supply. Perceptions of LFD capacity and capabilities were significantly and negatively related to purchasing a generator to help power water pumps or provide electricity during a wildfire event (B = −0.266, e^B = 0.766, p = .025). That is, as perceptions of LFD capability increased, residents were less likely to have purchased a generator. Residency (B = 1.815, e^B = 6.141, p < .001) and distance to the nearest neighboring property line (B = 0.216, e^B = 1.242, p = .030) were both significantly and positively related to purchasing a generator. Meanwhile, previous experience living in a wildfire prone area (B = 0.624, e^B = 1.553, p = .003) and owning a lakefront property (B = 0.624, e^B = 1.553, p = .015) were both positively and significantly related to designating a safe zone where people could safely shelter as a fire passed (e.g., structure, pool, bare ground).

Trust in extra-local FSOs (B = 0.284, e^B = 1.328, p = .038), residency (B = 0.522, e^B = 1.685, p = .049), income (B = 0.120, e^B = 1.127, p = .036), and wildfire insurance coverage (B = 1.411, e^B = 4.102, p = .009) were all significantly and positively related to resident installation of sprinklers on their home. That is, as trust in extra-local FSOs or income increased, so too did the likelihood that residents had installed sprinklers. Income (B = 0.117, e^B = 1.124, p = .048), wildfire insurance coverage (B = 1.094; e^B = 2.987, p = .028), and distance to the nearest neighboring property line (B = 0.301, e^B = 1.351, p = .011) were all positively and significantly related to installation of property sprinklers that could reach up to 50 feet (15 m) from their home. This means that at property size increased, so too did the likelihood of installing sprinklers

Table 4
Binary logistic regression models for home defense actions.

Variable	Driveway		Water Supply		Generator		Safe Zone		Sprinklers on home		Sprinklers reach 50 ft	
	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B
Perception of LFD capacity and capabilities	−0.113 (0.135)	0.893	0.083 (0.110)	1.086	−0.266* (0.119)	0.766	−0.001 (0.112)	0.999	0.071 (0.128)	1.073	0.022 (0.133)	1.022
Trust in LFD	−0.009 (0.131)	0.991	0.006 (0.110)	1.006	0.053 (0.120)	1.055	−0.108 (0.113)	0.898	−0.128 (0.137)	0.880	−0.056 (0.142)	0.946
Trust in extra-local FSOs	0.254 (0.134)	1.289	0.159 (0.111)	1.172	−0.008 (0.120)	0.992	−0.045 (0.114)	0.956	0.284* (0.136)	1.328[a]	0.243 (0.141)	1.275
Residency	1.020*** (0.269)	2.772[a]	0.709** (0.233)	2.031[a]	1.815*** (0.253)	6.141[a]	0.039 (0.228)	1.040	0.522* (0.265)	1.685[a]	0.331 (0.277)	1.393
Income	0.038 (0.060)	1.039	0.018 (0.050)	1.018	−0.010 (0.055)	0.990	−0.011 (0.050)	0.989	0.120* (0.057)	1.127[a]	0.117* (0.059)	1.124[a]
Age	0.025** (0.010)	1.026[a]	0.009 (0.008)	1.009	0.007 (0.009)	1.007	0.003 (0.008)	1.003	0.005 (0.009)	1.006	0.016 (0.010)	1.016
Previous experience living with fire risk	0.055 (0.169)	1.057	0.180 (0.140)	1.197	0.068 (0.153)	1.070	0.440** (0.146)	1.553[a]	0.201 (0.166)	1.222	0.122 (0.171)	1.130
Wildfire insurance coverage	1.070** (0.331)	2.915[a]	0.238 (0.304)	1.269	0.303 (0.333)	1.354	0.374 (0.317)	1.453	1.411** (0.542)	4.102[a]	1.094* (0.499)	2.987[a]
Lakefront	−0.568 (0.299)	0.567	0.871** (0.257)	2.388[a]	0.029 (0.278)	1.029	0.624* (0.256)	1.866[a]	0.148 (0.291)	1.160	0.322 (0.317)	1.379
Nearest property line	−0.021 (0.119)	0.979	−0.016 (0.094)	0.984	0.216* (0.100)	1.242[a]	0.069 (0.097)	1.071	−0.039 (0.112)	0.962	0.301* (0.118)	1.351[a]
X^2	50.597***		29.588**		109.593***		20.123*		27.763**		26.546**	
Nagelkerke R^2	.143		.075		0.258		.052		.079		.078	

Tests significant at *p < .05, **p < .01; ***p < .001.
[a] = lower limit of the 95% confidence interval for the odds ratio (e^B) is greater than 1.

Table 5
Binary logistic models for HIZ 0 actions.

Variable	Needles and leaves		Flammable materials		Firewood		Non-flammable siding		Fire-resistant plants	
	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B	B (SE)	e^B
Perception of LFD capacity and capabilities	0.001 (0.186)	1.001	0.250 (0.134)	1.284	0.322** (0.123)	1.379[a]	0.193 (0.119)	1.213	−0.039 (0.138)	0.962
Trust in LFD	−0.270 (0.178)	0.763	−0.055 (0.128)	0.947	−0.329** (0.125)	0.720	−0.381** (0.121)	0.683	−0.072 (0.140)	0.930
Trust in extra-local FSOs	0.489** (0.174)	1.630[a]	0.009 (0.129)	1.009	0.197 (0.120)	1.218	0.236 (0.124)	1.266	−0.058 (0.142)	0.944
Residency	0.253 (0.391)	1.288	−0.120 (0.263)	0.887	−0.255 (0.244)	0.775	0.121 (0.246)	1.129	0.829** (0.302)	2.292[a]
Income	0.111 (0.090)	1.117	0.001 (0.058)	1.001	−0.009 (0.054)	0.991	0.024 (0.054)	1.024	−0.010 (0.065)	0.990
Age	0.021 (0.013)	1.021	0.014 (0.009)	1.015	0.014 (0.009)	1.014	−0.010 (0.008)	0.990	0.035** (0.011)	1.036[a]
Previous experience living with fire risk	0.291 (0.230)	1.338	0.247 (0.161)	1.281	0.195 (0.152)	1.215	0.130 (0.152)	1.139	0.208 (0.185)	1.231
Wildfire insurance coverage	0.354 (0.453)	1.424	0.609 (0.327)	1.838	0.190 (0.331)	1.209	0.158 (0.329)	1.171	1.150* (0.506)	3.157[a]
Lakefront	0.829 (0.459)	2.290	−0.142 (0.290)	0.868	−0.409 (0.268)	0.664	−0.265 (0.275)	0.767	−0.311 (0.325)	0.733
Nearest property line	0.019 (0.149)	1.020	0.099 (0.111)	1.104	0.213* (0.105)	1.237[a]	0.032 (0.100)	1.033	−0.025 (0.118)	0.976
X^2	20.160*		11.126		27.816**		20.068*		30.809**	
Nagelkerke R2	.083		.033		.076		.055		.096	

Tests significant at *p < .05, **p < .01; ***p < .001.
[a] = lower limit of the 95% confidence interval for the odds ratio (e^B) is greater than or equal to 1.

covering a larger geographic area around the home.

Table 5 summarizes logistic regression outputs relevant to reported performance of mitigations in HIZ 0. To begin, trust in extra-local FSOs (B = 0.489, e^B = 1.620, p = .005) was significantly and positively related with respondents reporting the regular removal of accumulated needles and leaves from roofs, gutters, or decks. None of the independent variables were significantly related to removing flammable materials or vegetation within 5 feet of the home. Both perceptions of LFD capacity and capabilities (B = 0.332, e^B = 1.379, p = .009) and distance to the nearest property line (B = 0.213, e^B = 1.237, p = .043) were positively and significantly related to stacking firewood/lumber at least 30-feet (~9 m) from the residence. Meanwhile, trust in the LFD to respond to a fire on their private property (B = −0.329, e^B = 0.720, p = .009) was significantly and negatively related to stacking firewood/lumber at least 30 feet (~9 m) from the residence, implying that as trust in LFD increased, performance of distanced firewood stacking decreased. Trust in the LFD to respond to a fire event on the respondent's private property (B = −0.505, e^B = 0.603, p = .002) was significantly and negatively related to use of non-flammable siding materials such as tile, slate, brick, heavy timber, or stone in their building construction. Income was not significantly related to the performance of using non-flammable siding. Finally, residency (B = 0.829; e^B = 2.292, p = .006), age (B = 0.035; e^B = 1.036, p = .002), and wildfire insurance coverage (B = 1.150; e^B = 3.157, p = .023) were all significantly and positively associated with planting of fire-resistant plants around the home.

One advantage of logistic regression is that it provides odds ratios (e^B), and thus indications about how much more likely certain outcomes are given the associations between variables studied (Field, 2013). Below we highlight odds rations associated with select significant variables in our models, including the lower and upper bounds of their 95% confidence interval (CI). For example, full time residents in our study population were six times more likely to report having purchased a generator for firefighting than part-time respondents (e^B = 6.141, 95% CI [3.741, 10.082]) and nearly three times more likely to report maintaining their driveway for access by emergency vehicles (e^B = 2.772, 95% CI [1.636, 4.698]). Respondents with wildfire insurance coverage were approximately three-times more likely than respondents without wildfire insurance to report having: (1) appropriately prepared their driveway to be accessed by emergency vehicles (e^B = 2.915, 95% CI [1.525, 5.573]), (2) installed sprinklers that can reach up to 50 ft from their home (e^B = 2.987, 95% CI [1.124, 7.937]), and (3) planted fire-resistant plants around their home (e^B = 3.157, 95% CI [1.171, 8.505]). Similarly, respondents with wildfire insurance coverage were more than four times more likely to report installing sprinklers on their home when compared to those without wildfire insurance (e^B = 4.102, 95% CI [1.416, 11.877]).

Overall, models related to individual home defense actions and HIZ 0 actions explained relatively small amounts of variance (see Table 5). Models for planning fire resistant plants (Nagelkerke R^2 = 0.096) and removing needles and leaves (Nagelkerke R^2 = 0.083) explained the highest levels of variance among HIZ 0 actions. Models for ensuring driveway access (Nagelkerke R^2 = 0.143) and purchasing a generator to help power water pumps or provide electricity during a wildfire event (Nagelkerke R^2 = 0.258) explained the highest levels of variance among home defense actions (see Table 4).

5. Discussion

This research sought to explore resident perceptions of fire service organizations (FSOs) and their relation to the performance of various mitigation actions that promote wildfire preparedness and suppression effectiveness in the WUI. More specifically, we explored the relationships between resident perceptions of local fire department (LFD) capabilities, their trust in FSO ability to suppress fire, and resident performance of various wildfire risk reduction activities for home defense. We also explored the relationship between the above mitigations and a broader set of resident characteristics often found to be influential by existing wildfire literature (e.g., resident and property characteristics).

5.1. Variations in perceptions of fire service organizations

We found that residents largely trusted FSOs (i.e., local, state, federal, privately contracted) to suppress a fire event on their property and found evidence that the amount of reported trust decreased from local to federal agency providers. The high level of trust residents conferred upon their LFDs corroborates existing studies indicating high levels of faith in local entities to best understand and respond to place-specific

local interests during fire suppression, especially when compared to extra-local firefighters who may not have prior knowledge of local interests and protection priorities (Carroll et al., 2005, 2006, 2011; Fleming et al., 2015; Paveglio et al., 2015). Progressively lower levels of resident trust in state or federal organizations may reflect tendencies for rural populations to place more trust in smaller government and distrust extra-local or broader government bureaucracies with regards to natural resource or land management, including wildfire management. Such dynamics are acutely important in the rural U.S. West (Paveglio et al., 2015; Stasiewicz and Paveglio, 2017; Reid et al., 2018; Brunson, 2020; Rasch and McCaffrey, 2019). Residents conferred the lowest level of trust to privately contracted fire crews, which may reflect a lack of familiarity surrounding the roles of privately contracted fire crews in fire suppression and the general familiarity of the public with the professionalism and historical success of public FSOs.

While study participants largely trusted LFDs to respond to fires on their private property, they also indicated that LFDs did not have the capacity or capability to respond effectively to multiple private properties or protect residential values-at-risk during large fire events. These findings suggest that residents consider LFDs a necessary service, but not one that is equipped to addresses landscape-level management of wildfires without extra-local assistance. These findings indicate a somewhat realistic understanding of the larger fire management system, which includes hierarchical systems and procedures (e.g., Incident Command System, graduated levels of state and federal agency firefighting teams) that mobilize extra-local resources to aid local jurisdictions dealing with large fire events. Arrangements such as memorandums of understanding or mutual aid agreements among LFDs facilitate that resource sharing at smaller scales, and thus are one key place for future study of how those arrangements work in practice.

Trust in the LFD to respond and a concurrent understanding that LFDs may not be able to protect all threatened private properties during a wildfire event provides both challenges and opportunities in terms of shared responsibility or public support for fire management. State and federal initiatives to promote increased LFD wildfire response capabilities in the U.S. are partially related to national and local interest in keeping wildfire suppression costs low by keeping fires in the WUI small, minimizing the time it takes to mobilize and deliver extra-local resources, and reducing suppression resource scarcity during high-activity fire seasons (WFEC, 2014). Political and policy support for strengthening wildland-fire prone LFDs presents an opportunity for many LFDs to either expand into or enhance their wildland fire response potential, and to build stronger partnerships with state and federal partners (e.g., training, communication channels). However, LFDs in rural areas typically have a high proportion of volunteer members, and the additional training demand or expansion beyond structure firefighting priorities (and often emergency medical services) may not be feasible for department budgets, firefighter schedules, or shifting rural sociodemographics (NFPA Journal, 2017; Evarts and Stein, 2019). LFDs and their constituents may invest more resources in wildfire mitigation efforts or contemplate motivating passive or active civilian defense of property (e.g., sprinkler systems, firefighting equipment) to help address local suppression resource shortages.

The barriers to enhancing suppression capacities in rural residential areas is two-fold. First, the regulations that much of the existing wildfire literature and governments promote for wildfire mitigation on private property (e.g., adoption of International WUI Fire Code, modifying building and zoning codes for fire risk reduction) may not be politically palatable in rural settings (Paveglio et al., 2018b, 2019b; Wilson et al., 2018). The scale of policy implementation is also a factor that local governments and managers may need to consider to effectively tailor wildfire adaptation messaging and policies in rural settings, especially in jurisdictions with residential gradients similar to our study area that bring lake-front vacation property owners and ranchers and loggers within the same administrative unit (e.g., county, fire district). Managers, residents, and government officials who participated in Paveglio et al.'s (2019a) focus groups in Pend Oreille County highlighted how socially fragmented the county was, and how that social fragmentation influenced the effectiveness of managers' wildfire programs and messaging. This ultimately makes county-level or even district-level fire policy implementation challenging because the social scale is finer than the administrative unit.

5.2. *Exploring correlations between resident/property characteristics and resident performance of wildfire mitigations*

Our study highlights variability in the types or extent of factors that relate to resident performance of wildfire mitigations. The lack of consistently significant relationships between variables and resident performance of mitigation actions selected for this study highlights the need to explore actions independently, especially when they vary in terms of their cost and relative effort to residents (Penman et al., 2016). Like previous work, we found that actions typically categorized as less-expensive and less-labor intensive were more frequently noted as performed by residents (e.g., removing needles and leaves from roofs, gutters, or decks) (McFarlane et al., 2012; Brenkert-Smith et al., 2012; Price et al., 2016). Using fire-resistant landscaping around the residence was the least performed action despite being relatively low cost, which is substantiated by other wildfire mitigation studies (Faulkner et al., 2009; Olsen et al., 2017). This finding may be partially explained by low perceived effectiveness or importance of landscaping in reducing wildfire risk to private property (Bright and Burtz, 2006). Increasing wildfire literacy among homeowners, planners, and landscapers in the WUI can help prepare a workforce and residential population who can make their daily land and property management decisions through a wildfire risk lens. Additionally, conducting studies to quantify the effectiveness of utilizing fire resistant plants in landscaping may help demonstrate the utility of this action in terms of home survival and property damage and dissipate some of the potential confusion around this mitigation action to bolster its performance.

Measures of perceived LFD capabilities and FSO trust used in this analysis were largely insignificant as correlates with resident performance of the various mitigation actions studied. Trust in the LFD to respond was significantly related to resident implementation of two wildfire mitigations (i.e., stacking firewood and lumber more than 30 feet (~9 m) from the home and using non-flammable siding material in home construction) and had a negative relationship with nearly all the mitigation actions explored in this study. These negative correlations may reflect what some authors call the "guardianship model" of fire protection, where historical reliance on FSOs to protect WUI populations from fire risk dampens the motivation of residents to prepare their properties for wildfire (Goldstein et al., 2008; Abrams et al., 2015, 2017; Paveglio et al., 2018b). For example, residents who trust the LFD to respond may not take on the action of stacking firewood more than 30 feet (~9 m) from their home or using non-flammable siding materials because they believe that suppression efforts don't warrant the small change (e.g., firewood) or the more costly actions (e.g., non-flammable siding). Both of these examples reflect "guardianship" thinking.

Our LFD measures were significantly related to resident performance of mitigations that were less likely to be classified as housekeeping or yard maintenance tasks (e.g., purchasing a generator for use during a wildfire, installing non-flammable siding on the home). This suggests that perceptions of LFDs may have a limited relationship with resident performance of select mitigation actions and that messaging related to the limitations of LFD response might encourage the implementation of more expensive and fire-specific mitigations in rural areas. However, it is important to note that we did not account for the amount or types of interaction residents in this study had with LFDs (e.g., prevention and mitigation programming, seeking advice from LFD, delivering or providing wildfire risk mitigation information to homes). Further research should account for these kinds of interactions in evaluating whether and what types of LFD outreach might relate to resident

performance of select wildfire mitigations, especially those related to home defense. Likewise, future research efforts could advance our focus by expanding measures related to trust in FSOs and applying them to mitigations beyond HIZ 0 in order to better explore the multi-dimensionality of trust in LFDs and FSOs. For example, future studies could use scenarios to explore how resident perceptions of their LFD's capacity to deal with wildfire events might change under different circumstances (e.g., personnel, wildland fire ready equipment or training, anticipated response time). This data could be compared to their mitigation decisions, willingness to pay to better fund the fire department, or willingness to participate in cost-share wildfire mitigation programs.

Our results also suggest that perceptions of LFDs or FSOs can vary dramatically across populations in the same landscape. For instance, our results suggest that residents' trust in FSOs may relate to some residents to perform mitigations more than others. These findings corroborate existing lessons indicating varied residential preferences for interacting with or relying on government entities around wildfire risk, and suggest that additional research should explore the specific reasons that such perceptions engender or inhibit action (e.g., Paveglio et al., 2019b, 2018a). For instance, future studies could explore variations in trust across populations in the same or multiple fire departments with different capacity characteristics (e.g., volunteer vs. combo vs. career departments). Other areas for expansion in the study of LFDs might include temporal fluctuations in FSO trust due to failed or successful collaborations around wildfire mitigations or wildfire management efforts, especially since the majority of the focus in the wildfire literature has been on state or federal wildfire management agencies.

Results from this effort corroborate that ways in which select socio-demographic characteristics help explain resident performance of particular mitigation actions. It also extends those trends to rural portions of the inland U.S. West. For instance, full-time residents may be more likely than part-time residents or vacation-property owners to undertake time-consuming projects like installing a water supply for firefighting or installing rooftop sprinklers. This may also relate to residents' intended evacuation behaviors, for instance the tendency for part-time residents to evacuate early during fire events that may impact their property (Stasiewicz and Paveglio et al., 2021). Having wildfire insurance coverage was associated with residents' performance of higher cost and less frequently implemented actions (e.g., installing sprinklers, planting fire-resistant plants around home). Some wildfire mitigation research posits that wildfire insurance can subsidize the risk of living in fire-prone areas and disincentivize performance of mitigations (Winter and Fried, 2000; Brenkert-Smith et al., 2005; Collins, 2005, 2008; McFarlane et al., 2012). Those authors propose that insurance companies take a more active role in wildfire mitigation by requiring resident performance of wildfire mitigations for valid coverage or reducing premiums. Others found that residents purchase wildfire insurance and invest in mitigation as a "bundle" for addressing private property wildfire risk (Talberth et al., 2006). Similar to previous studies, we found that income was significantly related to resident performance of more expensive and less-frequently performed actions (i.e., installing sprinklers on the home, installing sprinklers that reach up to 50 feet (~15 m) from the home). However, income was not significantly associated with installing non-flammable siding, which can also be an expensive action. This finding suggests that more is at play than affordability when making decisions about home wildfire mitigations, especially the costly ones. While individuals with higher income levels may be more capable of performing wildfire mitigations on their property, there still exists a "law of diminishing returns" where property owners may see more benefit in investing their time elsewhere. More specifically, needing to find a contractor to perform the work, juggling multiple responsibilities (e.g., childcare), or preferring to spend their time at their property on other activities (e.g., hunting, skiing) may be the determining factor for mitigation performance over income.

Research efforts increasingly recognize the limited ability that property owners may have to execute traditional HIZ best practices when their property line is closer than 200 feet (~61 m) away, or when their structures are situated near property lines or other landowners (Meldrum et al., 2015; Calkin et al., 2014). Likewise, we found that proximity of a home to a neighboring property line was significantly related to the reported performance of certain mitigation actions (e.g., moving firewood more than 30 feet (~9 m) from the structure, installing sprinklers that reach at least 50 feet (~15 m) from the home). This result suggests that residents in densely developed areas may struggle to mitigate their risk not because they lack the motivation to perform actions, but because their property arrangement makes it less possible to do so. New innovations for addressing such physical barriers may need to be conceptualized, and while some areas have adapted ordinances that allow HIZ efforts to extend across private landownerships, such restrictions are unlikely to be instituted in rural areas such as the study area for this research. Similarly, owning lakefront property was significantly related to establishing a water supply for firefighting and designating a safe zone. However, some study participants noted that the lake constituted their water supply or safe zone, which may imply very little effort on the part of the homeowner or a poor life safety plan. Future research efforts could investigate the levels of effort or convenience involved in implementing various mitigations under different conditions that represent the local context of various properties.

6. Conclusions

Improved understandings surrounding resident perceptions of wildfire suppression organizations and their capabilities can be an important component of facilitating wildfire adaptation in fire-prone regions. In the United States, recent fire seasons have overwhelmed wildfire response networks that include hierarchical relationships between local fire suppression organizations (e.g., LFDs) and state or federal fire suppression or management organizations. We found that WUI residents in our study area trusted their LFDs to respond to their properties, but did not perceive that they had the capability or capacity to deal with large wildfire events alone. We also found progressively lower levels of resident trust in state or federal organizations. These findings are important because they may demonstrate an emerging understanding that not all wildfires are controllable through suppression activities. Our results also suggest that there are important relationships between residents' perceptions of FSOs and their performance of private property mitigations, but that some residents' trust in wildfire response may correspond with reduced performance of mitigation activities that are currently the focus of much wildfire management programming provided to at-risk populations. As such, community leaders, managers, and agency liaisons may find additional traction in promoting wildfire mitigations on private properties by appropriately highlighting capacity issues and FSO limitations that are unique to their regions. Additionally, the higher degrees of trust in LFDs we found in this study highlight the influence these groups may exert in championing additional wildfire mitigations on private property, but especially if they are able to tailor their efforts to the unique characteristics of target populations within their jurisdiction(s).

Credit author statement

Amanda M. Stasiewicz: Conceptualization, Methodology, Formal data analysis, Data visualization, Figure preparation, Writing – original draft, -reviewing and editing. Travis B. Paveglio: Conceptualization, Methodology, Formal data analysis, Writing – original draft, -reviewing and editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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