# "Should We Leave Now?": Behavioral Factors in Evacuation Under Wildfire Threat

*Jim McLennan*, School of Psychology and Public Health, La Trobe University, Bundoora, VIC, AUSTRALIA*

*Barbara Ryan, School of Arts and Communication, University of Southern Queensland, Toowoomba, QLD, AUSTRALIA*

*Chris Bearman, Appleton Institute, Central Queensland University Adelaide Campus, Adelaide, SA, AUSTRALIA*

*Keith Toh, School of Management, RMIT University, Melbourne, VIC, AUSTRALIA*

## Acknowledgements

We are grateful to the following for helpful feedback on a draft manuscript: Ruth Beatson, Brenda Mackie, Sarah McCaffrey, Joshua Whittaker and Lyndsey Wright. We thank two anonymous reviewers for their suggestions to revise a previous version of the paper.

---

* *Correspondence should be addressed to: Jim McLennan, Email: j.mclennan@latrobe.edu.au*

***Abstract***.

Wildfires pose a serious threat to life in many countries. For police, fire and emergency services authorities in most jurisdictions in North America and Australia evacuation is now the option that is preferred overwhelmingly. Wildfire evacuation modeling can assist authorities in planning evacuation responses to future threats. Understanding residents' behavior under wildfire threat may assist in wildfire evacuation modeling. A literature review was conducted to explore North American and Australian research into wildfire evacuation behavior published between January 2005 and June 2017. Wildfire evacuation policies differ across the two regions: in North America mandatory evacuations are favored, in Australia most are advisory. Research from both regions indicates that following a wildfire evacuation warning some threatened residents will wish to remain on their property in order to protect it, many will delay evacuating, and some residents who are not on their property when an evacuation warning is issued may seek to return. Mandatory evacuation is likely to result in greater compliance, enforcement policies are also likely to be influential. Self-delayed evacuation is likely if warnings are not sufficiently informative: residents are likely to engage in information search rather than initiating evacuation actions. The wildfire warning and threat histories of a location may influence residents' decisions and actions. The complexities of behavioral factors influencing residents' actions following an evacuation warning pose challenges for wildfire evacuation modeling. Suggestions are offered for ways in which authorities might reduce the numbers of residents who delay evacuating following a wildfire warning.

**Keywords:** Wildfire, Bushfire, Evacuation, Delay, Human behavior, Modeling

# "Should We Leave Now?": Behavioral Factors in Evacuation Under Wildfire Threat

## 1. Introduction

### *1.1 Background*

Wildfires pose a serious threat to individual households and entire communities in numerous countries. Despite advances in fire suppression and communications technologies, significant numbers of civilian wildfire deaths and injuries occur annually [1 - 4]. There is general agreement among wildfire researchers that destructive wildfire events will probably occur more frequently in the immediate future, for three reasons. First, increasing numbers of householders are choosing to reside in areas of high wildfire risk, particularly in wildland-urban interface (WUI) locations—areas where people and their properties meet, or intermix with, significant wildland vegetation fuels [5]. Second, climate change is resulting in reduced rainfall and higher average temperatures in many locations [6]. Third, policies of some land management agencies and local governments constrain fire suppression regimes and vegetation management programs [7 - 8].

The direct threat to life posed by wildfires results mostly from the high levels of thermal energies generated by the combustion of large masses of vegetation [9]. Many civilian wildfire deaths and injuries have resulted from exposure to radiant and/or convective heat. Automobile crashes during late evacuation attempts have also caused fatalities [2, 4, 9 - 12]. Residents facing imminent threat from wildfires have, in principle, three options for protecting themselves: contesting the threat by actively defending the property, enduring the

threat by sheltering in place, or avoiding the threat by evacuating (either as part of an organized evacuation endeavor or by self-evacuating). However, as discussed in Sections 3 and 4 of the paper, how community members respond to wildfire threat may be complex and involve many factors. For example, residents who intend, and prepare, to defend their property may shelter for a period of time while the main fire front impacts the property before resuming active defense.

For police, fire and emergency services authorities in most jurisdictions in North America and Australia evacuation is now the option that is preferred overwhelmingly [13, 14]. Late evacuations by residents under imminent wildfire threat are likely to result in deaths or injuries [2, 4, 11] and may impede suppression endeavors by fire agencies [15, 16]. Evacuation modeling can improve public safety by helping authorities to plan for evacuations from neighborhoods in the event of future wildfire threats [17]. The usefulness of wildfire evacuation models can be improved by incorporating representations of residents' behaviors following a wildfire evacuation warning [18,19].

### *1.2 Aims*

This special issue of *Fire Technology* is concerned primarily with fire evacuation modeling. In this paper we review published accounts of research about evacuation and late evacuation behavior by residents facing a wildfire threat. Our aim is threefold: first to summarize what researchers have found about residents' behavior when under wildfire threat; second, to inform those engaged in wildfire evacuation modeling about current knowledge concerning the actions of residents who experience wildfire threat; third, to present findings which might assist agencies to reduce the numbers of at-risk residents likely to not evacuate or delay evacuating when threatened by a serious wildfire.

### *1.3 Method*

Our method was similar to those used for recent reviews of social science research about community wildfire safety [20, 21]. Searches for reports of empirical research about wildfire evacuation behavior were made using *ScienceDirect*, *Scopus, Web of Science, PsychINFO, Google Scholar* and *Google Chrome* using the search terms evacuation AND wildfire, bushfire, forest fire. The searches covered refereed journal papers, conference proceedings, books and book chapters, and technical reports, written in English, published between January 2005 and June 2017; 157 publications were located. Titles and abstracts were read initially and works which appeared to be relevant were examined further. Publications were included in the review if they reported empirical information about residents' behavior or intentions in relation to wildfire threat warnings. Papers were excluded from further consideration if they (a) reported simulation or modeling research, (b) discussed only community wildfire safety policies or residents' preferences, or (c) simply referred to previously published papers about wildfire evacuation. A total of 27 papers were located which satisfied the criteria: 19 reported Australian research, 6 reported research conducted in the United States, and 2 reported Canadian research. No reports in English about wildfire evacuation research in other countries were located.

### *1.4 Overview*

The paper begins with brief summaries of authorities' community wildfire safety response policies in North America--Canada and the United States--(Section 2.1) and Australia (Section 2.2). These indicate a difference between the approaches taken by authorities in the two regions. In North America evacuation is usually mandated, in Australia evacuation is usually advisory—forced evacuations are rare. Because of this difference we chose to group research findings in Section 3 according to country: the United States (3.1), Canada (3.2) and Australia (3.3); we then summarize findings about residents' decisions and actions in response to wildfire threats, including evacuation and delayed evacuation. In Section 4 issues

associated with the effectiveness of wildfire threat warnings are discussed. In Section 5 we offer some tentative conclusions about behavioral factors related to residents not evacuating or delaying evacuation—these factors are likely to militate against the predictability of threatened residents' decisions and protective actions, thus presenting challenges to the development of wildfire evacuation models. Finally, we propose some potential implications of the research findings for agencies responsible for wildfire evacuations.

# 2. Community wildfire safety policies in North America and Australia

## *2.1 North America*

### *2.1.1 United States*

In the United States, since the end of the Second World War, the policy of authorities has been that evacuation, usually mandatory, of residents in the face of wildfire threat is the safest option [13, 22, 23]. A recent Federal Emergency Management Agency (FEMA) public advice document makes clear that timely evacuation continues to be the recommended action for US residents threatened by a wildfire:

> "When a wildfire threatens your area, the best action to protect yourself and your family is to evacuate early to avoid being trapped….Your goal now, before a fire happens, is to make your home or business and the surrounding area more resistant to catching fire and burning. This means reducing the amount of material that can burn easily in and around your home or business by clearing away debris and other flammable materials, and using fire-resistant materials for landscaping and construction…If the danger is imminent, local authorities may issue an evacuation notice to alert residents that a fire is nearby and it is important to leave the area. Evacuation orders vary by state and community and may range from voluntary to

> mandatory. When authorities issue a mandatory evacuation notice, leave the area immediately". [24, pp. 3-4]

Following the southern California Cedar Fire in 2003 authorities' emphasis on evacuation was questioned when the majority of the civilian fatalities apparently occurred while attempting to evacuate in vehicles [25, 26]. Ensuing discussion about alternatives to mass evacuations of residents [23, 27] made reference to the community wildfire ('bushfire' in Australia) safety position advocated at that time by the Australasian Fire Authorities Council which stated that staying and defending a suitably prepared home should be considered as a safe alternative (see 2.2). Despite this, evacuations—usually mandatory—continue to be the public safety response to wildfire threats implemented by authorities in the US under most circumstances.

### *2.1.2 Canada*

All fire management agencies in Canada recommend evacuation when public safety is threatened by a wildfire [16]. While mandatory evacuation orders can be issued and enforced, certain designated locations are exempt from mandatory evacuations. For most communities, provincial and territorial fire management agencies work with civil authorities to effect evacuations when there is a serious wildfire threat. Typically, a wildfire Incident Commander requests an evacuation order by the local government authority or Provincial Fire Commissioner. Following which:

> "Evacuation orders are enforced by the Royal Canadian Mounted Police or other police service, while the Provincial Emergency Management Program works with the local government authority to coordinate reception centres and support services for evacuees. Provincial agencies do not have the authority to order people to evacuate Indian reserves, Department of National Defence Reserves, or other federal lands. The

default practice is for the provincial agency representative to advise people living on such lands that it would be prudent to leave, and the RCMP or other police services help to promote this safety message. This practice may be interpreted by those affected as an evacuation order, even though there is no legislative requirement to leave". [28, p. 11]

### *2.2 Australia*

Over five decades following the end of the Second World War there was no nationally agreed approach to community bushfire safety. In 2005 the Australasian Fire Authorities Council published an official position that: "By extinguishing small initial ignitions, people of adequate mental, emotional and physical fitness, equipped with appropriate skills and basic resources can save a building that would otherwise be lost to fire" [29, p. 6]. This 2005 position, that residents should be encouraged to stay on their property in order to protect their suitably prepared homes against wildfire attack and thus remain safe, was adopted by Australian fire agencies, and summarized as the 'prepare, stay and defend or leave early' policy. The policy resulted from investigations by authorities following disastrous multi-fatality bushfires in Australia in 1967 and 1983 which found that residents under imminent bushfire threat were most likely to die as a result of either radiant heat exposure or vehicle accident while fleeing at the last moment and that suitably prepared homes could be successfully defended thus obviating the necessity for hazardous last-minute evacuation [30, 31].

Australia's 'prepare, stay and defend or leave early' policy came under intense critical scrutiny during hearings conducted by the 2009 Victorian Bushfires Royal Commission following the country's worst bushfire event to date. Disastrous wildfires impacted parts of the State of Victoria on 7 February 2009 killing 172 civilians and destroying more than 2000

homes [32]. It was found subsequently that 111 deceased individuals perished in houses or nearby structures such as sheds or garages [33]. Following the Royal Commission hearings the Australasian Fire and Emergency Services Authorities Council (AFAC) reviewed and revised its position on community bushfire safety to state that early self-evacuation before the threat is imminent is the safest option for residents. In 2012 the AFAC position was revised further to give greater emphasis to evacuation as the preferred option in the event of bushfire threat:

> 4.2.8 The safest action to protect life is for people to be away from the bushfire or threat of bushfire as early as possible. *Leaving a high risk bushfire location is the safest action, and leaving before a bushfire threatens is always safer than remaining until a bushfire starts. Leaving becomes increasingly appropriate with higher Fire Danger Ratings… where circumstances such as weather conditions, topography or fuel loads may create intense fire behavior, leaving early may be the only safe action, even for people who are prepared to defend well-prepared buildings*. (emphases in the original [14, pp. 5-6])

All Australian fire agencies modified their approaches to community bushfire safety promotion, education and response to align with the changed emphasis in the AFAC position statement. Across Australian states and territories there is not a policy of forced evacuation and fire agencies have opposed the introduction of such a policy, chiefly on the grounds that this would compromise property owners' rights and responsibilities to make decisions about their own financial assets. In some states there is the legal option of forced evacuations following the declaration of a state of emergency by the government, but such declarations are extremely rare and there have been only a few isolated instances of police officers forcing a resident to leave [34]. Currently, no Australian fire agency recommends planning to shelter in place. However, agencies recognize that evacuation is not always possible and recommend

at-risk residents have a contingency plan for taking last-resort survival shelter. Agencies also provide advice to residents about constructing wildfire shelters, or 'bunkers' on their property.

### *2.3 Discussion*

There are no indications that North American nor Australian authorities are considering any change from their overwhelming preference for residents to evacuate promptly in the event of a serious wildfire threat, despite some suggestions that both sheltering in place and active property defense should be considered as potential alternatives to evacuation [35]. There is also increasing interest in developing wildfire evacuation models which incorporate advances in communication technology, availability of big data and widespread use of social media [36 - 38]. Evacuation of residents is thus likely to remain the mainstay of authorities' community protection responses when serious wildfires threaten the public in North America and Australasia. However, other wildfire-prone regions around the world may differ in their community safety policies and response practices.

## 3. How residents respond to a wildfire threat

As indicated in Section 2, there has been a reasonable amount of discussion about the merits of residents evacuating under imminent wildfire threat versus sheltering in place or engaging in active property defense [35]. However, three previous reviews have suggested that the number of studies reporting research about residents' behavior under wildfire threat is relatively modest [15, 20, 21].

### *3.1. United States research*

In an early published study of US residents' responses to evacuation warnings, Taylor et al. [39] interviewed residents and fire agency personnel and conducted eight focus groups with residents following two Californian wildfires in 2003. There were five major findings.

Official information broadcasts were too infrequent and lacking in timely information. Residents under imminent threat reported that their search for information was urgent and emotionally-driven because of the high stakes involved; they sought real-time information and were less concerned with the source of the information (official or unofficial) than with its timeliness and apparent location relevance. Loss of electrical power supply limited residents' access to broadcast information. Once residents had commenced evacuation, it became more difficult for them to receive information that was up-to-date and accurate at the local level. Finally, a brief step-by-step evacuation planning guide brochure prepared for residents (*Get Ready, Get Set, Go*) by the local Fire Safe Council was reported by many of those interviewed to have been very helpful in assisting timely evacuation.

Cohn, Carroll and Kumagai [15] reported findings from 183 interviews with residents and public safety officials about evacuation warnings following wildfires in Montana (in 2000), Colorado (in 2002) and Arizona (in 2002). The researchers concluded that five stages of the overall evacuation process could be observed in all three locations: Anticipation, Warning, Displacement, Notification, and Return and Recovery. Each had distinctive features involving situational constraints and associated problems. The first two stages, Anticipation and Warning, are relevant to the present discussion. In the Anticipation stage, while agencies anticipated a potentially catastrophic fire event because of a long drought, few residents contemplated a possible fire threat. For most, anticipation of a possible need to take action only occurred when they saw smoke or heard about a fire through commercial news media. Once they were aware of a fire outbreak, their challenge was to judge the severity of the threat and prepare to take appropriate action while going about their everyday lives. For both agencies and residents, the major constraint was lack of knowledge about the likely path and rate of advance of the fire. In the Warning stage the primary problem for residents was how to interpret the information, including rumors, they were receiving from a range of sources—

radio, television, family and neighbors. While some reacted speedily, others delayed because they did not perceive a need for urgency. For authorities, the major situational constraint was timing of when to impose the evacuation order. When considering imposing an evacuation order public safety officials needed to balance allowing residents time to prepare to leave with the dangers of delaying evacuation. Delaying the evacuation could mean that some evacuation routes would become unavailable, that traffic jams may result, and that evacuees would impede access by firefighting personnel. A concern for law enforcement personnel was how to manage residents who refused to leave--mostly because they wanted to defend their properties or protect them from looters. What law enforcement officers saw as discharging their responsibilities to protect members of the public, some residents saw as infringing their rights as US citizens.

McCaffrey and Winter [40] reported findings from a mail survey of residents of wildfire-prone locations in California (in 2009), Florida (in 2009) and Montana (in 2010). Of the 1,483 survey returns, 551 were from residents who indicated that they had been threatened by a wildfire. The actions taken by these residents in response to the threats and the percentage taking these actions are shown in Figure 1.

---

Figure 1 about here

---

Of the 551 residents who had been threatened, 33% decided to stay on their property while 55% decided to leave—but more than half of these evacuating residents (33% of the total) chose to delay their evacuation.

Research suggests that wildfire evacuation practices in a given location are likely to have an appreciable effect on residents' compliance [22]. The researchers investigated residents' intended evacuation behavior if facing a wildfire threat. Postal survey data were

obtained from 1018 East Mountain, Arizona, residents. They were asked if they would evacuate under both voluntary and mandatory evacuation orders. The "yes" response for a voluntary evacuation order was 57 percent, while that for a mandatory evacuation order was 89 percent. The finding suggests that more residents are likely to delay evacuation under a voluntary evacuation warning than under a mandatory evacuation order. While most residents under mandatory evacuation orders will only have to decide how and when they will leave, many residents under voluntary warning conditions will have to decide first whether or not to leave, and if the decision is affirmative when and how they will leave. Probit analyses showed that a major determinant of residents' reported willingness to evacuate was their level of concern about the likely threat to their home posed by a wildfire. Women reported greater willingness to evacuate, and possession of animals reduced reported willingness to evacuate.

Paveglio et al. [41] analyzed responses to 1155 survey returns (a 61% completion rate) from Flathead County in northwest Montana. Residents were asked to indicate their level of agreement or disagreement with each of nine statements about their likely intentions if a wildfire threatened their property. Most (71%) respondents intended to remain and protect their property against small (spot) fires. The same percentage indicated that they intended to 'wait and see' how the wildfire threat unfolded before making a final decision. However, most (78%) agreed that they would evacuate when authorities told them to do so.

Apart from the study by Mozumder et al. [22] no research about demographic indicators and wildfire evacuation or delayed evacuation could be located. Clearly more research in relation to this topic is required. For other natural disasters (mostly involving hurricanes and floods) a recent systematic review of research on evacuations in the United States and other countries [42] reported that the following demographic indicators were associated with lower likelihood of evacuation: (a) male gender, (b) older age (65+ years), (c) non-Caucasian ethnicity, (d) households with no children, and (e) households with pets. It

is highly likely that these factors are relevant to wildfire evacuation, and they may also be associated with delayed evacuation.

### *3.2. Canadian research*

Beverly and Bothwell [16] compiled descriptive data on wildfire evacuations in Canada over the period 1980-2007. They reported that during the 27 year period there were 547 evacuation events involving 209,121 people. Ninety percent of those who evacuated did so in response to a general evacuation order by authorities, less than three percent made self-initiated evacuation decisions. However, these figures were based largely on newspaper accounts rather than agency data and their accuracy may be questionable. Over the 27 year period a total of 497 homes were destroyed and a single civilian death occurred (in 1989). The authors concluded that "With frequencies of wildfire-related home losses and civilian fatalities that contrast sharply with those in Australia and the United States, Canada represents a truly remarkable success story when it comes to protecting people and property from wildfire" (p. 593). While no studies were located which provided information about delayed evacuation or refusals to evacuate, Beverly and Bothwell's findings suggest that, overall, levels of residents' normative beliefs that evacuating promptly on receipt of a warning is what one should do are likely to be high in most at-risk regions in Canada. The Horse River Wildfire of May 2016 resulted in mandatory evacuation orders for several locations in the Fort McMurray, Alberta, region. Some 88,000 residents were evacuated. There were two fatalities associated with a vehicle accident. An investigative report into the fire for the Alberta Department of Agriculture and Forestry identified some shortcomings in aspects of the initial management of the fire [43], and evacuations were apparently hampered by breakdown of cell phone communications. Further empirical research is desirable to explore delayed evacuation and refusal to evacuate in Canada.

Cote and McGee [44] surveyed 12 focus group participants who were residents of Mount Lorne in Yukon Territory, Canada. In response to a question about what they would prefer to do in the event of a wildfire threat, all indicated that they would prefer to stay and defend their property. During discussion the perceived safety of properties was an important influence on evacuation intentions, as were the possibilities of produce, livestock and pet losses. As one participant explained, "You would hate to leave, or be told to leave, and then come back and see everything burnt down because an ember landed on your lawn chair" (p. 500). Eight participants agreed that if the fire threat seemed to be severe they would probably leave. However, participants indicated uncertainty about their ability to identify an extreme fire threat in order to leave in a safe, timely, manner.

### *3.3. Australian research*

*3.3.1 Post-wildfire Research* Tibbits and Whittaker [45] analyzed data from nine focus groups involving 73 participants from communities affected by bushfires in north-eastern Victoria in 2003. The aim was to ascertain residents' levels of understanding and support for the then *prepare, stay and defend or leave early* policy described in Section 2 and if they had implemented the policy during the fires. They found high levels of awareness of, and strong support for, the policy. The majority of residents opposed forced evacuations. The practicalities of preparing, staying and defending were well understood. However, there was confusion about self-evacuating 'early': for some it meant the day before a predicted severe fire weather threat, for others it was following a warning from authorities, and for some it was after a trigger-event such as seeing smoke, flames or embers. Tibbits and Whittaker found that influential factors in participants' decisions to stay and defend or to evacuate included: the number of people available to stay and defend, responsibility for vulnerable household members, level of financial and emotional investment in the property, and responsibility for livestock and pets. They noted that "….many of those who plan to stay and

defend their properties are not fully committed to doing so. Many of those who plan to stay and defend are consciously or unconsciously retaining late evacuation as a last-minute option…" (p. 289).

Proudley [46] interviewed 38 couples affected by a bushfire in South Australia's lower Eyre Peninsula in 2006 which caused nine fatalities, focusing on their uncertainty about staying in their home or evacuating to a safer location. Proudley found that it was difficult for households to decide whether to remain in their house for protection or to risk driving to presumed safety, chiefly because of differences between husbands and wives about what to do and concerns by mothers about their children's safety.

Immediately following the disastrous Victorian 2009 bushfires the AFAC requested the Bushfire Cooperative Research Centre (BCRC) undertake a program of field interviews with surviving householders in eight of the worst affected areas. The BCRC and its successor organization the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC) subsequently conducted additional post-bushfire field interviews on behalf of state fire agencies in Western Australia in 2011 and 2014, in New South Wales and Tasmania in 2013 and in South Australia in 2014. In these studies researchers visited properties which had been threatened and interviewed residents about their pre-bushfire risk perceptions, plans and preparations, warnings received on the day of the fire, and decisions made and actions taken on the day. The eight studies involved 23 bushfire events. A total of 1,641 interviews were conducted with residents who had been threatened (this total excludes residents interviewed who had not been on their property at the time of the fire). More information about the studies is available in [47 - 49]. The actions taken by these residents are summarized in Figure 2. Across all eight studies, the unweighted average percentage of residents who evacuated was 60 percent, and appreciable percentages of these (unweighted mean 21%, range 15% - 64%) delayed their evacuation. Residents of rural (farming and other

agribusinesses) properties were more likely to stay and defend them, residents of WUI properties were more likely to leave. The reported reasons for choice were reasonably consistent. Most residents who chose to stay and defend their property did so because they wanted to protect valued assets. They believed that they would be successful, with most accepting some degree of risk, and they feared that the assets would be destroyed in their absence. A small number chose to stay because their only evacuation route would have taken them through forested areas which they believed would expose them to greater danger than if they remained.

---

Figure 2 about here

---

Residents who evacuated reported that their reason for leaving was that failing to do so would expose them and other household members to the possibility of death or injury. The two major determinants of residents' actions (stay, leave) were (a) their pre-fire plan or intention—this was especially so for those who evacuated, and (b) the perceived severity of the fire threat. Many of those who initially planned to stay and defend their property changed their mind and evacuated when they perceived the fire to be more intense than they had expected (unweighted average = 20%, range = 11% to 28%).

In addition to the field interviews discussed above, the BCRC also commissioned postal surveys of 6,000 households impacted or threatened by fires in those areas (with an additional postal survey following the 2015 Sampson Flat fire in South Australia) [50]. A total of 1314 completed surveys were returned, a 25 percent response rate. Fifty three percent of respondents stayed to defend their properties, four percent sheltered passively, and 43 percent left—while a small number escaped a threatened township in a police-escorted convoy, most self-evacuated. The authors noted that:

> "Just over half of these respondents (54%) considered themselves to have left late or very late, with 16% leaving within 20 min of the fire arriving and one quarter (25%) leaving once the fire had arrived. Most (80%) perceived the level of danger to be high or very high when they left. With many experiencing difficulties associated with smoke (55%), poor visibility (35%), traffic (30%), embers (29%), flames (26%) and fallen trees (16%)". [50, p. 845]

An unexpected finding from studies following two of the bushfire events listed in Figure 2 was that some residents who were not at home when the bushfire evacuation warnings were issued attempted to return to their property before arrival of the fire front, and most did so successfully. Following the October 2013 fires in New South Wales 589 residents of affected areas responded to social media invitations to complete an online survey asking about their experiences [51]. Two hundred and twenty nine (58%) of the respondents were not at home when the evacuation warning was broadcast and 185 (64%) of these attempted to return to their properties before the arrival of the fire front, 147 of whom (80%) were successful. Following the January 2014 Perth Hills Western Australia fire, of the 91 residents interviewed, 87 were in the local area when the evacuation warning was broadcast; 25 of these (29%) were not at their property and 21 of them (84%) attempted to return. Three were prevented by police road blocks, but 18 returned to their property before the arrival of the fire front—4 stayed and defended their homes successfully while 14 left subsequently and drove to safer locations [52]. In both studies the reasons given for attempting to return included: to defend the property, to make final preparations for house protection, to take care of livestock or collect pets, and to collect valuables so as to keep them safe.

Detailed analyses of interviews with survivors of the 2009 Victorian bushfires showed that many of those who evacuated late did so because of uncertainty about (a) whether they were under imminent threat and (b) safe destinations and evacuation routes [53]. The

uncertainty resulted from failures by authorities to provide timely and location-specific warnings, compounded by widespread loss of electrical power, and destruction of telephone lines and mobile phone transmission towers [32]. Many of those interviewed, together with those who responded to a post-fire mail survey [50], reported that the extreme heat on 7 February 2009 had caused them to be resting inside darkened, air conditioned homes thus reducing their receptiveness to warnings and their awareness of environmental cues such as smoke and embers.

Inspection of the reports prepared following the post-bushfire interview studies [53 - 59] revealed that most of those residents who delayed their evacuation did so because they believed that they were unlikely to ever be threatened by a bushfire and were thus not prepared, psychologically and logistically, to evacuate when threatened. A smaller number had planned to wait if warned about a bushfire threat in order to see if their property was likely to be seriously threatened before making a final decision to leave or remain. Figure 3 summarizes the findings.

The unweighted average percentage of those who, before the fire, did not believe they were at risk of a bushfire threat was 18 percent. The unweighted average percentage of those who intended to wait and see how events developed in the event of a bushfire threat was 17 percent. The majority of those who intended to wait in order to see if evacuation was necessary did so, two thirds ultimately left, one-third remained on their property. The findings suggest that residents' level of pre-fire risk perception is an important determinant of delayed evacuation—consistent with the findings reported in the US study by Mozumder et al. [22].

---

Figure 3 about here

---

Accounts by residents in several of the reports indicated that for many, evacuation was delayed by lack of preparation, a factor noted by Wilkinson et al. [51]: "Even those who had planned on leaving early did not adequately prepare to do so. Many had not considered what they would pack or what they would do if they were not at home at the time of the fire to grab packed belongings" (p. 533). There was also evidence from the reports summarized in Figure 3 that impaired decision making due to high levels of anxiety and fear once the imminent fire danger was apparent contributed to delayed evacuation for some residents by slowing decision processes [53 - 55].

*3.3.2 Delayed Evacuation* McLennan Elliott and Beatson [60] analyzed 584 returns from a survey of residents in notably wildfire-prone locations in south-eastern Australia. Residents were presented with a hypothetical bushfire threat scenario and asked what action they would take. The responses were: 47 percent chose the 'leave as soon as possible' option, 24 percent chose the 'stay and defend the property' option, and 29 percent chose the 'wait and see how events develop' option. On the basis of negative-binomial regression analyses the major determinants of residents' reported strength of intention to stay and defend were levels of: (a) belief that staying and defending was the appropriate action to take, (b) sense of self-determination, (c) awareness of possible danger associated with staying and defending, and (d) belief that one is capable of defending successfully. The major determinants of strength of intention to leave were levels of: (a) belief that leaving was the correct action to take, (b) normative belief that others regard leaving as the appropriate action to take, (c) belief that one is capable of leaving safely, and (d) belief that leaving would be a safe course of action to take. Those who chose the 'wait and see' option were asked to describe their reasons for choosing this, rejecting the 'leave as soon as possible' option, and rejecting the 'stay and defend' option. Their responses were examined for content and categorized by two judges jointly. The results are summarized in Tables 1-3, respectively.

---

Tables 1, 2 and 3 about here

---

The reasons given by the residents for their choice to wait and see how the (hypothetical) bushfire threat developed rather than choosing either the 'leave as soon as possible' option or the 'stay and defend' option varied [61]. However, some themes were evident—particularly when considered in combination with the reasons given for rejecting the 'leave' and the 'stay' options. Many of those intending to wait and see did not perceive their property to be notably at risk of being threatened seriously by a bushfire. They also believed that if a threat occurred the danger would not be great, and delaying a decision was not viewed as adding to risk. For some there were potential dangers and costs associated with evacuating: this option was not seen as resulting necessarily in a positive outcome. However, the possibility of death or injury if trapped on the property by an intense fire was appreciated and feared. For many, it seems likely that evacuating unnecessarily or staying on the property and having to survive a serious bushfire attack were equally unattractive alternatives, leading to a mindset of waiting and hoping that an actual threat did not eventuate. This explanation of why some at-risk residents plan to wait and see how a wildfire threat develops before deciding whether or not to evacuate following a warning is consistent with findings reported by McNeill et al. [62]. In a longitudinal study, the researchers analyzed 189 responses from Western Australian residents of at-risk locations near to the capital city, Perth. They conceptualized residents' delaying planning to definitely leave or remain on their property to defend it as a decision avoidance problem. Multinomial logistical regression analyses were used to determine that choice of a 'delay' option resulted from a perceived lack of difference between leaving and staying in outcome desirability:

> "…it appears that that residents who are aware that they are living in an area at risk of wildfire and know that they should be planning their response to a wildfire threat feel stuck between two competing responses that serve competing highly valued outcomes (e.g. they do not want to lose their property or livestock, but they also want to keep themselves and their loved ones safe)" [62, p. 159].

It seems likely that a low level of perceived wildfire risk can play a role in residents delaying leaving following an evacuation warning. A review by McLennan et al. [63] suggests that residents' perceived levels of wildfire risk are likely to be low if (a) fire authorities do not regard the area as being at notably high risk of wildfire, and (b) the area has not experienced a significant bushfire threat for ten years or more. However, factors other than risk perception may also contribute—especially the anticipated possible adverse consequences of making what might turn out to be a 'wrong' decision to leave, or to stay.

*3.3.3 Demographic Factors* Research into demographic factors associated with evacuation has focused on gender. An analysis of circumstances associated with 552 civilian bushfire fatalities over the period 1900 – 2008 showed that men were more likely to die in the course of defending a property while women and children were more likely to perish while fleeing or while sheltering passively [64]. It has been well established that women are more likely than men to evacuate if threatened [65 - 67].

## *3.4. Summary*

While research on North American residents' actions under imminent wildfire threat is somewhat limited, six tentative general conclusions are suggested. (1) Regardless of whether an evacuation warning is mandatory or advisory, it should not be assumed that all residents of a threatened location will evacuate promptly following an evacuation warning or order: it is highly likely that some, perhaps a large percentage, will want to remain to protect their

property. A significant percentage are likely to delay leaving, with some taking action only when they perceive fire impact to be imminent because they believe the possible costs of evacuating to be high (dangers associated with evacuating, financial, inconvenience) and they want to be certain that evacuation is necessary. In addition, it is likely that some residents who are not at their properties when an evacuation warning is issued will attempt to return before the arrival of the fire front. (2) Policies and practices of the local emergency services and law enforcement agencies about evacuation are likely to influence the percentages of residents willing to evacuate. Mandatory evacuation orders are likely to result in higher evacuation rates and fewer residents delaying their evacuation, especially if residents are aware of provisions for enforcement. Community social norms that evacuation is the appropriate response to wildfire threat will enhance prompt evacuation. (3) Residents of WUI amenity dwellings may be more likely to evacuate, residents of farming and other agribusiness properties may be more likely to wish to stay and defend. The major motivator for prompt evacuation is likely to be concern about possible death or injury to self and family members. A common reason for wishing to stay and defend is the desire to protect valued assets which would otherwise be destroyed, coupled with a belief that defense efforts will be successful. (4) Residents will be more likely to take prompt evacuation action if their pre-warning perceptions are that a wildfire threat is possible and that their property is vulnerable to destruction in the event of a fire. These are likely to be related to authorities' publically stated wildfire risk assessments for the area, the region's recent wildfire history and the perceived safety of egress roads. (5) The limited data suggest that three important determinants of a resident's decisive action following a wildfire evacuation warning are likely to be (a) their prior plan or intention about what to do if threatened by a serious wildfire, (b) the perceived danger posed by the fire, and (c) their level of prior preparation to evacuate. (6) The nature of the evacuation warnings (modality, timing, content) may be a

crucial factor in the how residents respond to a wildfire threat. This is discussed in more detail in the next Section.

# 4. How residents respond to warnings.

## *4.1 Effects of wildfire evacuation warnings*

The research reviewed in Section 3 indicated that in many instances initial warnings from authorities led to a period of waiting prior to decision making and decisive action. For many threatened residents, the trigger for decisive action to leave was seeing smoke or flames, or calls from neighbors with reports of the fire's proximity, even though extremely high fire danger weather had been predicted by authorities [48, 49]. For some residents, only the obvious imminent impact of the fire on the property prompted (late) evacuation. Other residents received warnings but the urgency of the perceived threat situation prompted emotionally charged, and potentially flawed, decision-making about evacuation timing, routes, and even a return to their property [39, 51, 55]. Warnings could lead to conflict and indecision within families about what to do [46] and consequent delays in leaving. Delays could also result if power failures cut access to information sources [32, 39]. Evacuation decisions could be delayed by the receipt of competing, salient unofficial information relating to places of safe refuge or possible threat to an evacuation route [68].

For many residents, receipt of a wildfire evacuation warning prompted a search for more information rather than prompt action to leave for a safer location. This was often associated with warnings being infrequent, or lacking timely or location-specific information thus leading to a psychological state of uncertainty, resulting in information search rather than decisive action to evacuate [39, 48]. While research on the effects of wildfire warnings on residents is limited, the phenomenon of residents delaying and engaging in information search following warnings rather than taking protective actions has been discussed

extensively in relation to threats from other hazards such as hurricanes, tornadoes, floods and chemical and radiation contamination [69 - 71]. Several models of the hazard warning and action process conceptualize information seeking responses during the pre-impact phase as a sense-making endeavor which may result in delayed decision making and action [72 - 75]. Overall, these models suggest a general sequence of behavioral process stages when a disaster event threatens residents:

1. Receiving an alert.
2. Believing the source is credible and confirming the threat event.
3. Personalizing the threat.
4. Evaluating whether protective action is needed and feasible—often following information search.
5. Deciding what action to take.

The research described in Section 3 suggests that evacuation decision making can be delayed at any or all of the Belief, Personalizing and Evaluating stages. If the warning messages do not contain enough specific information, further information seeking is likely to be undertaken. For example, Trigg et al. [48] reported that the most common reactions to initial warnings by the residents interviewed following the South Australian bushfires of 2014 were to turn on the radio for information (39%), phone others close by (34%) or look up the fire agency website (33%), rather than taking protective action immediately. The importance of a sense making loop has been proposed by Ryan [76] to understand possible sources of delay, whereby a notionally threatened resident may engage in a cyclical process of seeking and obtaining information from a source or collection of sources, followed by renewed information seeking in the light of what was found during a preceding information cycle—including a return to sources already consulted. Thus, residents under imminent wildfire threat may choose to delay evacuating despite high levels of concern about possible danger.

This process is represented in Figure 4, where key features of the Mileti et al. [73-75] and Savolianen [63] models were integrated with research on Australian bushfire (wildfire) warnings by Ryan [76] to show in an information seeking model the steps a resident typically goes through when under threat. The diagram shows the range of factors and the complexity of collecting information on which decisions can be made, adding to the length of time it takes to make a decision. Lindell and Perry [71] provided detailed insights into the cognitive activity that informs decision-making occurring during this threat response process. Their Protective Action Decision Model (PADM) describes the three sets of perceptions that inform this cognitive activity – threat, protective action and stakeholder perceptions. These form the basis for the decision-making about the threat, whether it is imminent or developing over a longer term. The information seeking in the disaster model proposed by Ryan [76] expands the information search component of the PADM model and has been used here to illustrate the potentially time-consuming nature of the physical information seeking process following indications of a possible threat. Thus, residents under imminent wildfire threat may delay evacuation based on (a) perceptions formed prior to any threat indication, (b) the amount and type of information they receive just before and during the threat, and (c) perceptions they hold once they have processed this information, despite possibly high levels of concern about potential danger.

### *4.2 Effective wildfire evacuation warnings*

Effective warnings and disaster messages require sufficiently detailed information that is perceived by residents to be relevant to their situation, especially the location of the threat and instructions about what action to take. Frequent repetition of the warning is also important for the threat to be perceived as real and persisting [77] so that residents begin the decision and action process as soon as possible rather than engaging in unnecessary information searching [78]. Provision of details such as evacuation routes and safe locations

[75, 79], and the nature, location, time and source of the hazard [78, 80, 81] are all likely to increase the likelihood of timely evacuation [82, 83]. Incorporating visual aids such as up-to-date maps in television broadcasts, on websites, or on social media apps can motivate constructive action [54, 84, 85]. Such detailed information is likely to deter people from filling a void with rumors from unofficial sources [78, 80]. Overall, threatened residents are more likely to take action if messages contain specific details about what is happening and what actions authorities want residents to take, are communicated over multiple channels relevant to the local community, are sent out with high frequency from trusted official sources, and are confirmed by multiple channels [74].

### *4.3 Location warning history*

Another factor that could contribute to delayed evacuation is the history of wildfire warnings in the particular location. A "warning fatigue" effect has been identified by some researchers [86 - 88]. This effect may result if residents have been subjected to a past series of warnings with no subsequent threat, become desensitized to such messages, and pay no attention to a current threat warning. Concern about costs associated with unnecessary wildfire evacuations may also reduce the strength of intentions of at-risk residents to evacuate on receipt of a wildfire threat warning [38, 57]. Whittaker and Handmer [89] found that residents of Victorian (Australia) communities that had been warned to evacuate on the basis of predicted extreme fire danger weather but experienced no actual bushfire threat were less likely to take precautionary action following subsequent similar predicted extreme weather warnings. While the research is limited it seems likely that residents' actions when warned that evacuation may be necessary will be influenced by their history of warnings and fire events. In particular, a history of previous 'false alarms' of wildfire evacuation warnings may lead to residents delaying evacuation action until such time as they have credible information that the danger is real.

# 5. Conclusions

Compared with the situation for evacuation from building fires, where the published research on behavioral factors is extensive [90, 91], published research into behavioral factors involved in wildfire evacuation is more limited, particularly for North American communities. This means that conclusions about residents' evacuation behavior based on published research must be tentative. There is a need for more comprehensive investigations of the behavioral factors involved in residents delaying leaving following a wildfire evacuation warning. Recent research suggests that influences of community-level factors on residents' preparations for wildfire threat are likely to be important [92]. Based on the research discussed in this review some broad generalizations are suggested.

## *5.1 Behavior under wildfire threat*

In the course of most wildfire events involving an evacuation warning some residents will not comply, others will delay their evacuation to the point of their safety being compromised, and some who are not on their property when the warning is issued will attempt to return. Those who do not comply will mostly be motivated by a desire to protect valued assets (including pets and livestock) which they believe may be lost in their absence. The limited available research suggests that most residents who delay evacuation do not have a pre-event plan to evacuate in the event of a wildfire warning and have thus not prepared to evacuate—either psychologically or logistically. Their situation may be made worse by the stress of the threat situation degrading the quality of decision making thus further compromising safety. For some residents, the lack of preparation will most likely result from a prior failure to contemplate and engage with the possibility that their life and their property might be jeopardized by a future wildfire. Others may have considered the likelihood of a future wildfire threat but decided that the possibility is sufficiently remote as not to be deserving of

action in comparison with more salient concerns associated with daily life [93]. Some others will have accepted the possibility of a future wildfire threat and will have judged their vulnerability to be low so that evacuation would only be necessary if there was compelling evidence that their life was in danger—they will have planned to delay evacuation in order to wait and see if it is really necessary. For some residents, evacuation will be a difficult, and thus delayed, undertaking because of their adverse life circumstances—such as age, disability, social isolation or other disadvantage [11].

Contextual factors may affect the percentages of residents in a given location who will not comply with an evacuation warning or delay evacuation. These might include: policy as to whether evacuation is mandatory or optional and, if mandatory, enforcement practices; authorities' wildfire risk rating of the location and its previous wildfire history; the effectiveness of authorities' prior community wildfire safety promotion and education endeavors; the property mix of amenity residences and farming and agribusinesses; the egress road network; and the demographic makeup of the residents.

When a wildfire threatens, the nature of the warnings issued by authorities is likely to influence both compliance with an evacuation warning and timeliness of evacuations. Warnings with a long lead time before fire impact and frequent updates, and containing detailed information about the current fire situation, predicted location threats and times, and specific directions about safe evacuation destinations and routes, are likely to reduce levels of non-compliance and self-delayed evacuations.

### *5.2 Wildfire evacuation modeling*

As noted in Section 1 modeling the impact of a wildfire on a community can enable emergency services authorities to better understand, plan and prepare for evacuations facing a range of likely future wildfire threats under different weather, population characteristics,

egress route capacities and vegetation fuel load conditions [37]. Prompt evacuation from a threatened location does not guarantee that fleeing residents will be safe from harm. Safe evacuation is not simply a matter of authorities convincing residents to leave, or to leave sooner. The means to allow safe egress from the threatened area must be available. An ability to model likely progression of future wildfire evacuations from a given location under different conditions is particularly important because the road and transport infrastructures in some areas may not be able to cope with a large volume of vehicles and/or pedestrians all leaving at the same time. For example, during the 2016 Fort McMurray fire the major egress route (Canada Highway 63) became jammed with traffic due to a mass evacuation, with some vehicles running out of fuel, and those evacuees being immobilized and potentially exposed to hazardous conditions as the fire advanced [94].

The need to incorporate representations of behavioral aspects of evacuee performance in building egress models has been discussed by Kuligowski et al. [95]. It seems equally important for wildfire evacuation models to do likewise if they are to be useful, though not all do so [96]. The research findings discussed in this paper suggest that the complexities of modeling evacuee behavior under imminent wildfire threat may be somewhat greater than for evacuations from buildings because of the number of factors potentially influencing residents' responses to wildfire threats-- including the range of protective action options which might be available to residents and the influence of local contextual factors noted in 5.1. This implies that for models to prove useful, they should be able to incorporate detailed location-specific information about the residents' likely actions following an evacuation warning. In turn, agencies responsible for the wildfire safety of communities would need to collect and monitor relevant psychosocial information about: (a) residents' levels of perceived wildfire risk, wildfire safety plans, and wildfire safety preparations, in relation to (b) their key demographic characteristics such age, household compositions, special needs,

transport options and pet and livestock ownership, and also (c) the warning and threat history of the location. Such a proposal for agencies is by no means original, it was discussed by Mozumder et al. [22]. Yet it is uncertain how widespread such agency practices are currently.

### *5.3 Possible actions by Authorities to address late wildfire evacuations*

There are a number of actions that can be taken by authorities to reduce the number of residents who will delay evacuating following wildfire warnings.

1. Continue to improve the accuracy, comprehensiveness, timeliness, and *location-specificity* of wildfire warnings for residents in at-risk locations so as to reduce householder uncertainty about their threat situation and thus encourage early survival decisions and actions. Ongoing developments in social media-based communications technology are likely to contribute and new applications need to be developed and trialed.

2. Increase householders' knowledge and understanding of the risks involved in last-minute flight or last-ditch defense of an under-prepared property.

3. Reduce householders' reluctance to leave by:

   (a) assisting them with advice about preparations to leave which are minimally inconvenient but sufficient to survive, encouraging planning for staged moves to successively safer locations during the course of a wildfire event as their known threat level increases, and providing pre-fire information about likely safe evacuation destinations and routes;

   (b) emphasizing that a house can be prepared to survive wildfire attack without the resident having to be present to actively defend it. 'The safest place to be during a wildfire is somewhere else, and here are things to do so that your house is more likely be standing when you return';

   (c) concentrating on advising householders about low-cost actions they can take to reduce house vulnerability to bushfire, such as clearing vegetation and combustibles from around

the house, rather than emphasizing more costly measures such as retrofitting the house with fire-resistant construction materials;

(d) emphasizing the importance of being prepared to leave before a fire is near, and providing clear and simple advice on what such preparation entails;

(e) allaying concerns about looting;

(f) emphasizing that while residents should be alert for wildfire warnings from authorities, they should not expect to be contacted individually and told when to leave, they should instead decide beforehand on their own 'triggers' for leaving safely prior to imminent threat, and actively monitor the emerging fire situation utilizing both media information and environmental cues.

By way of a concluding comment, the last point (f) seems likely to present a particular challenge for fire agencies: how best to help residents understand what, for their situation, is likely to constitute an 'imminent' wildfire threat necessitating immediate evacuation? This issue clearly needs further research.

## References

[1] Ferris E, Petz D, Stark C (2013) It only takes a spark: the hazards of wildfires. In Ferris E, Petz D, Stark C (eds) The year of recurring disasters: a review of natural disasters in 2012, The Brookings Institution—London School of Economics. https://www.brookings.edu/research/the-year-of-recurring-disasters-a-review-of-natural-disasters-in-2012/ . Accessed June 2017

[2] Blanchi R, Leonard J, Haynes K, Opie K, James M, Oliveira FD (2014). Environmental circumstances surrounding bushfire fatalities in Australia 1901–2011. Environmental Science and Policy 37: 192-203 doi.org/10.1016/j.envsci.2013.09.013

[3] Cardil A, Molina DM (2015) Factors causing victims of wildland fires in Spain (1980–2010). Human and Ecological Risk Assessment: An International Journal 2: 167-80 doi.org/10.1080/10807039.2013.871995

[4] Diakakis M, Xanthopoulos G, Gregos L (2016) Analysis of forest fire fatalities in Greece: 1977–2013. International Journal of Wildland Fire 25: 797-809 doi: 10.1071/WF15198

[5] Mell WE, Manzello SL, Maranghides A, Butry D, Rehm RG (2010) The wildland-urban interface fire problem – current approaches and research needs. International Journal of Wildland Fire 19: 238-251 doi.org/10.1071/WF07131

[6] Intergovernmental Panel on Climate Change (2014) Assessing and managing the risks of climate change: Observed impacts, vulnerability and adaptation in a complex and changing world. https://www.ipcc.ch/report/ar5/wg2/docs/WGIIAR5_SPM_Top_Level_Findings.pdf Accessed January 2018

[7] Gibbons P, Van Bommel L, Gill AM, Cary GJ, Driscoll DA, Bradstock RA, Knight E, Moritz MA, Stephens SL, Lindenmayer DB (2012) Land management practices associated with house loss in wildfires. PloS one, 7(1), e29212 doi: 10.1371/journal.pone.0029212

[8] Gill AM, Stephens SL, Cary GJ (2013) The worldwide "wildfire" problem. Ecological Applications 23(2): 438-454. doi**:** 10.1890/10-2213.1

[9] Alexander ME (2006) You are about to be entrapped or burned over by a wildfire: what are your survival options? in D.X. Viegas, ed. Proceedings of 5th International Conference on Forest Fire Research, 27-30 November 2006, Figueira da Foz, Portugal. Elsevier B.V., Amsterdam, The Netherlands http://cfs.nrcan.gc.ca/publications?id=26669 Accessed June 2017

[10] Zárate L, Arnaldos J, Casal J (2008) Establishing safety distances for wildland fires. Fire Safety Journal 43: 565-575 doi/10.1016/j.firesaf.2008.01.001

[11] Handmer J, O'Neil S, Killalea D (2010) Review of fatalities in the February 7, 2009, bushfires. Centre For Risk and Community Safety RMIT University and Bushfire CRC: Melbourne http://www.bushfirecrc.com/managed/resource/review-fatalities-february-7.pdf Accessed June 2017

[12] Butler BW (2014) Wildland firefighter safety zones: a review of past science and summary of future needs. International Journal of Wildland Fire 23: 295-308 doi.org/10.1071/WF13021

[13] McCaffrey S, Rhodes A, Stidham M (2014) Wildfire evacuation and its alternatives: perspectives from four United States communities. International Journal of Wildland Fire 24: 170-178 doi 10.1071/WF13050

[14] Australasian Fire and Emergency Services Authorities Council (2012) Bushfires and community safety: position; version 5.0. AFAC: East Melbourne

http://www.afac.com.au/docs/position/bushfires-community-safety.pdf?sfvrsn=20 Accessed June 2017

[15] Cohn PJ, Carroll MS, Kumagai Y (2006) Evacuation behavior during wildfires: results of three case studies. Western Journal of Applied Forestry 21(1): 39-48

[16] Beverly JL, Bothwell P (2011) Wildfire evacuations in Canada 1980–2007. Natural Hazards 59: 571-596. doi: 10.1007/s11069-011-9777-9

[17] Cova T, Johnson JP (2002) Microsimulation of neighborhood evacuations in the urban-wildland interface. Environment and Planning A 34: 2211-2229 doi: 10.1068/a34251

[18] Vorst HCM (2010) Evacuation models and disaster psychology. Procedia Engineering 3: 15-21 doi: 10.1016/j.proeng.2010.07.004

[19] Kuligowski ED, Gwynne SM (2010) The need for behavioral theory in evacuation modeling http://ws680.nist.gov/publication/get_pdf.cfm?pub_id=861543

[20] McCaffrey S, Toman E, Stidham M, Shindler B (2013) Social science research related to wildfire management: an overview of recent findings and future research needs. International Journal of Wildland Fire 22: 15-24 doi: 10.1071/WF11115

[21] McCaffrey S (2015) Community wildfire preparedness: a global state-of-the-knowledge summary of social science research. Current Forestry Reports 1(2): 81-90 doi: 10.1007/s40725-015-0015-7

[22] Mozumder P, Raheem N, Talberth J, Berrens RP (2008) Investigating intended evacuation from wildfires in the wildland–urban interface: application of a bivariate probit model. Forest Policy and Economics 10(6): 415-423 doi/10.1016/j.forpol.2008.02.002

[23] Paveglio T, Carroll MS, Jakes PJ (2008) Alternatives to evacuation—protecting public safety during wildland fire. Journal of Forestry 106(2): 65-70.

[24] Federal Emergency Management Authority (2017) How to prepare for a wildfire. https://www.fema.gov/media-library-data/1409003859391-0e8ad1ed42c129f11fbc23d008d1ee85/how_to_prepare_wildfire_033014_508.pdf Accessed June 2017

[25] Mutch RW (2007) Faces: the story of the victims of southern California's 2003 fire siege. Wildland Fire Lessons Learned Center: Tucson, AZ https://nsjfire.org/wp-content/uploads/2014/04/Faces-20031.pdf Accessed June 2017

[26] Paveglio TB, Carroll MS, Jakes PJ (2010) Adoption and perceptions of shelter-in-place in California's Rancho Santa Fe Fire Protection District. International Journal of Wildland Fire, 19: 677-688 doi.org/10.1071/WF09034

[27] McCaffrey SM, Rhodes A (2009) Public response to wildfire: Is the Australian "stay and defend or leave early" approach an option for wildfire management in the United States?. Journal of Forestry 107(1): 9-15

[28] Taylor SW, Stennes B, Wang S, Taudin-Chabot P (2006) Integrating Canadian wildland fire management policy and institutions: sustaining natural resources, communities and ecosystems. In: Hirsch KG, Fuglem P (eds) Canadian Wildland Fire Strategy: Background Syntheses, Analyses, and Perspectives, Canadian Council of Forest Ministers, Canadian Forest Service, Northern Forestry Centre, Edmonton Alberta, pp 3-26 https://cfs.nrcan.gc.ca/publications?id=26529 Accessed January 2018

[29] Australian Fire Authorities Council (2005) Position paper on bushfires and community safety. AFAC, East Melbourne http://www.royalcommission.vic.gov.au/Documents/Document-files/Exhibits/TEN-001-001-0077 Accessed June 2017

[30] Gledhill J (2003) Community self-reliance during bushfires: the case for staying at home. Proceedings of the Third International Wildland Fire Conference, Sydney Australia http://www.fire.uni-freiburg.de/summit-2003/3-IWFC/Papers/3-IWFC-061-Gledhill.pdf Accessed June 2017

[31] Handmer J, Tibbits A (2005) Is staying at home the safest option during bushfires? Historical evidence for an Australia approach. Environmental Hazards 6(2): 81-91 doi: 10.1016/J.HAZARDS.2005.10.006

[32] Teague B, McLeod R, Pascoe S (2010) 2009 Victorian Bushfires Royal Commission final report. State Government of Victoria, Melbourne http://www.royalcommission.vic.gov.au/Commission-Reports/Final-Report Accessed June 2017

[33] Hart D (2014) Lessons learned from the Black Saturday Bushfires. Victoria Police & Bushfire CRC, East Melbourne http://www.afac.com.au/docs/default-source/assets/ lessons-learnt-black-saturday-final.pdf Accessed January 2018

[34] Eburn, M (2014) Legality of forced evacuations during NSW bushfires. Australian Emergency Law. https://emergencylaw.wordpress.com/2014/01/10/legality-of-forced-evacuations-during-nsw-bushfires/ Accessed June 2017

[35] McCaffrey S, Rhodes A, Stidham M (2015) Wildfire evacuation and its alternatives: perspectives from four United States' communities. International Journal of Wildland Fire 24*:* 170-178 doi.org/10.1071/WF13050

[36] Li D, Cova TJ, Dennison PE (2015, November) An open-source software system for setting wildfire evacuation triggers. In Proceedings of the 1st ACM SIGSPATIAL International Workshop on the Use of GIS in Emergency Management, Seattle, WA doi: 10.1145/2835596.2835600

[37] Beloglazov A, Almashor M, Abebe E, Richter J, Steer KCB (2016) Simulation of wildfire evacuation with dynamic factors and model composition. Simulation Modeling Practice and Theory 60: 144-159 doi: 10.1016/j.simpat.2015.10.002

[38] Gan HS, Richter KF, Shi M, Winter S (2016) Integration of simulation and optimization for evacuation planning. Simulation Modeling Practice and Theory 67*:* 59-73 doi: 10.1016/j.simpat.2016.07.001

[39] Taylor JG, Gillette SC, Hodgson RW, Downing JL (2005) Communicating with wildland interface communities during wildfire (No. 2005-1061). US Geological Survey https://pubs.er.usgs.gov/publication/ofr20051061 Accessed June 2017

[40] McCaffrey SM, Winter G (2011) Understanding homeowner preparation and intended actions when threatened by a wildfire. In: McCaffrey SM, Fisher CL (eds) Proceedings, Second Conference on the Human Dimensions of Wildland Fire, USDA Forest Service, Northern Research Station, General Technical Report NRS-P-84. pp 88-95 https://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs-p-84.pdf#page=94 Accessed June 2017

[41] Paveglio T, Prato T, Dalenberg D, Venn T (2014) Understanding evacuation preferences and wildfire mitigations among Northwest Montana residents. International Journal of Wildland Fire 23*:* 435-444 doi.org/10.1071/WF13057

[42] Thompson RR, Garfin DC, Silver RC (2017) Evacuation from natural disasters: A systematic Review. Risk Analysis, 37 812-839. doi: 10.1111/risa.12654

[43] MNP LNP (2017) A review of the 2016 Horse River wildfire Alberta Agriculture and Forestry preparedness and response. Prepared for Forestry Division, Alberta Agriculture and Forestry, Edmonton AB Canada https://www.alberta.ca/assets/documents/Wildfire-MNP-Report.pdf Accessed July 2017

[44] Cote DW, McGee TK (2014) An exploration of residents' intended wildfire evacuation responses in Mt. Lorne, Yukon, Canada. The Forestry Chronicle 90: 498-502 doi: 10.5558/tfc2014-100

[45] Tibbits A, Whittaker J (2007) Stay and defend or leave early: Policy, problems and experiences during the 2003 Victorian bushfires. Environmental Hazards 7: 283-290 doi.org/10.1016/j.envhaz.2007.08.001

[46] Proudley M (2008) Fire, families and decisions. The Australian Journal of Emergency Management 23(1): 37-43.

[47] McLennan J, Paton D, Wright L (2015) 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: 319-327. doi: 10.1016/j.jdrr.2015.02.007

[48] Trigg J, Rainbird S, Thompson K, Bearman C, Wright L, McLennan J (2015) Capturing community experiences: South Australian bushfires January 2014. Bushfire and Natural Hazards CRC, Melbourne Australia https://www.bnhcrc.com.au/publications/biblio/bnh-1663 Accessed June 2017

[49] McLennan J, Elliott G, Omodei M (2011) Issues in community bushfire safety: analyses of interviews conducted by the 2009 Victorian bushfires research task force. Bushfire Cooperative Research Centre and School of Psychological Science La Trobe University, Melbourne Australia http://www.bushfirecrc.com/sites/default/files/managed/resource/issues_in_community_bushfire_safety-analyses_of_interviews_conducted_by_the_2009_victorian_bushfires_0.pdf Accessed June 2017

[50] Whittaker J, Haynes K, Handmer, J, McLennan J (2013) Community safety during the 2009 Australian 'Black Saturday' bushfires: an analysis of household preparedness and response. International Journal of Wildland Fire 22: 841-849 doi: 10.1071/WF12010

[51] Wilkinson C, Eriksen C, Penman, T (2016) Into the firing line: civilian ingress during the 2013 "Red October" bushfires, Australia. Natural Hazards 80:521-538 doi 10.1007/s11069-015-1982-5

[52] McLennan J (2014) Capturing community members' bushfire experiences: Interviews with residents following the 12 January 2014 Parkerville (WA) Fire. Bushfire & Natural Hazards Cooperative Research Centre, East Melbourne https://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireResearch/DFES-Bushfire-Experiences-Parkerville-Bushfire-Jan12-2014.pdf Accessed June 2017

[53] McLennan J, Elliott G, Omodei M (2012) Householder decision-making under imminent wildfire threat: stay and defend or leave?. International Journal of Wildland Fire 21: 915-925. doi.org/10.1071/WF11061

[54] McLennan J, Dunlop P, Kelly L, Elliott G (2011) Lake Clifton Fire 10 January 2011 – community bushfire safety. East Melbourne: Bushfire Cooperative Research Centre, School of Psychological Science La Trobe University, Melbourne, School of Psychology University of Western Australia http://www.bushfirecrc.com/managed/resource/fesa_report_lake_clifton_fire.pdf Accessed June 2017

[55] Heath J, Nulsen C, Dunlop P, Clark P, Burgelt P, Morrison D (2011) The 2011 fires at Roleystone, Kelmscott and Red Hill. Bushfire Cooperative Research Centre East Melbourne, School of Psychology University of Western Australia

http://www.bushfirecrc.com/managed/resource/bushfire_final_report_0.pdf Accessed June 2017

[56] Boylan J, Cheek C, Skinner T (2013) Preliminary report on the January 2013 fires in the south-eastern Tasmania research project. University of Tasmania Rural Clinical School, Burnie Tasmania http://www.bushfirecrc.com/sites/default/files/managed/resource/report_on_the_january_2013_fires_in_the_south-eastern_tasmania_research_project.pdf Accessed June 2017

[57] Mackie B, McLennan J, Wright L (2013) Community understanding and awareness of bushfire safety: January 2013 bushfires. Bushfire Cooperative Research Centre, East Melbourne http://www.bushfirecrc.com/resources/research-report/community-understanding-and-awareness-bushfire-safety-january-2013-nsw-bus Accessed June 2017

[58] McLennan J, Wright L, Birch A (2013) Community understanding and awareness of bushfire Safety: Residents' experiences of the October 2013 bushfires in three areas. Bushfire & Natural Hazards Cooperative Research Centre, East Melbourne http://www.bushfirecrc.com/sites/default/files/nsw_rfs_october_2013_fires_report_part_1_final_version.pdf Accessed June 2017

[59] McLennan J, Elliott G, Omodei M, Whittaker J (2013) Householders' safety-related decisions, plans, actions and outcomes during the 7 February 2009 Victorian (Australia) wildfires. Fire Safety Journal 61*:* 175-184 doi: 10.1016/j.firesaf.2013.09.003

[60] McLennan J, Elliott G, Beatson R (2013) Householders' stated bushfire survival intentions under hypothetical bushfire threat: factors associated with choosing to leave, stay and defend, or wait and see. La Trobe University School of Psychological Science, Melbourne http://www.bushfirecrc.com/sites/default/files/managed/resource/final_-

_community_bushfire_intentions_survey_report_revised_2012hg-charts.pdf Accessed June 2017

[61] McLennan J, Elliott G (2013) "Wait and see": the elephant in the community bushfire safety room? In Thornton RP, Wright LJ (eds) Proceedings of the AFAC/Bushfire CRC Research Forum, Perth, September 2012. Bushfire CRC, East Melbourne, pp 56-69 http://www.bushfirecrc.com/sites/default/files/managed/resource/final_mclennan_j.pdf Accessed June 2017

[62] McNeill IM, Dunlop PD, Skinner TC, Morrison, DL (2015) Predicting delay in residents' decisions on defending *v.* evacuating through antecedents of decision avoidance. International Journal of Wildland Fire 24: 153-161 doi.10.1071/WF12213

[63] McLennan J, Every D, Bearman C, Wright L (2017) On the concept of denial of natural hazard risk and its use in relation to householder wildfire safety in Australia. International Journal of Disaster Risk Reduction 21: 176-186 doi: 10.1016/j.ijdrr.2016.12.006

[64] Haynes K, Handmer J, McAneney J, Tibbits A, Coates L (2010) Australian bushfire fatalities 1900–2008: exploring trends in relation to the 'Prepare, stay and defend or leave early' policy. Environmental Science & Policy 13: 185-194 doi: 10.1016/j.envsci.2010.03.002

[65] Eriksen C, Gill N, Head L (2010) The gendered dimensions of bushfire in changing rural landscapes in Australia. Journal of Rural Studies 26*:* 332-342. doi: 10.1016/j.jrurstud.2010.06.001

[66] Tyler M, Fairbrother P (2013) Bushfires are "men's business": The importance of gender and rural hegemonic masculinity Journal of Rural Studies 30: 110-119. doi: 10.1016/j.jrurstud.2013.01.002

[67] Whittaker J, Eriksen C, Haynes K (2016) Gendered responses to the 2009 Black Saturday bushfires in Victoria, Australia. Geographical Research 54: 203-215. doi: 10.1111/1745-5871.12162

[68] McLennan J (2010) Use of informal places of shelter and last resort on 7 February 2009. School of Psychological Science La Trobe, University and Bushfire Cooperative Research Centre, Melbourne Australia. http://www.bushfirecrc.com/sites/default/files/managed/resource/cfa_nsps_informal_places_of_reguge_final_0.pdf Accessed June 2017

[69] Sorensen JH, Shumpert BL, Vogt BM (2004) Planning for protective action decision making: evacuate or shelter-in-place. Journal of Hazardous Materials: 109:.1-11 doi.org/10.1016/j.jhazmat.2004.03.004

[70] Dash N, Gladwin H (2007) Evacuation decision making and behavioral responses: Individual and household. Natural Hazards Review 8(3): 69-77. doi: 10.1061/(ASCE)1527-6988(2007)8:3(69)

[71] Lindell MK, Perry RW (2012) The protective action decision model: theoretical modifications and additional evidence. Risk Analysis: 32:.616-632. doi: 10.1111/j.1539-6924.2011.01647.x

[72] Savolainen R (1995) Everyday life information seeking: Approaching information seeking in the context of "way of life". Library & Information Science Research 17: 259-294. doi: 10.1016/0740-8188(95)90048-9

[73] Mileti DS, O'Brien PW (1992) Warnings during disaster: normalizing communicated risk. Social Problems 39: 40-57 doi: 10.2307/3096912

[74] Mileti DS, Fitzpatrick C (1992) The causal sequence of risk communication in the Parkfield earthquake prediction experiment. Risk Analysis 12: 393-400 doi: 10.1111/j.1539-

6924.1992.tb00691.x.

[75] Mileti, DS, Sorensen JH (1990) Communication of emergency public warnings. Colorado State University, Washington DC http://www.cires.org.mx/docs_info/CIRES_003.pdf Accessed June 2017 Accessed June 2017

[76] Ryan, B (2016) Developing an understanding of information seeking during the impact phase of a natural disaster. PhD thesis, School of Property, Construction and Project Management, RMIT University, Melbourne https://researchbank.rmit.edu.au/view/rmit:162001 Accessed June 2017

[77] Lindell MK, Perry RW (1991) Understanding evacuation behavior: an editorial introduction. International Journal of Mass Emergencies and Disasters 9(2): 133-136.

[78] Sutton JN, Palen L, Shklovski I (2008) Backchannels on the front lines: Emergency uses of social media in the 2007 Southern California Wildfires (pp. 624-632). In: Fiedrich F, Van de Walle B (eds) Proceedings of the 5th International ISCRAM Conference, Washington DC, May 2008 http://jeannettesutton.com/uploads/BackchannelsISCRAM08.pdf Accessed June 2017

[79] Lindell M, Perry R (1987) Warning mechanisms in emergency response systems. International Journal of Mass Emergencies and Disasters, 5: 137-153

[80] Mileti DS (1995) Factors related to flood warning response. In US-Italy Research Workshop on the Hydrometeorology, Impacts, and Management of Extreme Floods (pp. 1-17). http://www.engr.colostate.edu/ce/facultystaff/salas/us-italy/papers/46mileti.pdf Accessed June 2017

[81] Sorensen JH (2000). Hazard warning systems: Review of 20 years of progress. Natural Hazards Review 1(2): .119-125 https://doi.org/10.1061/(ASCE)1527-6988(2000)1:2(119) Accessed June 2017

[82] Donner WR., Rodriguez H, Diaz W (2007) Public warning response following tornadoes in New Orleans, LA, and Springfield, MO: A sociological analysis. In Second Symposium on Policy and Socio-economic Research, 87th Annual Meeting of the American Meteorological Society, San Antonio, Texas https://ams.confex.com/ams/pdfpapers/120774.pdf Accessed June 2017

[83] Mileti DS, Peek L (2000) The social psychology of public response to warnings of a nuclear power plant accident. Journal of Hazardous Materials 75: 181-194 doi.org/10.1016/S0304-3894(00)00179-5

[84] Benight C, Gruntfest E, Sparks K (2004) Colorado Wildfires 2002, University of Colorado, Colorado Springs, http://www.colorado.edu/hazards/research/qr/qr167/qr167.html Accessed June 2017

[85] Goolsby R (2010) Social media as crisis platform: The future of community maps/crisis maps. ACM Transactions on Intelligent Systems and Technology (TIST), 1(1) 7. doi: 10.1145/1858948.1858955

[86] Kordek ME (2013) Alert fatigue by other names: review of contributing fields regarding the 'cry wolf' effect. Scholar Archive 910 http://digitalcommons.ohsu.edu/etd/910 Accessed June 2017

[87] Mackie B (2013) Warning fatigue: insights from the Australian bushfire context. (PhD thesis) Canterbury University, Christchurch New Zealand http://ir.canterbury.ac.nz/handle/10092/9029 Accessed June 2017

[88] LeClerc J, Joslyn S (2015) The cry wolf effect and weather-related decision making. Risk Analysis 35: 385-395. doi; 10.1111/risa.12336

[89] Whittaker J, Handmer J (2010) Community bushfire safety: a review of post-Black Saturday research. The Australian Journal of Emergency Management 25(4): 7-13.

[90] Kobes M, Helsloot I, De Vries B, Post JG (2010) Building safety and human behavior in fire: A literature review. Fire Safety Journal 45: 1-11 doi:10.1016/j.firesaf.2009.08.005

[91] Ronchi E, Nilsson D (2013) Fire evacuation in high-rise buildings: a review of human behaviour and modelling research. Fire Science Reviews 2: 7-21 doi: 10.1186/2193-0414-2-7

[92] Paveglio TB, Moseley C, Carroll MS, Williams DR, Davis EJ, Fischer AP (2015) Categorizing the social context of the wildland urban interface: Adaptive capacity for wildfire and community "archetypes". Forest Science 1: 298-310. doi: 10.5849/forsci.14-036

[93] Eriksen C, Gill N (2010) Bushfire and everyday life: examining the awareness-action 'gap' in changing rural landscapes. Geoforum 41: 814-825 doi: 10.1016/j.geoforum.2010.05.004

[94] Thurton D (2016, October 26) Traffic-clogged highway during Fort McMurray wildfire spurs call for 2nd highway. CBC News, Edmonton, Canada http://www.cbc.ca/news/canada/edmonton/traffic-clogged-highway-during-fort-mcmurray-wildfire-spurs-call-for-2nd-highway-1.3821671 Accessed January 2018

[95] Kuligowski E, Gwynne S, Kinsey M, Hulse L (2017) Guidance for the model user on representing human behavior in egress models. Fire Technology 53: 649-672 doi: 10.1007/s1-016-0586-20694

[96] Shahparvari S, Chhetri P, Abbasi B, Abareshi A (2016) Enhancing emergency evacuation response of late evacuees: Revisiting the case of Australian Black Saturday

1 bushfire. Transportation Research Part E: Logistics and Transportation Review 93: 148-176

2 doi.org/10.1016/j.tre.2016.05.010

3