4-20-2021

Preparing for wildfire evacuation and alternatives: Exploring influences on residents' intended evacuation behaviors and mitigations

Amanda M. Stasiewicz
San Jose State University, amanda.stasiewicz@sjsu.edu

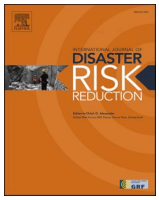
Travis B. Paveglio
University of Idaho

International Journal of Disaster Risk Reduction 58 (2021) 102177

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: http://www.elsevier.com/locate/ijdrr



Preparing for wildfire evacuation and alternatives: Exploring influences on residents' intended evacuation behaviors and mitigations

Amanda M. Stasiewicz [a,*], Travis B. Paveglio [b]

[a] Department of Environmental Studies, San Jose State University, 1 Washington Square Hall, San Jose, CA, 95192, United States
[b] Department of Natural Resources and Society, College of Natural Resources, University of Idaho, 875 Perimeter Drive, Moscow, ID, 83844, USA

ARTICLE INFO

Keywords:
Evacuation
Wildfire
Alternatives to evacuation
Home ignition zone
Mitigation

ABSTRACT

Understanding residents' intended evacuation behaviors is an increasingly important component of managing complex wildfire events in the United States and elsewhere. Growing evidence suggests that local populations consider a range of potential evacuation behaviors during fire events, yet fewer efforts explore rural residents' evacuation intentions or their relationship to wildfire mitigations that reduce risk or aid in fire suppression. This study explores evacuation intentions among wildland-urban interface residents in Pend Oreille County, Washington, USA. We explore how mitigation performance (e.g., fuel reduction efforts, structure improvements, active firefighting preparation) differs across three emergent categories of evacuation intentions and evaluate whether a range of factors correlate with participants' evacuation intentions. Our results suggest that a relatively high proportion of residents in the study area intend to stay and defend their property from a wildfire, with smaller proportions intending to evacuate or shelter in place. Individuals who intend to stay and defend are more likely to implement fuel reduction and property mitigation strategies when compared to those intending to evacuate or shelter in place. We found that elements of residency status, sex, age, presence of children in the home, and perceptions of personal efficacy and whether the property was prepared enough to not need firefighting were significant influences on group affiliation. For instance, part-time residency was significantly correlated with intending to evacuate, while full-time residents were more likely to stay and defend. Greater agreement that firefighting was not needed because a property was well-prepared was significantly related to staying and defending over evacuating.

1. Introduction

Fire and emergency management professionals across several countries promote resident evacuation during wildfire events to prioritize resident safety and minimize the complexity of wildfire management decision-making. Early evacuation from an area threatened by a wildfire event is widely promoted as the safest course of action for populations threatened by wildfire. However, existing research and lessons from wildfire events demonstrate that an early and safe evacuation response may not always be possible for residents (e.g., fast-moving fires, limited ingress and egress). Occasions where residents delay evacuation or do not have enough time to evacuate safely can lead to injuries or fatalities during evacuation (e.g., Black Saturday Fires 2009, AUS; Cedar Fire 2004, USA; Camp Fire 2018, USA) [1–5]. Furthermore, there is a tradition of research and evidence suggesting that residents may choose to remain on their property during wildfire events [6–8], and that they can safely do so if they have made significant preparations (e.g., equipment, training, infrastructure) to implement specific plans [9,10]. Consequently, citizens, managers, and policy makers also discuss various alternatives to evacuation, including: (1) stay and defend (SD), where residents prepare and defend their property from a wildfire by actively putting out spot fires or reducing the probability of structure ignition throughout the fire; and (2) shelter in place (SIP), where residents safely shelter in their home or a common area (e.g., community shelter, school) that protects them from exposure to heat and flames during the primary flame front. Prevailing research on divergent approaches to wildfire mitigation and management in fire-prone areas of the United States suggests that populations characterized by particular patterns of social characteristics (e.g., self-reliance, distrust of government, ties to working landscapes) may be more likely to consider SD as a viable option during fire events [11,12]. Several studies have noted that support for SD actions is particularly prevalent in rural areas [6,13],

* Corresponding author.
E-mail address: amanda.stasiewicz@sjsu.edu (A.M. Stasiewicz).

https://doi.org/10.1016/j.ijdrr.2021.102177
Received 27 August 2020; Received in revised form 1 March 2021; Accepted 7 March 2021
Available online 23 March 2021

while both wildland fire management policies and wildfire studies have highlighted increased interest in enabling certain populations to contribute to wildfire suppression in the U.S. [14–16].

Evacuation intentions (including alternatives to evacuation) require varying degrees of individual preparation to execute safely and effectively. Preparation for such actions may include reducing wildland fuels near structures or across the larger property; home and structure modifications; identifying evacuation routes; delineating temporary lodging; or acquiring and maintaining equipment, skills, and the personal fitness and mental preparedness to safely engage in fire suppression activities [10]. Existing research demonstrates that most individuals living in fire-prone areas are aware of wildfire risk where they live and have created a plan for evacuation or alternatives when fires threaten their property [7,8,17,18]. However, critiques of evacuation policies in the United States (i.e., Ready, Set, Go!) and Australia (i.e., Stay and Defend or Leave Early) contend that such guidance is underdeveloped in outlining the preparatory action, skills, or equipment necessary for effective resident evacuation behaviors [19]. It is still unclear to what extent residents execute various mitigation actions when preparing their property for intended evacuation behaviors, including whether there are distinct differences in the ways that residents prepare their properties across a range of potential options (e.g., evacuation, SD, SIP) [20].

The work presented here builds from select studies to explore the relationship between residents' intended wildfire evacuation behaviors and performance of wildfire mitigations. We use data from a self-reported survey of residents in northeastern Washington state, USA, to examine intended evacuation behaviors across a range of rural populations and determine which structure and vegetation mitigation actions those populations have undertaken to prepare for wildfire events. We also explore the relationship between evacuation preferences and resident characteristics (e.g., residency, age, sex, perceptions of defensibility of property, nearest neighboring property line) to explore factors related to evacuation preferences in rural areas.

2. Literature review

2.1. Evacuation and alternatives to evacuation

Government entities involved in emergency management and wildfire response predominately support resident evacuation during a wildfire event. However, able-bodied adult residents in the United States often retain the right to execute a variety of actions on their private property during a fire event and cannot be required to evacuate [21,22]. Exceptions exist if individuals are less than 18 years old or considered to be a member of a vulnerable population (e.g., sick, unable to make decisions regarding their safety). Resident evacuation during a wildfire event can simplify fire managers' decision-making considerations through the removal of populations who are not actively involved in suppression actions. It can reduce the need for resident rescue, road congestion, or the need to re-evaluate suppression tactics for structure protection due to concerns about civilians being in the area (e.g., backburns, felling trees) [23].

The International Association of Fire Chiefs adopted the "Ready, Set, Go!" (RSG) program across the United States in 2011 to enhance wildfire evacuation planning among fire departments and communities. RSG instructs residents to be: (1) "ready" for evacuation by implementing vegetation management and structure improvements that enhance home survivability and firefighter safety; (2) "set" with provisions, pets, and documents necessary for a short or longer-term evacuation; and (3) for residents to "go" (i.e., evacuate) early during a fire that is likely to threaten their property [24]. The Australian "Stay and Defend or Leave Early" (SDLE) approach and the inclusion of "early" to the US "Ready, Set, Go!" approach both highlight the importance of leaving early if a resident intends to evacuate [25]. There are multiple examples across wildfire and broader natural hazards literature where late evacuations led to congested roadways, exposing evacuees to conditions that increase their inherent risk, including heat stroke, car accidents, or being overtaken by the hazard event (e.g., fire, flood, volcanic eruption) [26].

Several wildfire response and evacuation researchers have raised concerns about mismatches between the pace of residential development in the wildfire-prone areas constituting the wildland urban interface (WUI) and improvement of road networks necessary for evacuating from a wildfire [21,27–31]. Single-lane dirt or gravel roads, limited ingress and egress points, reduced visibility due to smoke and switchbacks, and evacuation of large animals (e.g., horses) or livestock can complicate evacuation dynamics in rural areas around the world [3,5,32–36]. Such challenges highlight a need for increased understandings of rural resident evacuation behaviors in the United States. There is some evidence that rural residents also anticipate an evacuation notice from an official [8,21,37], which can be challenging to deliver in low-density residential areas given that fewer emergency personnel are available in rural areas and cell phone reception can be unreliable (thus impacting Reverse 911 or instant alert texts) [14,38,39]. Multi-stage approaches to evacuation (including RSG) may help perpetuate a notion that US residents can count on advanced notice and multiple warnings when making evacuation decisions. However, fire conditions can create circumstances where risk exposure is too rapid for emergency managers to issue timely warnings or necessitates immediate evacuation. Residents may not be prepared for such circumstances, and dissemination of evacuation notices may be particularly unrealistic among rural properties.

Residents who intend to implement alternatives to evacuation (i.e., SD or SIP) also must conduct significant preparations to successfully implement their strategy and reduce potential risk [9,13]. SIP is commonly considered a last resort and is often contingent on performance of comprehensive mitigations actions such as creating defensible space (e.g., reducing the amount of vegetation within 100–200 ft (~30–61 m) of the home), reducing the ignitability of the home (e.g., using fire-resistant siding, clearing gutters and roofs of debris), and reducing risks to individual safety (e.g., closing windows to keep smoke out, having a drinking water supply). SIP is only possible under high levels of mitigation or in very safe zones because it includes passive resident sheltering from the flame front and toxic fumes with no active resident actions [4,32].

Several studies have noted an increased chance of home survival if someone is present to defend the property during a wildfire event [40–42] and this is one reason for residents' decisions to stay and defend their property [43]. Others intend to SD in cases where evacuation is too dangerous, the intent being to preserve life safety rather than to protect homes or possessions [44]. Governments supporting SDLE often generate information and consultation opportunities to maximize resident and firefighter safety during wildfire response [45], although SD-supportive consultation opportunities are less frequently promoted in U.S. contexts. Individuals planning to stay and defend their property need to be mentally prepared and physically capable of engaging in strenuous fire suppression activities [10]; purchase or establish water sources, generators and equipment (e.g., sprinklers, hoses, rakes, ladders); and have appropriate personal protective equipment (e.g., boots, fire resistant clothing) [9,46,47]. Alternatives to evacuation are not widely promoted in many U.S. contexts, although conversations about incorporating civilians into wildland fire response and community planning for SIP have been increasing in recent years [15,35,48–52].

Existing wildfire research suggests that evacuation behaviors can sometimes be conceived of as a spectrum ranging from evacuation to waiting and seeing and then to staying and defending. The "wait and see" group tends to remain on their property until they feel threatened, which conflicts with messages around leaving early. Rural residents may be more apt to "wait and see" during fire events due to a lack of short- or long-term housing options [53], disruptions to livelihoods (e.g., potential loss of crops, equipment or infrastructure), difficulty finding places to board or keep livestock and large animals [33,54,108], and concerns

about accessing health care or other services in rural regions [55]. Those same considerations also may lead them to consider alternatives to evacuation. Strong cultural ties to the land [56], possession of local knowledge that could be useful in firefighting [14–16,57], an inability to evacuate without assistance [35,109], and the belief or past experience that well-prepared residents can reduce losses to their private property while ensuring life safety are additional reasons threatened populations may choose to employ alternatives to evacuation [40–42].

Individuals with wait and see intentions may reflect intentions to SD unless certain criteria (e.g., fire proximity, smoke) are met [8,13,58,59]. Wait and see intentions also could reflect additional safety risks residents anticipate encountering during the evacuation process (e.g., narrow roads). Additionally, evacuated residents can be denied entry into evacuated areas during wildfires. Such denials can lead to conflict between residents and security personnel; an inability to return from other locations to prepare or defend property from wildfire; and challenges for evacuating pets, animals, or dependents [16,60,61].

2.2. Intended evacuation behavior, mitigation actions, and resident characteristics

Recent and historic wildfires resulting in resident fatalities (e.g., Black Saturday Fires 2009, AUS; Camp Fire 2018, USA) highlight the complexity of evacuation decision-making and executing intended behaviors (i.e., SD, SIP, evacuate) safely. Those fires underscore how intended evacuation plans can become difficult to implement during changing fire circumstances and their contingency on others' actions before or during the wildfire event. Such understandings highlight a broader need to explore the mitigations individuals with different evacuation preferences are preforming to prepare their property to survive the fire event. Vegetation mitigations in the home ignition zone (HIZ)—the 100 to 200-foot (~30–60 m) area surrounding a structure—are often a focal point of preparing properties for any evacuation behavior. Paveglio et al. [6] found several significant differences in performance of vegetation mitigations across groups of individuals intending to evacuate, SD or SIP, the latter of which also included residents uncertain of their intended evacuation behavior (hereafter "SIP/I don't know"). For instance, the SD group was significantly more likely than the SIP/I don't know group to implement vegetation mitigation actions in the HIZ. Differential performance of mitigations among evacuation groups also extended across actions in different "zones" outlined for the HIZ (e.g., 0–30 feet (~0–10 m), 30–100 feet (~10–30 m) and 100–200 feet (~30–60 m)) [6,58]. These actions include: (1) stacking firewood and lumber more than 30 feet (10 m) from the structure; (2) clearing leaves and other debris from roofs, gutters, or decks; and (3) using non-combustible materials in structure construction, among others. Additional measures, such as installing sprinklers on structure roofs or around a home could also facilitate active or passive home defense by decreasing property ignition potential without requiring an individual to actively engage in fire suppression. Edgeley and Paveglio [58] found that individuals intending to evacuate in McCall, Idaho, USA, were significantly more likely to establish a water supply for firefighting than members of the SIP/I don't know group. The authors also found that SD individuals were more likely to utilize fire-resistant plants in their landscaping than individuals who intended to evacuate [58].

Existing wildfire literature illuminates some potential explanations surrounding residents' preferences for evacuation or alternatives to evacuation. For instance, several studies indicate that men are generally more likely than women to remain during a wildfire event to defend property [7,62–65]. Children under the age of 18, elderly individuals, pregnant women, or individuals with health concerns (e.g., asthma) often are inclined and encouraged to evacuate early [7,43,66–69] with other adults often feeling compelled to accompany them [62]. Some have found that part-time residents are more likely to evacuate when compared to full-time residents, the latter of which are more likely to SD [6,58]. Additionally, individuals' perceptions of their capabilities and efficacy, and those of firefighters to defend their home, also have a variable influence on resident decision-making surrounding evacuation [8,54,70,71].

The research presented here builds from and replicates portions of the preceding research by investigating rural residents' intended evacuation behaviors, their performance of mitigations, and potential influences on their choice of a particular evacuation preference category. We investigate the utility of an existing measurement scale for assessing evacuation preferences categories across a gradient of residential development. We explore performance of mitigation actions across intended evacuation behaviors to examine how rural residents are preparing for future wildfires. Our geographically stratified sample and focus on rural WUI populations allows us to expand investigation to less studied populations with regards to evacuation planning in the U.S. We use the following research questions to guide our investigation:

1) What types of actions do residents intend to implement during a wildfire event?
2) How does property-level wildfire risk mitigation vary across emergent evacuation groups?
3) What resident characteristics and perceptions of individual and firefighter efficacy correlate with evacuation preferences?

3. Methods and materials

3.1. Study area and sample frame

We selected Pend Oreille County in northeastern Washington, USA, as our study area due to previous research indicating that populations in the county were "socially fragmented," indicating the presence of socially diverse populations featuring individuals who were likely to select and implement a range of approaches to wildfire risk mitigation or evacuation [72]. Pend Oreille County is predominately comprised of rural populations that are not affiliated with a census-designated city and has a high proportion of public lands inducing historical ties to natural resource industries, recreation or tourism, and amenity migration. Participants in Paveglio et al.'s [72] study noted that dense residential development around multiple lakes in the southern portion of the county raised potential challenges regarding quick and effective evacuation. They also noted how select populations in the area with a long history of resource extraction and utilization (i.e., timber and agriculture) or personal independence meant that some residents prefer to stay and defend their properties or contribute equipment and skills during active wildfire suppression. Participants also noted dramatic variation in residential development patterns (e.g., parcel size and dimensions), residency status, and a continued influx of amenity migrants and retirees, all of which might influence evacuation dynamics [72]. As such, the area presented a strong opportunity for a study exploring differential approaches to evacuation across a range of development types (e.g., developed-to-rural) and a variety of socio-demographic characteristics.

The sample frame for this research effort began with four lakes identified by key informants and study participants as representative of the areas of dense development within the predominately rural area [72]. We sampled across three distinct geographic zones extending from each lake in order to capture potential geographic variation across populations ranging from dense lakeside development to larger, more rural properties near large tracts of public lands. We used waterbody shapefiles acquired from the Washington National Hydrography Dataset Area or NHD Waterbody Layers [107] as a geographic reference for delineating geographic zones. More specifically, we used waterbody layers and GIS parcel data acquired from the Pend Oreille County Assessor's Office to identify potential study participants across three distinct zones extending from each lake. The region 1 buffer extended 500 feet from a lake edge and was comprised of any residential parcels

(e.g., homes, cabins, mobile homes) with a centroid within that 500-foot (~152 m) zone. The region 2 buffer encompassed all residential parcels with a centroid up to 1.5 miles (~2.4 km) from the outer edge of region 1. The region 3 buffer consisted of all residential parcels with a centroid within 1.5 miles of the outer edge of region 2. The 1.5-mile (~2.4 km) buffer distance represents a commonly referenced measure for delineating the WUI and the distance an ember can travel from a forest fire and ignite flammable materials at a distant location [73]. Our distance buffer and sampling approach also mirrors existing research exploring resident evacuation and private landowner performance of wildfire mitigations (e.g., Refs. [58,74]. Parcels associated with land trusts, businesses or commercial use, apartments, or condominiums were removed from the sample frame to ensure that recruited participants represented residential property owners who might be evacuated during a wildfire event, and who have the ability to make decisions about mitigating wildfire risk on the property. Surveys were only delivered to the primary tax mailing address of owners to ensure that residents in the study area were asked to respond to only one survey about their primary residential property in the region.

We administered a survey to the sample frame in August 2018 using a mixed-mode approach tailored to residential types in the region. More specifically, we (1) sent a mail survey to second homeowners (what others sometimes refer to as part-time residents or recreational property owners) using the methods recommended by Dillman et al. [75] (i.e., the "Tailored Design Method") and (2) conducted a drop-off, pick-up approach among primary residential property owners [76,77]. We used GIS parcel and tax data to assign each parcel in the sample frame as primary or secondary and determine the most appropriate administration method. Members of the research team visited primary residences in-person as part of the drop-off, pick-up administration mode to deliver, discuss, and collect the survey. We elected to use a drop-off, pick-up approach to administer the survey to primary residents because of its documented propensity for yielding higher response rates than mail surveys when in rural areas, especially when implemented in geographically distinct areas [76,77]. A team of five researchers visited primary residences (n=600) during 15 consecutive days to deliver and collect surveys using a shared protocol. Each researcher arranged to return to collect the completed survey within 24 hours. If surveys were not completed at the agreed upon pick-up time, researchers revisited properties in a systematic fashion to ensure adequate opportunities to contact participants and ample time for participants to complete surveys. We elected to focus our drop-off, pick-up efforts on two lakes with the highest populations to maximize opportunities for response to permit the research team to make multiple return trips when necessary.

Mail survey administration was extended to populations across all four lakes to compensate for potential lower survey response rates from second homeowners across the sample. We administered the mail survey to 957 second homeowners in August 2018. We utilized sequential mailing phases adapted from Dillman et al. [75] to administer the mail survey to remote participants, including: (1) an introductory letter; (2) a survey booklet and a prepaid return envelope; (3) a thank you/reminder postcard with the option complete the survey online using Qualtrics; and (4) a final reminder letter with second invitation to complete the online survey. Each mailing was sent approximately 1-week apart.

We administered surveys to a total of 1513 residential landowners. We collected or received a combined total of 770 completed surveys for a collective response rate of 49.5%. The response rate for the drop-off, pick-up effort was considerably higher (470 completed surveys, 78.3% response rate) than the mail/online effort (300 completed surveys, 31.3% response rate).

3.2. Select survey measures

The survey instrument for this research adapted and expanded questionnaires used to study intended evacuation behaviors and wildfire mitigation efforts in McCall, Idaho, and Flathead County, Montana (e.g., Refs. [6,58,74]). The 16-page survey used in this study included questions regarding the performance of parcel-level wildfire mitigation actions, intended behaviors during a wildfire event, perspectives about wildfire management and suppression, and respondents' sociodemographic characteristics.

We explored respondents' intended evacuation behaviors using nine, 5-point, agree-disagree Likert scale questions. Statements covered a variety of related actions observed across wildfire evacuation events, and were replicated from past studies (see Refs. [6,58]) and were also informed by wildfire preparedness check-lists or other studies (e.g., Refs. [78,79]; Price et al., 2016; [80]). Those measures are outlined in Table 2. We asked each respondent whether they had performed various mitigation actions in different zones of the HIZ or as broader means to improve firefighter safety using a series of dichotomous (i.e., yes/no) measures. Mitigation questions were grouped by HIZ zone. Six mitigation statements related to home survivability and the immediate HIZ zone (0–5 feet or ~1.5 m from the home), four addressed typical fuel reduction actions related to tree and shrub management and dispersion in HIZ 1, three focused on vegetation mitigations in HIZ 2, and two addressed vegetation mitigations in HIZ 3 (see Tables 2 and 3 for mitigations included). An additional group of measures implicated actions often promoted as necessary to safely defend properties or provide firefighters with opportunities to safely protect private property (see Table 2).

Respondents were asked a series of sociodemographic questions referenced in broader literature as salient indicators of intended evacuation behaviors. These sociodemographic variables included residency status (i.e., full-time, part-time), sex, age, and whether there were children under the age of 18 living on the property during the wildfire season (i.e., May–October). Participants also were asked to indicate their level of agreement or disagreement with three statements concerning their perceived efficacy to address wildfire risk and that of professional firefighters due to past research indicating potential influence of such beliefs on evacuation behaviors [8,9,33,70,81]. More specifically, statements covered: (1) residents' perceived ability to protect their property from fire impacts; (2) perceived ability of professionals to prevent damages to their property; and (3) whether firefighting would be less necessary on their property because it is well prepared.

Table 1
Description of independent variables for multinomial logistic regression.

Variable	N	Range (response frequency)	Mean (SD)
Residency	755	1= Full time (63.7%) 0= Part time (36.3%)	
Sex	702	1= Male (57.4%) 0= Female (42.6%)	
Age	683	Range: 20-96	62.67 (12.59)
Children <18 years old present during fire season	692	1= present during fire season (May–October) (34.4%) 0= not present (65.6%)	
My ability to protect my property from fire impacts	717	−2= Strongly disagree −1= Moderately disagree 0= Neutral 1= Moderately Agree 2= Strongly Agree	0.67 (1.31)
The ability of professionals to prevent damages to my property	729	−2= Strongly disagree −1= Moderately disagree 0= Neutral 1= Moderately Agree 2= Strongly Agree	0.92 (1.26)
Firefighting would be less necessary on my property because it is well prepared	719	−2= Strongly disagree −1= Moderately disagree 0= Neutral 1= Moderately Agree 2= Strongly Agree	−0.34 (1.11)

Table 2
Mean Likert response by evacuation preference category. Higher mean values are associated with greater agreement with the statement based on a 5-point scale where 5= strongly agree and 1=strongly disagree.

Evacuation statement	Evacuate	Stay and defend	Shelter in place/I don't know
I would remain at home and help defend my home by putting out spot fires	2.06	**4.34**	3.59
I would evacuate as soon as I hear about a fire that may impact my property	**4.14**	2.04	2.93
I would wait to see how bad the wildfire is and evacuate if I think it is too dangerous	2.22	**4.02**	3.67
Some members of this household would evacuate and others would remain to protect the property	1.47	**3.47**	2.72
I would evacuate when the authorities tell me to do so	**4.73**	3.94	4.36
My neighbors and I would work together to evacuate promptly	**3.99**	3.32	3.50
I would remain on my POC property regardless of authorities' evacuation orders	1.07	**2.23**	1.72
I would remain at home and safely shelter in my home without putting out spot fires	1.18	1.23	**2.12**
I would not know what to do during a wildfire	1.94	1.51	**3.28**
n=	200	289	186

3.3. Analysis

Analysis of survey responses was conducted using the quantitative data analysis software package SPSS 26 (IBM, 2020). We began by performing an exploratory principal components analysis with a Varimax rotation and Kaiser normalization on data associated with the nine evacuation preference measures (see left column of Table 1). Principal components analysis provides the means to derive a smaller set of variables (i.e., principal components) from a larger list while still explaining a similar amount of observed variance. Principal components analysis is one strategy for informing the creation of composite variables as it partitions the variance explained by the larger set into independent linear combinations of associated measures. Principal components that had eigenvalues greater than one were retained for continued analysis [82,83]. We used results from the principal components analysis to inform a k-means cluster analysis [84]; we calculated individual average scores for each resident for each component. K-means cluster analysis is an algorithm that groups similar individuals into "clusters" that are distinct from each other. Individuals classified as a group are broadly similar based on distance from the cluster mean (i.e., centroid). Respondents who did not answer all nine evacuation-related statements were excluded from sample and subsequent analysis.

We used Pearson's Chi square tests to explore whether there were statistically significant differences in performance of various wildfire mitigations across the three evacuation preference classes that emerged from our principal components and k-means cluster analyses. Post-hoc z-tests with a Bonferroni correction were used in concert with the Pearson's Chi square to evaluate significant differences in performance across each evacuation group.

We used multinomial logistic regression [85,86] to estimate the relationships between individual respondent characteristics (e.g., sex, residency status, age) or their perceptions about efficacy, and their dominant evacuation intention (i.e., evacuate, SD, SIP). Multinomial logistic regression is appropriate when the dependent variable is categorial, as is the case with our evacuation intention groupings. We used evacuation as the reference category in the regression, as it is the most commonly advocated strategy during wildfire events.

4. Results

4.1. Population descriptive statistics

Descriptive statistics for the independent variables utilized in our multinomial logistic regression are presented in Table 1. Nearly two-thirds of our sample was comprised of full-time residents (full time=63.7%; part-time=36.3%) and 57.4% of the population was male (female=42.6%). Participants were 20–96 years old with an average age of 62.67 years (SD=12.59). Approximately one-third of respondents (34.4%) had at least one child under the age of 18 years old on premises during the fire season (May–October). Study participants reported slight agreement that they had the personal ability to protect their property from fire impacts (M=0.67; SD=1.31) and that firefighters had the ability to prevent damages on their property (M=0.92; SD=1.26). On average, residents also reported slight disagreement with the statement that firefighting would be less necessary on their property because it is well prepared for wildfire (M=−0.34; SD=1.11).

Table 3
Percentage performance and significant differences in Home Ignition Zone (HIZ) property defense and HIZ 0/immediate zone mitigations across evacuation preference categories.

Property defense mitigation	Evacuate (a)	Stay and defend (b)	Shelter in place/I don't know (c)	X^2
Designated a safe zone on my property (e.g., structure, pool, bare ground) where people could safely shelter as a fire passed	35.4%	45.3%	37.4%	.064
Purchased a generator to help power water pumps or provide electricity during a wildfire event	32.5%$_a$	57.0%$_b$	41.7%$_b$	<.001***
Established a water supply for firefighting	42.8% $_a$	57.2% $_b$	45.9% $_a$	.004**
Ensured that the driveway meets access requirements for emergency vehicles	62.6% $_a$	84.0% $_b$	70.9% $_a$	<.001***
Installed external (outdoor) sprinklers on my home	22.2%	24.6%	24.4%	.813
Installed external sprinklers that can reach up to 50 ft (15 m) away from my house	15.0% $_a$	25.5% $_b$	23.2% $_{a,b}$	.021*
HIZ 0/immediate zone mitigation (0–5 feet, ~1.5 m)	Evacuate (a)	Stay and defend (b)	Shelter in place/I don't know (c)	X^2
Used non-flammable siding materials such as tile, slate, brick, heavy timber or stone	30.6%	31.9%	31.4%	.952
Stacked firewood/lumber at least 30 feet from the residence	61.9% $_a$	74.1% $_b$	68.2% $_{a,b}$	.017*
Planted fire-resistant plants around the residence	16.3%	22.1%	18.5%	.284
Regularly removed the accumulation of needles and leaves from roofs, gutters, or decks	90.9% $_{a,b}$	93.4% $_b$	86.3% $_a$	.036*
Removed any flammable materials or vegetation within 5 feet of your home	71.9% $_a$	82.2% $_b$	76.7% $_{a,b}$	.026*

Subscripts indicate which evacuation preference categories differ at the 0.05 error level.
Probabilities are significant at: *, $P < .05$; **, $P < .01$; ***, $P < .001$.

4.2. Stated evacuation preferences

Table 2 provides mean responses to the nine evacuation statements included in our analysis. More than half of our study participants moderately (33.9%) or strongly agreed (26.9%) that they would remain on their Pend Oreille County property and help defend their home by putting out spot fires. Thirty-six percent of residents (19.7% moderately agreed, 16.3% strongly agreed) indicated that they would evacuate as soon as they heard about a fire that may impact their property. Many residents demonstrated support for a wait and see approach, with 32.0% moderately agreeing and 26.2% strongly agreeing that they would wait and see how bad a wildfire was and evacuate if they thought it was too dangerous. Approximately one-third of respondents reported that household members would split their response, with some evacuating and some remaining to protect the property (20.8% moderately agreed, 14.7% strongly agreed). Study participants indicated an overall intention to comply with authorities' evacuation orders, with 62.4% strongly and 18.9% moderately agreeing that they would evacuate when authorities told them to do so. A relatively high proportion of respondents indicated moderate agreement (29.2%) or strong agreement (24.4%) that they would work with their neighbors to evacuate promptly. Few in the study population intended to remain on their property regardless of authorities' evacuation orders (moderately agreed=5.1%, strongly agree= 5.1%). Overall, study participants did not indicate an intent to passively shelter in place, with only 2.7% of participants moderately agreeing and 2.5% strongly agreeing they would implement passive SIP. Few residents indicated that they had not considered their wildfire plans, with 9.7% moderately agreeing and 4.9% strongly agreeing that they would not know what to do during a wildfire event.

Results of the principal components analysis revealed three principal components with eigenvalues greater than 1. These three principal components explained 59.1% of the variance in the nine evacuation behaviors (see Table 2). The Kaiser-Meyer-Olkin measure resulting from the principal components analysis was 0.726, which indicates that our survey size was adequate for the analysis. Rotated factor loadings for individual measures ranged from 0.63 to 0.86. The Bartlett's test of sphericity was highly significant ($p < .001$) resulting in a rejection of the null hypothesis [82] and support for deriving components from our data. The resulting components generally reflected three evacuation preference categories matching past studies using similar measures, specifically: (1) evacuate, (2) stay and defend (SD), and (3) shelter in place (SIP)/I don't know. Subsequent classification of respondents using the k-means cluster analysis resulted in 29.6% of respondents' preferences most closely aligning with the evacuate category, 42.8% aligning with the SD category, and 27.6% with the SIP/I don't know category.

Residents in the SD category reflected intentions to remain at home and help defend their properties by putting out spot fires (rotated factor loading= 0.80) and to not evacuate immediately (rotated factor loading= −0.74). Members of the SD category also had a propensity to wait and see how bad the fire was and evacuate if they thought it was too dangerous (rotated factor loading=0.75), They also were more likely to indicate that their households would implement a split evacuation response, with some members evacuating and others staying to protect the property (rotated factor loading= 0.66). Participants in the evacuate category indicated intentions to evacuate when authorities told them to do so (rotated factor loading=0.86), to work with neighbors to evacuate promptly (rotated factor loading=0.63), and to not ignore authorities' recommendations (rotated factor loading= −0.75). Members of the SIP/I don't know category were most likely to remain at home and not suppress spot fires (rotated factor loading= 0.76) or indicate that they do not know what to do during a wildfire event (rotated factor loading=0.67). Mean Likert responses for each group are provided in Table 2.

4.3. Evacuation preference and wildfire mitigations

Comparisons across intended evacuation behavior categories suggest significant differences in performance of property-level wildfire risk mitigation across zones of the HIZ. The Chi square test revealed significant or highly significant differences in the performance of four property defense mitigations (see Table 3). More specifically, there were significant differences between evacuation groups with regards to purchasing a generator, establishing a water supply for firefighting, ensuring that the driveway meets emergency vehicle access requirements, and installing external sprinklers that reach up to 50 feet (15 m) from the home. Tests of proportions between groups revealed that respondents in the evacuate category were least likely to purchase a generator to help power water pumps or provide electricity during a wildfire event ($p < .001$), with members of the SD group and SIP group both significantly more likely to have performed those mitigations. Members of the SD group were more likely to establish a water supply for firefighting ($p=.004$) and ensure their driveway met access requirements for emergency vehicles ($p < .001$) in comparison to the other evacuation preference groups. The SD group was also more likely to install external sprinklers that could reach up to 50 feet (15 m) from the home when compared to the evacuate group, but not the SIP/I don't know group ($p=.021$).

Chi square tests for mitigations in the immediate HIZ zone (i.e., HIZ 0) revealed three significant differences in mitigation performance across evacuation groups (see Table 3). Individuals in the SD group were more likely to stack firewood/lumber 30 feet (~9 m) from their home ($p=.017$) and remove flammable materials within 5 feet (~1.5 m) of their home ($p=.026$) when compared to members of the evacuate group, but not the SIP/I don't know group. Respondents affiliated with the SD group were more likely to regularly remove the accumulation of needles and leaves from roofs, gutters, or decks than members of the SIP/I don't know group, but not the evacuate group ($p=.036$).

Results of the Chi square tests and subsequent tests of proportions among evacuation groups for vegetation mitigations in the HIZ are provided in Table 4. For HIZ 1 vegetation mitigations, members of the SD group were more likely to remove branches of trees lower than 10 feet (~3 m) from the ground than members of the SIP/I don't know group, but could not be distinguished from the evacuate group ($p=.002$). Members of the SD group were also more likely to clear or maintain a 30 foot (~9 m) "green space" around their home ($p < .001$) and space trees or shrubs at least 10 feet (~3 m) apart ($p < .001$) when compared to either of the other groups. There were also highly significant differences in performance of vegetation mitigations in HIZ 2 and HIZ 3 across evacuation groups. Respondents in the SD category were more likely to perform all five mitigations in the HIZ 2 and 3 categories when compared to members of the evacuate or SIP/I don't know groups. For HIZ 2 specifically, SD individuals were more likely than members of both the evacuate and SIP/I don't know groups to (1) remove/thin trees and shrubs to reduce the density of vegetation ($p < .001$), (2) remove branches of trees less than 10 feet (~3 m) from the ground ($p < .001$), and (3) maintain thinning of trees and shrubs performed more than 10 years ago ($p < .001$). Members of the SD group also were significantly more likely to remove/thin trees and shrubs to reduce the density of vegetation in HIZ 3 ($p < .001$) and maintain thinning of trees and shrubs in HIZ 3 performed more than 10 years ago ($p < .001$).

4.4. Influences on intended evacuation behavior during wildfire

Results of our multinomial logistic regressions are outlined in Table 5. The final model explains a significant amount of variation in evacuation group affiliation (likelihood ratio $X^2= 186.085$, $p < .001$), and a relatively high amount of variance in the sample. Full-time residents were more likely than part-time residents to be in the SD category when compared to the evacuate category (B=1.176, $p < .001$), all else constant. The odds ratio associated with the multinomial logistic

Table 4
Percentage performance and significant differences across HIZ zones for vegetation mitigations across evacuation preference categories.

HIZ 1 vegetation mitigations (0–30 feet, ~9 m from home)	Evacuate (a)	Stay and defend (b)	Shelter in place/I don't know (c)	X^2
Removed trees less than 10 ft from your home	59.1%	68.2%	58.2%	.042*
Removed branches of trees lower than 10 feet from the ground	70.3% $_{a,b}$	76.7% $_{b}$	61.5% $_{a}$	.002**
Cleared or maintained a 30 ft "green space" around home	46.7% $_{a}$	69.8% $_{b}$	44.7% $_{a}$	<.001***
Spaced trees or shrubs at least 10 feet apart	25.2% $_{a}$	53.0% $_{b}$	21.8% $_{a}$	<.001***
HIZ 2 vegetation mitigations (30–100 feet, ~9–30 m, from home)	Evacuate (a)	Stay and defend (b)	Shelter in place/I don't know (c)	X^2
Removed/thinned trees and shrubs to reduce the density of vegetation	58.6% $_{a}$	73.3% $_{b}$	56.8% $_{a}$	<.001***
Removed branches of trees lower than 10 feet from the ground	52.0% $_{a}$	63.0% $_{b}$	44.5% $_{a}$	<.001***
Maintained thinning of trees and shrubs performed more than 10 years ago	44.9% $_{a}$	59.4% $_{b}$	38.0% $_{a}$	<.001***
HIZ 3 vegetation mitigations (100–200 feet, ~30–60 m from home)	Evacuate (a)	Stay and defend (b)	Shelter in place/I don't know (c)	X^2
Removed/thinned trees and shrubs to reduce the density of vegetation	34.4%$_{a}$	53.0%$_{b}$	37.4%$_{a}$	<.001***
Maintained thinning of trees and shrubs performed more than 10 years ago	65.6%$_{a}$	47.0%$_{b}$	62.6%$_{a}$	<.001***

Subscripts indicate which evacuation preference categories differ at the 0.05 error level.
Probabilities are significant at: *, $P < .05$; **, $P < .01$; ***, $P < .001$.

regression indicates that as residency status changes from part-time (0) to full-time (1) the change in the odds of being in the SD category rather than the evacuate category is 3.241. Put another way, the odds of a full-time resident being in the SD category is approximately 3.24 times more likely than for part-time residents. The sex of the respondent significantly influenced whether a respondent was affiliated with the SD or evacuate group, all else constant. Male residents were approximately 3.53 times more likely to be in the SD category than the evacuate category (B= 1.260, p<.001) and nearly twice as likely to be in the SIP/I don't know category than the evacuate category when compared to females (B=0.687, p=.005). Older respondents were significantly more likely to be in the SIP category rather than the evacuate category (B=0.020, p=.045), all else constant.

Initial regressions and exploration of collinearity diagnostics led us to explore additional interactions between conceptually related independent variables. Specifically, we introduced an interaction term for the presence of children during wildfire season and age variables. We found a significant and negative interaction effect between these two variables when comparing the SD and evacuate categories (B=−0.049, p=.011). The odds ratio tells us that as age increases in combination with having children present on site during fire season (May–October) the change in the odds of staying and defending rather than evacuating was 0.95. Put another way, as the presence of children changes from none (0) to present (1), younger residents become less likely to stay and defend and more likely to evacuate.

Respondents who indicated that their decision to evacuate would be influenced by personal ability to protect their property from wildfire impacts were two times more likely to be in the SD category (B=0.751, $p < .001$) when compared to the evacuate category. Individuals who displayed higher levels of agreement that their personal ability to protect their property from wildfire impacts would influence their decision to evacuate were also nearly two times more likely to be in the SIP/I don't know evacuation intention category when compared to the evacuation group (B=0.474, $p < .001$). Study participants reporting higher levels of agreement that firefighting would be less necessary on their property because it is well prepared were significantly more likely to be affiliated with the SD category (B=0.440, $p < .001$) when compared to the evacuate group.

5. Discussion

This research sought to explore intended wildfire evacuation behaviors in a rural U.S. setting and their relationship with residents' performance of structural, vegetative, and property defense actions in the home ignition zone (HIZ). We also were interested in whether select respondent attitudes help explain evacuation preferences. We found significant differences in wildfire preparation activities performed by respondents across the evacuation groups that emerged from our analysis, with the greatest number of differences occurring between the SD category and the evacuation/SIP groups. This finding corroborates existing research suggesting that individuals' planned evacuation behavior during wildfire can correspond with the mitigation actions they are willing to undertake [6,58,67,87,88]. For instance, performance of nearly all vegetation mitigations in the HIZ gauged for this research differed across at least two of the evacuation groups that resulted from our analysis. However, it appears that actions related to HIZ 0 were less likely to differ among groups and these patterns are more inconsistent. Finally, we found that select respondent characteristics significantly correlated with evacuation preferences, including residency, sex, age, the interaction between age and the presence of children on site during fire season, and perceptions of personal self-efficacy related to fire suppression.

The three evacuation preference categories emerging from our principal components analysis match commonly reported approaches outlined in existing literature on wildfire evacuation behavior [8,18,54,68,89]. They also reflect the evacuation preference patterns and factor loadings found in other studies utilizing a similar survey instrument and evacuation statements, suggesting the scale used provides a reliable means for understanding intended evacuation behavior [6,58]. In particular, the consistent performance of the evacuation scale across three studies— (1) sampling across a rural county [6], (2) a small city [58], and (3) our study of rural lake populations further demonstrates the integrity of these prompts as a base scale for exploring wildfire evacuation behaviors across populations. We found few significant differences between the SIP/I don't know and evacuate groups in our study area, which suggests that these groups may have more in common in this location when compared to other study sites. A potential explanation is that there may be overlap around the "wait and see" approach to evacuation where respondents' are hesitating between leaving early and staying and defending. Another potential explanation is that members of our rural study population who largely do not intend to SD may be reluctant to evacuate early due to the distance they may have to evacuate to find short or longer-term housing and the need to evacuate and board pets and livestock [33,53,54,108]. Like Edgeley and Paveglio [58], additional measures could be incorporated into the suite of evacuation prompts to examine the existence of more nuanced descriptions outlined in evacuation "archetypes" emerging in broader evacuation literature (see Ref. [68]).

Residents in our Pend Oreille County, WA, sample displayed several similarities when compared with results from an evacuation study in McCall, ID [58]. The population in the Flathead County, MT study [6] was more likely to agree or strongly agree that they would stay and defend or wait and see how bad the fire was before evacuating. All three populations displayed a high preference (i.e., moderately agree or

Table 5
Results of multinomial logistic regression for variables influencing intended behavior during a wildfire. Variable coding provided in Table 1.

	Stay and Defend vs. Evacuate					SIP/I don't know vs. Evacuate				
	95% CI for Odds Ratio					95% CI for Odds Ratio				
	Lower	Odds Ratio	Upper	B (SE)	Sig	Lower	Odds Ratio	Upper	B (SE)	Sig
Demographics										
Residency	1.979	3.241	5.307	1.176 (0.252)	<.001***	1.048	1.705	2.775	0.534 (0.248)	.032*
Sex	2.190	3.527	5.679	1.260 (0.243)	<.001***	0.687	1.987	3.193	0.687 (0.242)	.005**
Age	0.985	1.012	1.040	0.012 (0.014)	.382	1.001	1.031	1.062	0.020 (0.015)	.045*
Children under 18 years old present during fire season	0.832	8.281	82.397	2.114 (1.172)	.071	0.384	2.689	57.230	1.545 (1.276)	.226
Children*Age	0.917	0.952	0.989	−0.049 (0.019)	.011*	0.931	0.969	1.009	−0.31 (0.020)	.123
How influential or uninfluential are the following factors in your decision to evacuate										
My ability to protect my property from fire impacts	1.639	2.045	2.551	0.715 (0.113)	<.001***	1.298	1.606	1.987	0.474 (0.209)	<.001***
The ability of professionals to prevent damages to my property	0.805	1.005	1.255	0.005 (0.113)	.967	0.838	1.046	1.305	0.045 (0.113)	.694
Please indicate the extent to which you agree or disagree with the following statements about firefighting in Pend Oreille County										
Firefighting would be less necessary on my property because it is well prepared	1.257	1.553	1.918	0.440 (0.108)	<.001***	0.997	1.235	1.529	0.221 (0.109)	.053

Note: R^2= 0.274 (Cox and Snell), R^2= 0.310 (Nagelkerke). Model $X^2(16) = 186.085$, $p < .001$. Alkaike Information Criteria (AIC): Intercept only= 1241.121, final= 1087.036.
*$p < .05$; **$p < .01$; ***$p < .001$.
Evacuate is the reference category

strongly agree) for evacuating when authorities told them to do so (MT: 77.5%, ID: 81.2%, WA: 81.3%). Concurrently, all three populations indicated low levels of agreement with the statement that they would evacuate as soon as they heard about a fire that may impact their property (MT: 27.2%, ID: 32.9%, WA: 36.0%). These consistencies may begin to underscore that populations in the region are generally responsive to evacuation orders from authorities, but may not be as likely to evacuate promptly during wildfire in the absence of explicit directions from professionals. Expectations of evacuation orders from authorities in rural areas, including our study area, may pose additional problems for resident safety during a fire event because evacuation cues can be challenging to deliver to dispersed, rural homes serviced by few emergency personnel. Inconsistent internet and cell service can also represent an obstacle to fire and evacuation information delivery via social media, email, or text alert in remote areas [14,38,55,90]. The convergence of expected evacuation notices from authorities and difficulties communicating with rural populations may exacerbate a need for adaptive evacuation plans and alternatives to evacuation in rural, fire-prone areas.

Our research broadens understandings about planned evacuation behavior by linking them to a broader set of mitigations or attitudes. This includes a focus on preparations related to the SD and SIP evacuation categories, including home defense actions or those that facilitate fire suppression response effectiveness. We found that members of the SD group were significantly more likely to establish a water supply for firefighting and to clear their driveways for emergency vehicle access than the other two evacuation groups emerging from our data, potentially hinting at an elevated consciousness of potential water resource scarcity, a need for support from fire professionals during their stay and defend effort, and/or a need for a safe evacuation route if they become overwhelmed and unable to shelter in their home. SD and SIP/I don't know members were more likely to purchase a generator than evacuate group members, which may imply that these groups are thinking about how to enable their remaining on site during a wildfire if electricity was lost. Expansion of the evacuation prompts described above, and their pairing with motivations for performing different mitigation actions in future studies could help explore these linkages further. SD group members were more likely to install sprinklers that can reach up to 50 feet (15 m) from the home—a strategy increasingly heralded as a benefit for home defense during active suppression or for mitigating property damage in the absence of firefighter response [91,92]. Overall, SD group members were frequently more likely to implement home defense actions than members of the evacuate group and SIP/I don't know groups. Similarly, Edgeley and Paveglio [58] found that members of the evacuate group in McCall were more likely to implement various preparations for evacuation than both the SD and SIP/I don't know group (i.e., identify a place to stay, identify an evacuation route). Collectively, these results demonstrate that residents interested in more active forms of evacuation behavior, such as SD, are more likely to take on additional mitigation responsibilities recommended for private property owners to enhance firefighter safety and effectiveness in the wildland-urban interface, potentially because they perceive of themselves as being in a firefighter's position.

We found that performance of several actions related to home survivability and mitigations in the immediate zone (i.e., HIZ 0) also were significantly different across evacuation categories. For instance, our results indicate that members of the SD category were more likely to perform wildfire-related landscaping and home maintenance tasks (removing flammable vegetation within 5 feet (1.5 m) of the home; stacking firewood/lumber at least 30 feet (~9 m) from the home) than members of the evacuate category and more likely to remove needles and leaves from roofs, gutters, and decks than members of the SIP/I don't know category. This contrasts the findings of Paveglio et al. [6], who did not uncover significant differences in performance of these actions across similar evacuation groups among Flathead county participants. For example, Paveglio et al. [6] did not find significant differences between evacuation groups with regard to stacking firewood at least 30 feet (~9 m) from the home or regularly removing the

accumulation of needles and leaves from roofs, gutters, or decks. Since Paveglio et al. [6] collected their data in 2011, the "fire-adapted community" messaging now associated with the National Cohesive Management Strategy (2014) and Firewise/USA program in the U.S. has become increasingly widespread. This may be one reason why the proportion of our study population that performed many of the HIZ 0 tasks (e.g., using fire-resistant plants in landscape, using non-flammable siding materials) was more than twice those who reported performing the mitigations in Flathead, Montana, USA in 2011. Differences in local culture, engagement with outreach efforts, and trust in local officials also may be reasons for these differences. Such trends may also highlight temporal shifts in national conversations about private landowner responsibility for mitigating wildfire risk and the influence of large, highly impactful wildfires in the western U.S. since the Flathead study (i.e., Camp Fire, Thomas Fire, Carlton and Okanogan Complex fires).

The categorization of many fire risk mitigations in HIZ 0 as "routine housekeeping" and landscaping chores can make it challenging to identify factors that make individuals more likely to implement those actions specifically to reduce fire risk. Likewise, socio-demographic indicators can be inconsistent predictors of such actions [93]. The emergence of several statistically significant differences between evacuation groups around our suite of HIZ 0 actions and the general lack of significant relationships found by others suggests it is a topic that warrants future consideration in other evacuation studies. Many of the actions our SD group members performed are less likely to overlap with housekeeping or landscaping tasks and may be more of a direct resident response to concerns about fire risk. Future research should explore these linkages in more depth and/or confirm that such actions were taken to facilitate potential evacuation strategies. Such studies could explore respondents' interactions with fire department or emergency professionals about their intended evacuation behavior and what resources or support they accessed to implement their decision, especially as conversations around increasing local suppression capacities increase in the U.S. context [14–16,94].

Individuals in the SD category were often significantly more likely to implement vegetation mitigations in HIZ 1, 2, and 3, with the exception of maintaining thinning of trees and shrubs in HIZ 3 performed more than 10 years ago (100–200 feet, ~30–60 m, from the home). However, SD group members were more likely than the other groups to *themselves* remove/thin trees and shrubs in HIZ 3, which suggests that SD group members are the ones actually performing fuel reduction/vegetation mitigation activities in HIZ 3 that were not previously performed on their property. Thus, our results suggest that individuals intending to stay and defend are much more likely to have performed mitigations that are suggested for active defense, home survivability or decreased burden on firefighters, and therefore are taking more responsibility for their personal contributions to landscape-level wildfire management [67,88,95]. Meanwhile, individuals intending to evacuate and not be on site during a wildfire event are less likely to perform the vegetation mitigations recommended by fire professionals that enhance suppression success, home defensibility, and which enable fire to play a more natural role in ecosystems. This finding corroborates concerns that the legacy of predominately successful fire suppression efforts in the U.S. has contributed to the dampening of WUI resident initiative to prepare their property for wildfire [96–99].

We found few differences in performance of HIZ vegetation mitigations among the evacuate and SIP/I don't know groups. There are a few potential explanations for that finding, including those already discussed above. For one, the evolving message about shared fire management among professionals and residents is increasingly about private responsibility in addressing home protection from large fire events. That narrative can be somewhat at odds with the historical focus on early and prompt evacuation so that residents are "out of the way," leaving responsibility for fire suppression to fire service organizations who respond to events. The result, some claim, has been the fostering of populations who expect or are reliant on broader society to protect their property through the funding of government firefighting resources [100,101]. The removal of civilians from active fire management spaces may intensify the separation between what WUI residents perceive as fire managers' and their own personal responsibility during and leading up to a wildfire event, including in active (i.e., stay and defend) or passive (e.g., installing sprinklers) roles. Overall, the apathy of evacuate and SIP/I don't know group members towards wildfire risk reduction activities, especially vegetation management and home defense actions related to first responder safety, echoes concerns raised by others that certain segments of at-risk property owners are not doing their part to address increasing wildfire risk. That lack of comprehensive mitigation action among populations fails to address wildfire risk concerns across property boundaries [93].

We found that full-time residents and men were significantly more likely to plan for stay and defend as an evacuation option, while and women and part-time residents were more likely to intend to evacuate [8,23,37,67]. These results substantiate similar findings across multiple countries. However, we also found that older residents were slightly more likely to be in the SIP/I don't know category than the evacuate category, which is not as typical of existing results and may reflect the caution of rural populations who do not intend to SD but hesitate to evacuate due to infrastructure concerns. We also discovered a significant interaction between age and presence of younger children that helps explain why younger residents were less likely to SD [26,54]. That is, younger families with children were more likely to evacuate, potentially to protect younger populations from risks associated with SD.

Finally, the work presented here extends existing research on evacuation intentions by considering the influence of various perceptions on categories of intended behavior. Perceptions of self-efficacy have been highlighted as a major influence on resident performance of mitigation actions and select evacuation intentions [8,102,103]. In fact, McLennan et al. [70] noted that self-efficacy and susceptibility to threat (which is similar to our need for firefighters measure) were instrumental in predicting the intention to stay and defend. Our work also helps to verify that relationship and extend it to a new context in the rural U.S. West. Respondent perceptions of their ability to protect their property from wildfire impacts was a highly significant influence on SD or SIP intentions when compared to evacuation intentions. This relationship hints that SIP/I don't know group members may be waiting to see whether the fire is going to overwhelm their abilities before deciding to evacuate, a similar mindset (in this case) that many SD members might have but in a more active (e.g., intending to engage the fire front) context. Similarly, individuals who believed their property was well prepared and would not need firefighting were less likely to evacuate and more likely to stay and defend, which substantiates existing literature [6,8,21]. We also found that perceptions of professional firefighter capabilities was not a significant influence on evacuation intentions. This suggests a decoupling between the capabilities of firefighters and residents' evacuation intentions, reflecting a local culture of self-reliance documented in other studies of the rural U.S. West [34,72]. However, the lack of relationship between perceptions of firefighting capabilities and evacuation intention may also hint at obstacles for collaborative fire adaptations among fire departments or managers and a residential population who view private property protection or wildfire risk mitigation as an individual responsibility. Future research could investigate the potential occurrence and influence of these dynamics to better link evacuation planning or intention with a broader suite of considerations surrounding wildfire management.

The practical outcomes of our results for practitioners and emergency mangers begin with a reaffirmation that significant numbers of residents in this area are considering alternatives to evacuation. This means that messages surrounding early evacuation, including the Ready, Set. Go! Program, may not have reached or convinced residents that early evacuation is the best course of action during fire events. It also is possible that this population would prefer to take the additional risk of remaining at home to protect their property, or that they are well

prepared to ensure their personal safety [8]. While our results do not assess which of these outcomes are the case for individuals in our sample, emergency managers should acknowledge the preference for alternatives to evacuation by presenting more comprehensive information about the significant preparations (mentally, physically, and in terms of infrastructure/equipment) that would be necessary to implement SD as viable option for life safety and property protection during fire events. That information should likely be presented alongside evacuation messages so that residents can consider the tradeoffs between approaches.

Examples of specific information to be provided in expanded evacuation communications could include video examples of the fire conditions that might be experienced in area vegetative conditions should residents decide to SD, the necessary HIZ vegetation clearance and other mitigations necessary to provide residents with shelter protection during the initial flame front, clothing and breathing apparatus recommendations, and best practices for putting out spot fires prior to or following the flame front. Another key communication would stress the importance of sticking to a SD plan, and to avoid late evacuation that might occur when using a "wait and see" approach. Formal presentation of such information might achieve multiple strategic outcomes, including: (1) better preparing the significant population of residents who are considering SD approaches, and (2) promoting evacuation as a safer and somewhat simpler choice for those not willing to take the significant effort necessary to SD, which could serve as a deterrent for populations who may be poorly suited for the latter. Presentation of SD requirements and preparation alongside evacuation messaging such as the Ready, Set, Go! Program could allow residents to assess the tradeoffs between such choices and make fully reasoned decisions. This may be especially important among rural populations, such as those in our study area, who often respond poorly to mandatory evacuations or directorates from government entities [11,104].

Another practical implication of this work concerns our finding that residents considering SD are much more likely to perform vegetative mitigations on their properties. Performance of such actions are a significant focus of national efforts to reduce the significant burden facing wildfire management and suppression agencies driven in no small part by the increasing need to protect private property owners who choose to live in fire-prone conditions. Our results suggest that the increasing number of part-time residents in this region and plans to evacuate may serve as a disincentive for addressing the personal responsibility for managing private property as part of ongoing efforts to manage wildfire across ownership boundaries. As such, it seems important to emphasize the importance of mitigation actions for protection of property *and* provision of safer evacuation. It also should be made clear that it is not firefighters' sole responsibility to protect property, especially property that is not well maintained [9]. Our results suggest some initial populations these messages could be targeted to, including those with second or vacation homes in the area, households with children, and those in the SIP category who had not performed vegetative mitigations.

Finally, results such as ours suggest a practical need for emergency managers, fire professionals, and communities to more comprehensively consider and catalog residents who may be considering different evacuation strategies [6,8]. For instance, fire districts could collect information about those individuals who are considering SD to be more efficient with their evacuation notifications, and to better understand where potential liabilities (e.g., need for rescue) or resources (equipment, water sources, sheltering points) exist during a fire event. Likewise, populations who intend to evacuate could be encouraged to develop trigger points, confirm their enrollment in notification systems, work with likeminded neighbors to plan evacuation drills, and ensure they have a destination for long-term evacuation. Collection and aggregation of data about area residents plans for evacuation or alternatives can serve as a useful exercise for engaged community members and help provide professionals with geospatial data that they might not have the time to collect themselves.

6. Conclusion

Facilitating safe and effective response to wildfire events among residential populations requires nuanced understandings of intended evacuation behaviors. While wildfire and emergency managers often seek to facilitate quick and early evacuation of all populations in areas at immediate risk from wildfire, results of our research and past literature indicate that residential populations may pursue a broader range of evacuation strategies. For instance, we found that nearly 42.8% of our respondents most closely aligned with intentions to stay and defend their property from wildfire risk—an action that is not always recommended by fire departments and emergency professionals. Our research extends past work suggesting that individuals who intend to stay and defend may be taking more responsibility for their personal wildfire risk through the performance of wildfire risk mitigation activities such as implementing defensible space or retrofitting their home with fire resistant materials. More specially, our unique focus on performance of mitigations in HIZ 0, or the immediate zone (0–5 m) around structures, indicates that residents most closely aligning with intentions to stay and defend their properties were more likely to perform several activities in the immediate zone around their home than other evacuation groups.

Acknowledgement that resident evacuation intentions and associated property mitigations vary significantly across residents in the same landscape continues to raise interesting challenges regarding the best ways to ensure both firefighter and resident safety during fire events that continue to grow in size and severity. Our results suggest that there are opportunities to address those challenges by striking a balance between trying to protect at-risk populations and encouraging them to be partners in reducing potential risks during complicated wildfire evacuations. Potential solutions revolve around careful presentation of best practices and uncertainties surrounding the dynamic and divergent nature of risk that populations might face during a wildfire event. For instance, firefighting, agency, and emergency management professionals could expand their programs to provide additional information about the high level of preparation necessary to implement stay and defend plans as a means to empower select WUI residents, while also discouraging those not willing to adequately prepare and for whom evacuation is a safer option. Likewise, our results suggest that providing information about options to stay and defend, or the critical need to perform mitigations to aid firefighters in the protection of structures owned by evacuees, provide tailored ways to encourage the performance of mitigations that reduce future burdens of wildfire suppression. In short, evacuation planning may need to better embrace the reality of diverse evacuation planning (or lack thereof) by better gauging resident expectations ahead of significant fire events and experiment with updated guidance that allows residents to make informed choices that support their safety and effective response.

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.

Acknowledgments

Partial funding for this research came from the National Science Foundation (Hazard SEES 1520873) and the United States Forest Service Rocky Mountain Research Station (15-JV-11221636-121 and 18-JV-11221636-078).

References

[1] J. Gledhill, Community self-reliance during bushfires: the case for staying at home, in: Pap. Presented at the 3rd Int. Wildland Fire Conf, 2003, October, pp. 2–3.

[2] R.W. Mutch, FACES: The story of the victims of Southern California's 2003 Fire Siege. Wildland Fire Lessons Learned Center, 2007. Available online at, https://pdfs.semanticscholar.org/d5d0/006fcfee8cb866e837cfd4940d5ffd24a81d.pdf. (Accessed 12 July 2020).
[3] A. Tibbits, J. Handmer, K. Haynes, T. Lowe, J. Whittaker, Prepare, stay and defend or leave early: evidence for the Australian approach, in: J. Handmer, K. Haynes (Eds.), Community Bushfire Safety, CSIRO Publishing, Melbourne, 2008, pp. 59–71.
[4] J. Handmer, M. Van der Merwe, S. O'Neill, The risk of dying in bushfires: a comparative analysis of fatalities and survivors, Progress in Disaster Science 1 (2019) 100015.
[5] K. Haynes, K. Short, G. Xanthopoulos, D. Viegas, L.M. Ribeiro, R. Blanchi, Wildfires and WUI fire fatalities, in: Samuel L. Manzello (Ed.), Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires, Springer, Cham, Switzerland, 2020, p. 16.
[6] T. Paveglio, T. Prato, D. Dalenberg, T. Venn, Understanding evacuation preferences and wildfire mitigations among Northwest Montana residents, Int. J. Wildland Fire 23 (3) (2014) 435–444.
[7] J. Whittaker, C. Eriksen, K. Haynes, Gendered responses to the 2009 Black Saturday bushfires in victoria, Australia, Geogr. Res. 54 (2) (2016) 203–215.
[8] S. McCaffrey, R. Wilson, A. Konar, Should I stay or should I go now? Or should I wait and see? Influences on wildfire evacuation decisions, Risk Anal. 38 (7) (2018) 1390–1404.
[9] R.W. Mutch, M.J. Rogers, S.L. Stephens, A.M. Gill, Protecting lives and property in the wildland–urban interface: communities in Montana and southern California adopt Australian paradigm, Fire Technol. 47 (2011) 357–377.
[10] C. Eriksen, T. Prior, Defining the importance of mental preparedness for risk communication and residents well-prepared for wildfire, International Journal of Disaster Risk Reduction 6 (2013) 87–97.
[11] T.B. Paveglio, M.S. Carroll, T.E. Hall, H. Brenkert-Smith, 'Put the wet stuff on the hot stuff': the legacy and drivers of conflict surrounding wildfire suppression, J. Rural Stud. 41 (2015) 72–81.
[12] T.B. Paveglio, M.S. Carroll, A.M. Stasiewicz, D.R. Williams, D.R. Becker, Incorporating social diversity into wildfire management: proposing "pathways" for fire adaptation, For. Sci. 64 (5) (2018) 515–532.
[13] A. Tibbits, J. Whittaker, Stay and defend or leave early: policy problems and experiences during the 2003 Victorian bushfires, Environ. Hazards 7 (4) (2007) 283–290.
[14] J. Abrams, E.J. Davis, K. Wollstein, Rangeland Fire Protection Associations in Great Basin rangelands: a model for adaptive community relationships with wildfire? Hum. Ecol. 45 (6) (2017) 773–785.
[15] A.M. Stasiewicz, T.B. Paveglio, Factors influencing the development of Rangeland Fire Protection Associations: exploring fire mitigation programs for rural, resource-based communities, Soc. Nat. Resour. 30 (5) (2017) 627–641.
[16] A.M. Stasiewicz, T.B. Paveglio, Wildfire management across rangeland ownerships: factors influencing Rangeland Fire Protection Association establishment and functioning, Rangel. Ecol. Manag. 71 (6) (2018) 727–736.
[17] E. Niall, A. Rhodes, S. Russell, Community Safety (Wildfire) Post Incident Analysis, Part 2: Community Information Flow, Preparedness and Response, Country Fire Authority, Burwood East, 2004.
[18] J. McLennan, G. Elliott, M. Omodei, J. Whittaker, Householders' safety-related decisions, plans, actions and outcomes during the 7 February 2009 Victorian (Australia) wildfires, Fire Saf. J. 61 (2013) 175–184.
[19] J. Cohen, The wildland-urban interface fire problem: a consequence of the fire exclusion paradigm, Forest History Today. Fall 20–26 (2008) 20–26.
[20] T.B. Paveglio, A.D. Boyd, M.S. Carroll, Alternatives to evacuation in a post Black Saturday landscape: catchy slogans and cautionary tales, Environ. Hazards: Human and Policy Dimensions 11 (1) (2012) 52–70.
[21] P. Mozumder, N. Raheem, J. Talberth, R.P. Berrens, Investigating intended evacuation from wildfires in the wildland–urban interface: application of a bivariate probit model, For. Pol. Econ. 10 (2008) 415–423.
[22] S.M. McCaffrey, A. Rhodes, Public response to wildfire: is the Australian 'stay and defend or leave early' approach an option for wildfire management in the United States? J. For. 107 (1) (2009) 9–15.
[23] B.S. Roberson, D. Peterson, R.W. Parsons, Attitudes on wildfire evacuation: exploring the intended evacuation behavior of residents living in two Southern California communities, Journal of Emergency Management 10 (5) (2012) 335–346.
[24] International Association of Fire Chiefs (IAFC), Ready, Set, Go!, 2020. https://www.wildlandfirersg.org/s/?language=en_US. (Accessed 25 August 2020).
[25] Australian Fire Authorities Council, Position paper on bushfires and community safety, AFAC, East Melbourne Australia, 2005. http://royalcommission.vic.gov.au/getdoc/fe3ec0fe-04a0-4ee7-8ef0-29a245d0ad96/TEN.001.001.0077.pdf. (Accessed 25 August 2020).
[26] R.R. Thompson, D.R. Garfin, R.C. Silver, Evacuation from natural disasters: a systematic review of the literature, Risk Anal. 37 (4) (2017) 812–839.
[27] P.J. Cohn, M.S. Carroll, Y. Kumagai, Evacuation behavior during wildfires: results of three case studies, West. J. Appl. For. 21 (1) (2006) 39–48.
[28] N. Dash, H. Gladwin, Evacuation decision making and behavioral responses: individual and household, Nat. Hazards Rev. 8 (3) (2007) 69–77.
[29] B. Wolshon, E. Marchive III, Emergency planning in the urban-wildland interface: subdivision-level analysis of wildfire evacuations, J. Urban Plann. Dev. 133 (1) (2007) 73–81.
[30] A.M. Gill, S.L. Stephens, Scientific and social challenges for the management of fire-prone wildland–urban interfaces, Environ. Res. Lett. 4 (3) (2009), 034014.
[31] T.J. Cova, Evacuation, in: Samuel L. Manzello (Ed.), Encyclopedia of Wildfires and Wildland-Urban Interface (WUI) Fires, Springer, Cham, Switzerland, 2020, p. 8.
[32] J. Handmer, A. Tibbits, Is staying at home the safest option during bushfires? historical evidence for an Australian approach, Global Environ. Change B Environ. Hazards 6 (2) (2005) 81–91.
[33] D.W. Cote, T.K. McGee, An exploration of residents' intended wildfire evacuation responses in Mt. Lorne, Yukon, Canada, For. Chron. 90 (4) (2014) 498–502.
[34] S. McCaffrey, A. Rhodes, M. Stidham, Wildfire evacuation and its alternatives: perspectives from four United States' communities, Int. J. Wildland Fire 24 (2) (2015) 170–178.
[35] T.J. Cova, F.A. Drews, L.K. Siebeneck, A. Musters, Protective actions in wildfires: evacuate or shelter-in-place? Nat. Hazards Rev. 10 (4) (2009) 151–162.
[36] J. Whittaker, M. Taylor, C. Bearman, Why don't bushfire warnings work as intended? Responses to official warnings during bushfires in New South Wales, Australia, International Journal of Disaster Risk Reduction 45 (2020) 101476.
[37] I.M. McNeill, P.D. Dunlop, J.B. Heath, T.C. Skinner, D.L. Morrison, Expecting the unexpected: predicting physiological and psychological wildfire preparedness from perceived risk, responsibility, and obstacles, Risk Anal. 33 (10) (2013) 1829–1843.
[38] K. Dow, S.L. Cutter, Emerging hurricane evacuation issues: hurricane Floyd and South Carolina, Nat. Hazards Rev. 3 (1) (2002) 12–18.
[39] J. Dellemain, S. Hodgkin, J. Warburton, Time, terrain and trust: impacts of rurality on case management in rural Australia, J. Rural Stud. 49 (2017) 50–57.
[40] R. Blanchi, J.E. Leonard, R.H. Leicester, Lessons learnt from post-bushfire surveys at the urban interface in Australia, For. Ecol. Manag. 234 (1) (2006) S139.
[41] B. Pool, Do-it-yourself fire crew saves California neighborhood, *The Christian Science Monitor* Nov 26 (2007), 2007.
[42] A.D. Syphard, J.E. Keeley, Factors associated with structure loss in the 2013–2018 California wildfires, Fire 2 (3) (2019) 49.
[43] P.F. Johnson, C.E. Johnson, C. Sutherland, Stay or go? Human behavior and decision making in bushfires and other emergencies, Fire Technol. 48 (1) (2012) 137–153.
[44] Wilderness Ranch Fire Protection District [WRFPD], When wildfire approaches... alternatives to Evacuation, 2008. Available online at: http://www.wroa.org/document_library/wrfpd_mailing_2008_aug.pdf.
[45] Victorian Bushfires Royal Commission, Final Report: Summary, 2010. http://www.royalcommission.vic.gov.au/Commission-Reports/Final-Report. (Accessed 12 July 2020).
[46] Y. Cao, B.J. Boruff, I.M. McNeill, Defining sufficient household preparedness for active wildfire defense: toward an Australian baseline, Nat. Hazards Rev. 17 (1) (2016), 04015021.
[47] Tasmania Fire Service, Bushfire Action Plan, 2020. http://www.fire.tas.gov.au/Show?pageId=colbushfirePrepareActSurvive. (Accessed 22 August 2020).
[48] T.J. Cova, P.E. Dennison, F.A. Drews, Modeling evacuate versus shelter-in-place decisions in wildfires, Sustainability 3 (10) (2011) 1662–1687.
[49] T.B. Paveglio, M.S. Carroll, P. Jakes, Alternatives to evacuation during wildland fire: exploring adaptive capacity in one Idaho Community, Environ. Hazards: Human and Policy Dimensions 9 (2010) 379–394.
[50] T.B. Paveglio, M.S. Carroll, P.J. Jakes, Adoption and perception of shelter-in-place in California's Rancho Santa Fe fire district, Int. J. Wildland Fire 19 (2010) 677–688.
[51] A.S. Fu, The facade of safety in California's shelter-in-place homes: history, wildfire and social consequence, Crit. Sociol. 39 (2013) 833–849.
[52] K. Steer, E. Abebe, M. Almashor, A. Beloglazov, X. Zhong, On the utility of shelters in wildfire evacuations, Fire Saf. J. 94 (2017) 22–32.
[53] A.C. Christianson, T.K. McGee, W.L.F. Nation, Wildfire evacuation experiences of band members of whitefish lake first nation 459, alberta, Canada, Nat. Hazards 98 (1) (2019) 9–29.
[54] J. McLennan, B. Ryan, C. Bearman, K. Toh, Should we leave now? Behavioral factors in evacuation under wildfire threat, Fire Technol. 55 (2) (2019) 487–516.
[55] J.C. Kulig, D. Edge, S. Smolenski, Wildfire disasters: implications for rural nurses, Aust. Emerg. Nurs. J. 17 (3) (2014) 126–134.
[56] H.W. Asfaw, T. McGee, A.C. Christianson, The role of social support and place attachment during hazard evacuation: the case of Sandy Lake First Nation, Canada, Environ. Hazards 18 (4) (2019) 361–381.
[57] G. Setten, H. Lein, "We draw on what we know anyway": the meaning and role of local knowledge in natural hazard management, International Journal of Disaster Risk Reduction 38 (2019) 101184.
[58] C.M. Edgeley, T.B. Paveglio, Exploring influences on intended evacuation behaviors during wildfire: what roles for pre-fire actions and event-based cues? International Journal of Disaster Risk Reduction 37 (2019) e101182-e101182.
[59] K. Strahan, J. Gilbert, The wait and see literature: a rapid systematic review, Fire 4 (1) (2021) 4.
[60] P.J. Jakes, E.L. Langer, The adaptive capacity of New Zealand communities to wildfire, Int. J. Wildland Fire 21 (6) (2012) 764–772.
[61] C. Wilkinson, C. Eriksen, T. Penman, Into the firing line: civilian ingress during the 2013 "Red October" bushfires, Australia, Nat. Hazards 80 (1) (2016) 521–538.
[62] M. Proudley, Fire, families and decisions, Aust. J. Emerg. Manag. 23 (2008) 37–43.
[63] C. Eriksen, N. Gill, Bushfire and everyday life: examining the awareness-action 'gap' in changing rural landscapes, Geoforum 41 (2010) 814–825.
[64] K. Haynes, J. Handmer, J. McAneney, A. Tibbits, L. Coates, Australian bushfire fatalities 1900–2008: exploring trends in relation to the 'prepare, stay and defend or leave early' policy, Environ. Sci. Pol. 13 (2010) 185–194.

[65] J. Whittaker, K. Haynes, J. Handmer, J. McLennan, Community safety during the 2009 Australian 'Black Saturday' bushfires: an analysis of household preparedness and response, Int. J. Wildland Fire 22 (6) (2013) 841–849.
[66] R.T. Graham, Technical Editor, Hayman Fire Case Study. Gen. Tech. Rep. RMRS-GTR-114, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT, 2003, p. 396.
[67] C. Eriksen, T. Penman, B. Horsey, R. Bradstock, Wildfire survival plans in theory and practice, Int. J. Wildland Fire 25 (4) (2016) 363–377.
[68] K. Strahan, J. Whittaker, J. Handmer, Self-evacuation archetypes in Australian bushfire, International Journal of Disaster Risk Reduction 27 (2018) 307–316.
[69] T.K. McGee, Mishkeegogamang Ojibway Nation, A.C. Christianson, Residents' wildfire evacuation actions in mishkeegogamang ojibway nation, ontario, Canada, International Journal of Disaster Risk Reduction 33 (2019) 266–274.
[70] J. McLennan, S. Cowlishaw, D. Paton, R. Beatson, G. Elliott, Predictors of south-eastern Australian householders' strengths of intentions to self-evacuate if a wildfire threatens: two theoretical models, Int. J. Wildland Fire 23 (8) (2014) 1176–1188, https://doi.org/10.1071/WF13219.
[71] L.N. Dupéy, J.W. Smith, Close but No cigar: How a Near-Miss wildfire Event Influences the Risk perceptions and Mitigation behaviors of Residents who Experienced a Recent, Nearby wildfire, Institute of Outdoor Recreation and Tourism, Logan, UT, 2019. Retrieved from: https://digitalcommons.usu.edu/extension_curall/1959.
[72] T.B. Paveglio, M.S. Carroll, A.M. Stasiewicz, C.M. Edgeley, Social fragmentation and wildfire management: exploring the scale of adaptive action, International Journal of Disaster Risk Reduction 71 (74) (2019) 12–23.
[73] V.C. Radeloff, R.B. Hammer, S.I. Stewart, J.S. Fried, S.S. Holcomb, J.F. McKeefry, The wildland-urban interface in the United States, Ecol. Appl. 15 (3) (2005) 799–805.
[74] T.B. Paveglio, C.M. Edgeley, A.M. Stasiewicz, Assessing influences on social vulnerability to wildfire using surveys, spatial data and wildfire simulations, J. Environ. Manag. 213 (2018) 425–439.
[75] D.A. Dillman, J.D. Smyth, L.M. Christian, Internet, Phone, Mail and Mixed-Mode Surveys: The Tailored Design Method, fourth ed., John Wiley & Sons, Hoboken, NJ, 2014.
[76] J. Steele, L. Bourke, A.E. Luloff, P.S. Lian, G.L. Theodori, R.S. Krannich, The drop-off/pick-up method for household survey research, Community Dev. 32 (2) (2001) 238–250.
[77] C. Trentelman, J. Irwin, K. Petersen, N. Ruiz, C. Szalay, The case for personal interaction: drop-off/pick-up methodology for survey research, Journal of Rural Social Sciences 31 (3) (2016) 68–104.
[78] H. Brenkert-Smith, J.R. Meldrum, P.A. Champ, Climate change beliefs and hazard mitigation behaviors: homeowners and wildfire risk, Environ. Hazards 14 (4) (2015) 341–360.
[79] K. Dickinson, H. Brenkert-Smith, P. Champ, N. Flores, Catching fire? Social interactions, beliefs, and wildfire risk mitigation behaviors, Soc. Nat. Resour. 28 (8) (2015) 807–824.
[80] National Fire Protection Association (NFPA), Preparing Homes for Wildfire, 2020. https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Preparing-homes-for-wildfire. (Accessed 12 November 2020).
[81] J. Handmer, S. O'Neill, Examining bushfire policy in action: preparedness and behaviour in the 2009 Black Saturday fires, Environ. Sci. Pol. 63 (2016) 55–62.
[82] J.P. Stevens, Applied Multivariate Statistics for the Social Sciences, fifth ed., Routledge, Taylor & Francis Group, New York, 2009.
[83] A. Field, Discovering Statistics Using IBM SPSS Statistics, Sage, London, 2013.
[84] J. Lattin, J.D. Carroll, P.E. Green, Analyzing Multivariate Data, Brooks/Cole-Thomson Learning, Pacific Grove, OR, 2003.
[85] C.A. Cameron, P.K. Trivedi, Microeconometrics: Methods and Applications, Cambridge University Press, New York, 2005.
[86] C.A. Cameron, P.K. Trivedi, Microeconometrics Using Stata, Stata Press, College Station, TX, 2009.
[87] J. McLennan, D. Paton, L. Wright, At-risk householders' responses to potential and actual bushfire threat: an analysis of findings from seven Australian post-bushfire interview studies 2009–2014, International Journal of Disaster Risk Reduction 12 (2015) 319–327.
[88] J. McLennan, D. Paton, R. Beatson, Psychological differences between south-eastern Australian householders' who intend to leave if threatened by a wildfire and those who intend to stay and defend, International Journal of Disaster Risk Reduction 11 (2015) 35–46.
[89] H.D. Walpole, R.S. Wilson, S.M. McCaffrey, If you love it, let it go: the role of home attachment in wildfire evacuation decisions, Environment Systems and Decisions 40 (1) (2020) 29–40.
[90] Parliament of Victoria, 2009 Victorian Bushfires Royal Commission: Final Report Summary, 2010. Retrieved from, http://www.royalcommission.vic.gov.au/finaldocuments/summary/PF/VBRC_Summary_PF.pdf.
[91] J.F. Johnson, T. Downing, K.C. Nelson, External sprinkler systems and Defensible space: Lessons Learned from the Ham Lake Fire and the Gunflint Trail, University of Minnesota, College of Food, Agricultural and Natural Resource Sciences, 2008, p. 31.
[92] T.J. Venn, J. Quiggin, Early evacuation is the best bushfire risk mitigation strategy for south-eastern Australia, Aust. J. Agric. Resour. Econ. 61 (3) (2017) 481–497.
[93] T.D. Penman, C.E. Eriksen, B. Horsey, R.A. Bradstock, How much does it cost residents to prepare their property for wildfire? International Journal of Disaster Risk Reduction 16 (2016) 88–98.
[94] Wildland Fire Executive Council [WFEC], The National strategy: The Final phase in the Development of the National Cohesive Wildland Fire Management Strategy, 2014. http://www.forestsandrangelands.gov/leadership/WFEC/index.shtml.
[95] S.L. Stephens, M.A. Adams, J. Handmer, F.R. Kearns, B. Leicester, J. Leonard, M. A. Moritz, Urban–wildland fires: how California and other regions of the US can learn from Australia, Environ. Res. Lett. 4 (1) (2009), 014010.
[96] T.W. Collins, Households, forests, and fire hazard vulnerability in the American West: a case study of a California community, Global Environ. Change B Environ. Hazards 6 (1) (2005) 23–37.
[97] T.W. Collins, What influences hazard mitigation? Household decision making about wildfire risks in Arizona's White Mountains, Prof. Geogr. 60 (4) (2008) 508–526.
[98] B.E. Goldstein, Skunkworks in the embers of the Cedar Fire: enhancing resilience in the aftermath of disaster, Hum. Ecol. 36 (2008) 15e28.
[99] B.L. McFarlane, T.K. McGee, H. Faulkner, Complexity of homeowner wildfire risk mitigation: an integration of hazard theories, Int. J. Wildland Fire 20 (8) (2012) 921–931.
[100] C. Kousky, S. Olmstead, R. Sedjo, In harm's way: homeowner behavior and wildland fire policy, in: K.M. Bradshaw, D. Lueck (Eds.), Wildfire Policy: Law and Economics Perspectives, Resources for the Future, New York, New York, USA, 2012, pp. 178–199.
[101] R. Gorte, The Rising Cost of Wildfire Protection, Headwaters Economics, Bozeman, MT, 2013.
[102] W.E. Martin, I.M. Martin, B. Kent, The role of risk perceptions in the risk mitigation process: the case of wildfire in high risk communities, J. Environ. Manag. 91 (2) (2009) 489–498.
[103] H. Brenkert-Smith, P.A. Champ, N. Flores, Trying not to get burned: understanding homeowners' wildfire risk–mitigation behaviors, Environ. Manag. 50 (6) (2012) 1139–1151.
[104] L. Strawderman, A. Salehi, K. Babski-Reeves, T. Thornton-Neaves, A. Cosby, Reverse 911 as a complementary evacuation warning system, Nat. Hazards Rev. 13 (1) (2012) 65–73.
[107] Washington State Department of Ecology, Washington geospatial open data portal. http://geo.wa.gov/datasets, 2018. (Accessed 20 June 2020).
[108] Dodd, W., Scott, P., Howard, C., Scott, C., Rose, C., Cunsolo, A., & Orbinski, J. (2018). Lived experience of a record wildfire season in the Northwest Territories, Canada. Can. J. Public Health, 109(3), 327-337.
[109] C.A. Kolden, C. Henson, A socio-ecological approach to mitigating wildfire vulnerability in the wildland urban interface: a case study from the 2017 Thomas fire, Fire 2 (1) (2019) 9.