# Understanding wildfire mitigation and preparedness in the context of extreme wildfires and disasters

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## Social science contributions to understanding human response to wildfire

*Sarah McCaffrey*[1], *Tara K. McGee*[2], *Michael Coughlan*[3], *Fantina Tedim*[4,5]
[1]Rocky Mountain Research Station, USDA Forest Service, Fort Collins, CO, United States; [2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada; [3]Institute for a Sustainable Environment, University of Oregon, Eugene, OR, United States; [4]Faculty of Arts and Humanities, University of Porto, Porto, Portugal; [5]Charles Darwin University, Darwin, NWT, Australia

## 8.1 Introduction

Recent years have witnessed a growing number of stories about extreme wildfires that have had significant social impacts, from Australia to Portugal to California. Although this has heightened the call to find ways to better "coexist with fire," it must be recognized that wildfire—human interactions are as old as humanity itself. Humans around the world have ignited and used fire as a basic tool for millennia; people have and continue to use confined fires for a range of quotidian reasons including cooking, heating, and processing of materials (e.g., in the production of brick, ceramics, metals). Use of broadcast landscape fire for hunting, gathering, agriculture, and construction purposes is another age-old practice. Although more recently such broadscale burning has become frowned on in many places, particularly more industrialized countries, the current practice of prescribed fire derives from these traditions. The use of landscape fire was and continues to be indispensable to our evolution as a species and to the development of our many and diverse social and economic systems.

Even today only a small portion of wildfire-human interactions occur in contexts where fire presents a serious hazard to life and property. The use of and dependence on fire and fire-causing technologies creates an inherent and ubiquitous hazard for people inhabiting fire-prone environments. Although in many places significant resources have been directed toward prevention and suppression of wildfires, losses from wildfires persist and are increasing in some areas. A key reason for the increased attention to wildfire is the growing human exposure and negative impacts on human health, livelihoods, and well-being. The causes of the increased exposure vary geographically and

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across socioeconomic gradients with the level of risk determined by a range of large-scale social factors including population growth, changing settlement patterns, and shifts in natural resource management practices. How these factors may contribute to extreme fire damage can vary considerably. In some areas, people moving from urban areas into more fire-prone rural landscapes are seen as increasing wildfire risk as landscape fragmentation and new settlements are seen to complicate fire and land management decisions in ways that increase wildfire hazards. In other places, such as Mediterranean Europe, individuals moving from rural to urban areas for economic opportunities can contribute to increased wildfire risk as unplanned afforestation resulting from agricultural land abandonment can increase fuel loading in rural communities where traditional land-use practices involved the use of fire. In other places the fire risk is effectively brought to established communities. For example, a key source of increased risk in parts of Portugal results from the initial introduction of eucalyptus in the 20th century and the more recent expansion of eucalyptus plantations for the pulp industry.

Similarly, the reasons individuals live in fire-prone areas are highly variable. In many cases economic considerations, such as livelihood opportunities and housing affordability, are a key factor influencing residency choices. In other cases, people may be attracted to fire-prone landscapes by natural amenities such as scenery, recreational opportunities, and solitude. Furthermore, many people such as First Nations in Canada and rural Portuguese have lived in fire-prone areas settled by their ancestors, long before wildfire risk became a significant challenge.

Ultimately, there is no single explanation for what has led to increased fire risk in a given location, and it is important to carefully assess the accuracy of the beliefs around how social dynamics contribute to extreme fire risk in a specific location. A challenge with understanding social issues around wildfire preparedness and mitigation at a global level is that local context is critical as both the level of wildfire risk and potential social outcomes can be contingent on specific local dynamics such as local culture, land management and building practices, and institutional histories [1]. Therefore this chapter will not focus on regional specifics but provide a broad overview of a range of factors and dynamics to consider in assessing specific local conditions.

## 8.2 Social science theoretical insights into preparedness and mitigation

Several fields of study provide useful insights into understanding the human−wildfire relationship: (1) natural hazards, (2) diffusion of innovations, and (3) risk and crisis communication. The first field of research provides a framework for how societies and individuals perceive and respond to the wildfire hazard, the second provides further insight into factors that may influence adoption of fire mitigation measures, and the third helps identify key dynamics to consider in effective outreach efforts.

All three fields address decision-making in the face of uncertainty. The uncertainty around when and where an event may occur, and if it does occur just how negative the outcomes will be is a key factor that informs and shapes human response to a hazard.

"Risk arises not just from how some future can be described, but from the uncertainty, actual or perceived, surrounding that description. Indeed, it is only because we need to act under conditions of uncertainty that the concept of risk is of any interest whatsoever. Living with natural processes that are periodically hazardous means that people have choices to make …." [2]. It is this uncertainty that is an underlying focus of many scientific efforts: Studies about natural hazards and risk and crisis communication both focus on understanding how individuals interpret and respond to the uncertainty created by a potential hazard event, while diffusion of innovations has been described as "an uncertainty-reduction process" [3].

### 8.2.1 Natural hazards

By definition, a natural hazard results from human nature interactions: A hazard is simply a normal biophysical process that only becomes seen as a hazard when it begins to have a significant negative effect on something humans value, whether that is homes, water quality, or an endangered species. Water flowing in a stream is a beneficial process—providing everything from drinking water to recreational fishing and boating opportunities—until it begins to overflow the stream bed and damage crops or homes; at that point the natural process has become a natural hazard. Natural hazards research works to understand the range of factors that influence adoption of measures to decrease, or mitigate, potential damage and why certain responses to a hazard are favored over others.

The natural hazards field grew out of Gilbert White's work on early US flood control policy: specifically why, despite all the levees and dams built under the 1936 Flood Control Act, US flood damage continued to rise. At the time, the rational actor model of human behavior prevailed, and it was assumed that as long as individuals understood the risk, they would choose to make the most cost-effective or economically optimal choice. In the case of floods, they would recognize areas of higher flood danger, value that land less, and choose to live elsewhere [4]. Instead, White's work, and a plethora of subsequent natural hazards studies, demonstrated that human response to hazards was not based purely on hazard-related economic calculations but also was influenced by a range of factors such as sufficient resources to undertake protective actions, beliefs and attitudes toward the problem, and available mitigation options.

Over time, the field expanded its scope beyond a focus on individual decision-making to examine how larger scale factors, including mescoscale (mid-level) and macroscale variables, influenced the hazard itself as well as how humans responded to it. Of note is that important macrolevel and mesolevel variables often are not directly related to the hazard: "both institutional and cultural phenomena may buffer or focus damage, without being tied to specific vulnerabilities or agents of damage" [5]. This idea that a hazard may be exacerbated from external actions not directly related to the hazard is an important point for understanding the wildfire risk around the world. As indicated earlier, in some places the fire hazard has increased because of decreased agricultural burning, often as a result of larger scale economic drivers leading to rural

depopulation while in other locations the hazard has increased because of the establishment of eucalyptus plantations by both industrial and smaller scale landholders.

### 8.2.2 Societal stages of response to natural hazards

Through a series of international case studies, natural hazards research developed a framework in the 1970s that identified four different societal stages for coping with a natural hazard: loss absorption, acceptance, reduction, and change [4,6]. Understanding which stage a society or an individual or community might be at can help decision-makers more readily identify disconnects between the current societal stage and the actions being taken and identify appropriate next steps.

The first stage, loss absorption, takes place when a hazard's effect is small enough to impose relatively few costs to society and adaptations are unconsciously made to absorb them. Carrying a raincoat if it looks like it might rain is a simple example of such an action. Once a hazard's effect begins to exceed a society's natural absorptive capacity, the effected group begins to see the biophysical process as something that is potentially hazardous and to make adjustments. At first these are fairly passive; the potential for loss is recognized but little is done to alter the hazard as bearing the cost is preferable to the effort and uncertainty of making any significant changes. Instead, the focus is on minimizing impacts by finding ways to help those most directly affected by an event to absorb the loss. After an event, these measures include governmental and charity disaster relief. Before an event, a primary mechanism is insurance which effectively spreads the risk of individual loss across a larger population. Here it is worth noting that although some may see insurance as a potential means of changing behavior, it is not the main intended function of insurance.

Once the societal costs of the hazard become too large to easily absorb, more active measures begin to be taken, alongside existing redistributional mechanisms, to actively reduce or mitigate potential damage. Initially the focus of these mitigation efforts tends to be on physical actions, generally engineering or technological fixes, to modify the environment (sometimes referred to as structural mitigation) to prevent or diminish the effect of the hazard by shifting its location, its timing, or the process that creates it. At this point, the hazard is generally seen as correctable with technology, often via larger scale engineering fixes (e.g., dams and levees). Such technical attempts to modify the environment are appealing because they can generally be accomplished directly through government action, avoiding the need for individual or community involvement [7].

However, for many hazards, including wildfire, such physical environmental modifications fail to effectively reduce the negative outcomes over time. Resulting from natural biophysical processes, it ultimately is not possible to completely eliminate a natural hazard. And for some hazards the physical modifications only serve to raise the hazard threshold—there may be fewer hazardous events overall, but when they do occur it will be because they overwhelm the structural safeguards which often then contributes to more extensive harmful consequences. The failure of the levees around New Orleans after Hurricane Katrina is a good example of this dynamic. Similarly, a singular focus on fire prevention and complete fire suppression as the main

means of mitigating fire risk is a clear example of large-scale government attempts to modify the environment to eliminate or minimize the fire hazard. However, it is not possible to prevent all wildfires and, in many ecosystems, suppressing has led to fuel buildup that, overtime, can contribute to an increased rather than decreased long-term fire risk as higher fuel loads contribute to more extreme fire behavior that can overwhelm response capacity.

As the limitations of physical mitigation measures are recognized, mitigation actions begin to turn toward efforts to modify human behavior (sometimes referred to as nonstructural mitigation) through both voluntary and regulatory measures, as well as more indirect efforts to shift cultural norms and rules. *Voluntary measures can involve a range of outreach and financial or technical incentives measures such as one-on-one homeowner consultations or assistance with vegetative debris disposal*. Regulatory actions include tools such as building codes, local ordinances, and zoning. Building codes to help increase ability of buildings to withstand a hazard via both construction standards (e.g., nail spacing—particularly relevant for hurricanes and earthquakes) and material requirements (such as fire-resistant roofs) are one of the more widely used regulatory measures as, for a number of hazards, they are quite effective at mitigating risk, can be adapted to meet local norms/needs, and tend to be more feasible to implement. Local ordinances also can help regulate activities that may contribute to a hazard such as vegetation clearance requirements. Policy can also be written to provide economic incentives or sanctions to encourage desired behavior. Although use of regulatory measures may appeal as a "simple fix," enacting regulatory measures is generally a time-intensive and unpredictable process with effectiveness dependent on cultural acceptance of such mandates and the ability to enforce them. Social norms and rules are less tangible and harder to address directly but over time can have perhaps a longer and more significant influence on both hazard creation and mitigation. In the case of the wildfire hazard, studies have shown that belief that neighbors have positive views of fire mitigation activities is positively associated with other individuals adopting those actions [7a].

Besides the potential for larger scale physical mitigation measures to simply raise the hazard threshold, a less discussed concern with the tendency to focus on physical and technical fixes has been that historically this focus has often, intentionally and unintentionally, led to elimination of existing mitigative behaviors. In many places, traditional uses of fire to improve range conditions or minimize fire risk has been discouraged and is often labeled as arson [8]. In the United States, as the emphasis on suppression increased in the 1930s, education programs were developed to discourage and demonize local use of fire which had often been conducted in part to minimize the fire hazard. This has meant that, ironically, more recent outreach efforts have had to be targeted toward increasing local comfort with reintroduction of fire as a management tool. Therefore, although the tendency to focus on larger scale physical/technical mitigation measures is unsurprising given the greater ability for more centralized and governmental control of such endeavors, countries where fire is only beginning to become a significant hazard may want to resist the tendency to focus solely on technical solutions and move immediately to an approach that also values promoting existing as well as new adaptive behavioral responses. It also is important to note that while the structural (environmental modification) and

nonstructural (behavior change) categories provide a neat division in mitigation approaches, in practice, the two are not distinct. Changing building characteristics in practice could be seen as an environmental or structural mitigation measure, however, ensuring it occurs at a meaningful scale may also require non structural measures to changing human behavior *(e.g., financial incentives, building codes)*.

The final of the four coping stages occurs only when the negative impacts from the hazard have become so extreme that, despite mitigation efforts, complete change—of land-use or living methods— is required. This stage is quite rare as most cultures and societies, particularly highly developed ones, are resistant to such large-scale change as the overall societal costs are too high. Arguing that individuals should simply not live in fire-prone areas ignores *both the broad geographic extent of such areas as well as* wide range of personal, economic, and social reasons why communities have developed in those areas.

### 8.2.3 Wildfire preparedness/mitigation measures

Preparedness, mitigation, and prevention are often used interchangeably in the wildfire response world. Although interrelated, they refer to specific dynamics in response to a hazard, and it is important to distinguish between the terms and clarify their meaning. Emergency response is generally divided into four distinct phases: mitigation, preparedness, response, and recovery. Preparedness generally refers to activities undertaken to be ready to respond to an actual event. With wildfires, this includes ensuring availability of equipment, such as engines and airplanes, and firefighting personnel with appropriate training. It also includes planning and coordination of response activities, such as evacuation. Mitigation focuses, as discussed previously, on actions to reduce vulnerability and potential impacts of an event. With wildfire, the primary focus has been on actions to reduce vegetative fuel, at multiple scales, and to increase fire resistance of structures and infrastructure. It can also include actions to decrease, or prevent, ignitions. Here it is important to note that while prevention is frequently conflated with mitigation, often used to describe a range of activities beyond preventing unwanted ignitions, in reality it is the inverse with wildfires where prevention effectively is a specific type of mitigation. While preventing, an event does reduce potential impact, many actions—such as vegetation management—that are often described as prevention in reality cannot prevent an event but do reduce (mitigate) its potential negative impacts. This is not a minor distinction as lack of clarity or confusion over the goal of an action can decrease the chances it will be adopted.

Scale is an important consideration in understanding natural hazard preparedness and mitigation. At larger macro spatial scales, the likelihood of a damaging wildfire in a given year is often high, and regional and national levels of government have significant incentives to develop and implement mechanisms to respond to the hazard. As the scale of focus decreases, the exposure also tends to decrease; from a pure probability perspective the odds of a wildfire occurring in a specific rather than general area are lower. In general, the smaller the scale the lower the incentive to expend significant attention or resources to mitigate the local risk to a specific hazard. As a result, higher levels of government are more likely to devote specific resources to assessing, planning for, and responding to a hazard, while local governments and individual

residents are less likely to have concerns about a specific hazard high on their radar in comparison with the other competing priorities of everyday life. In her integrative framework for studying natural hazards, Palm [9] identifies three key scales to consider: macro, meso, and micro. These levels are useful to think about how wildfire preparedness and mitigation measures might be vary at different levels.

### 8.2.4 Societal (macroscale)

At the societal or national scale, a broad array of factors may come into play to influence preparedness and mitigation efforts for a particular hazard. This can be via funding priorities, strategic direction, establishment of national programs, and provision of resources and incentives targeted toward improving outcomes for the specific hazard. However, at this level, the influence of such efforts is complex and does not inherently lead to better outcomes. For instance, national policies may serve only to shift the risk to other areas or hazards (e.g., individuals not allowed to live in fire-prone areas may instead live in flood plains) or other timeframes (e.g., as indicated earlier in the United States a national policy of fire suppression minimized the immediate fire risk but in many places over time has increased the long-term risk). In addition, many large-scale socioeconomic factors not directly related to the hazard can influence preparedness and mitigation. Economic opportunities or constraints may draw individuals to hazardous environments and "institutional and cultural phenomena may buffer or focus damage, without being tied to specific vulnerabilities or agents to damage" [5]. As a result, any effort to minimize risk from a particular hazard needs to consider the larger social context in which the hazard is situated.

### 8.2.5 Intervening or mid-level factors (mesoscale)

Middle-level factors, often in the form of local programs and governmental organizations, can be key conduits between larger scale resources and on the ground preparedness and mitigation efforts. This level can be critical as it often acts as a convener and interpreter that determines how interactions between larger scale factors and individual decisions are negotiated. Whether or how a national or provincial/state policy is implemented can depend on how more local actors choose to interpret the policy which in turn can constrain or enable an individual's mitigation choices [9]. Convening entities also can play a key role in securing resources, gaining public and organizational support for mitigation activities, and coordinating activities between groups.

At the mesoscale, key mitigation actions can focus on both structural and nonstructural elements. Structural mitigation efforts to modify the environment can include land management activities to reduce fuels and increase landscape resiliency. Nonstructural elements tend to focus on two ways to change behavior. The first is through regulatory means such as zoning, building codes, and land-use regulations. Land-use regulations can be designed to encourage activities that decrease fire risk, such as limiting unmanaged eucalyptus plantations or how new development takes place. Zoning bylaws could require that wildland fire be addressed in general plans, and subdivision development plans could require use of fire-resistant building

materials, adequate access, firebreaks, etc. A key challenge here is that, other than building codes, there is limited empirical evidence on the type of development that most effectively decreases fire risk and how this might differ depending on local context. It is likely that the best development practices to mitigate fire risk will vary depending on local fire regime, topography, or building practices. A second key more behaviorally focused mesoscale preparedness activity involves organizational support for the programs and individuals who can provide the information, resources, and coordination needed to build capacity to undertake mitigation activities such as defensible space or evacuation planning.

### 8.2.6 Individual/household (micro) scale

On an individual or household level, fire mitigation generally can be described as activities that are undertaken to increase the likelihood of both human and structural survival during a wildfire. There is good empirical evidence that actions to (1) modify the environment around a building to decrease fire intensity and minimize ignition sources (primarily embers) and (2) increase a structure's ignition resistance can greatly increase the chance a building will survive with or without active protection [10,11]. Environmental modification primarily involves activities to break up the continuity of vegetation and decrease the available fuel adjacent to the building. This includes pruning low-lying tree branches, thinning vegetation, and removing dead matter and excess groundcover. Generally, the area surrounding a structure is divided into a series of expanding zones, with the degree of vegetation modification needed decreasing as distance from the structure increases. Actual characteristics of each zone, distance and degree of needed vegetation modification, for a specific structure will vary depending on factors such as topography and type of vegetation. The most basic recommendation is to modify vegetation for a minimum of 30 feet around a structure. Given the habit of vegetation to grow, fuel management is an on-going effort, requiring some level of periodic maintenance to be effective.

Specific activities to increase resistance of structures to fire vary by regional building styles; areas where the default standard are stone buildings likely have less work to undertake than regions where the preference is for wooden structures raised a few feet from the ground on stilts. A key focus of any of these efforts is on actions that can protect the structure from ember attack, the dominant cause of structural ignition during wildfires. These actions can include use of fire-resistant roofing (the single most effective action) and siding materials; screening of vents, eaves, and other openings; *cleaning out and/or* enclosing overhanging space (such as under decks) where heat convection can draw embers into the structure; and availability of screens, heavy curtains, or plywood to cover windows (the most vulnerable part of a building to radiant heat) in the event of a fire.

During a fire, the key protective actions revolve primarily around evacuation decisions. Fire is a particularly challenging hazard when it comes to evacuation as the conditions can be more variable than other hazards in several ways. First, rapid changes in fire direction and speed due to weather, particularly wind changes, mean that predicting where and when a fire might impact a population can be difficult. It also means that individuals may have anywhere from only minutes of warning that a fire is imminent or

several days to prepare. Second, these rapid changes mean that evacuation may not always be the safest option, such as when evacuation routes have been cut off or there has been little warning, particularly if the property has been well prepared and residents are knowledgeable and mentally and physically prepared to stay on their property safely. Third, with proper preparation and in non-extreme conditions, evidence indicates that staying and protecting the home increases the odds it will survive. Fourth, in extreme conditions, plans and preparations that might be sufficient property protection for most fires are less likely to be effective. This means that the best course of action for the same individual and property can be quite variable, depending on where the fire originates, level of mitigation and preparedness, and environmental conditions at the time. This variability suggests that no single approach is likely to ensure safety in all situations.

## 8.3 Factors that influence individual protective action decisions, with reference to specific fire research findings

Understanding individual perceptions of and response to a hazard is a central focus of natural hazards research. Perhaps more than many other natural hazards, effective fire mitigation is influenced by individual action—it is not just a case of enacting effective building codes (which are critical for tornado and earthquake mitigation) but of changing both behavior and opinions on more personal matters of home construction and siting, vegetation and esthetic preferences, and acceptance of large-scale vegetation management practices in the surrounding landscape. Although historically wildfire has not been a significant focus of natural hazards research [12], since the late 1990s a growing number of studies have examined various aspects of individual response to wildfire, particularly whether and why homeowners choose to undertake mitigation on their property, individual perspectives about fuels treatments, and evacuation decision-making [1]. Findings from this work by and large parallel those found for other hazards on key factors found to influence hazard response and preparedness. These are discussed below with specific examples drawn from the wildfire literature. It is important to note that most of the social wildfire research has come from the United States and more recently Australia and Canada. Although specific dynamics are likely to vary by location, comparing results across these studies suggests that the general dynamics in terms of which variables are most influential appear to be reasonably consistent across countries [1].

### *8.3.1 Risk interpretation*

While hazard and risk are often used interchangeably, they do not inherently refer to the same process. While the definition of hazard is fairly variable, the most common perspective focuses on hazard as potential: that the term refers to the conditions that create the *potential* for loss or damage. Comparatively, risk is most often defined as the probability of an event with harmful consequences. While potential and probability

seem similar, potential focuses on conditions that may contribute to various outcomes, while probability focuses on the likelihood of a specific outcome: Flipping a coin twice has the *potential* for it to land on heads both times but the actual *probability* of this occurring is only 25%. With wildfires, a hazard characteristic is the amount and configuration of fuels, both vegetation and buildings, while wildfire risk takes into account these conditions along with the likelihood of ignition (e.g., ignition sources, weather): If ignition is unlikely (e.g., high humidity), even highly hazardous conditions may have a low fire-risk.

Early risk-related research assumed that people's actions would be directly related to the calculated probability of the event and the magnitude of its consequences—the factors that risk analysis focuses on. However, research demonstrated that how individuals perceive and respond to risk is a complex dynamic that reflects a range of factors such as personal ability to influence, voluntariness of exposure, risk attitudes, economic considerations, and benefits of exposure. While these processes are often lumped together and described as risk perception, it is perhaps more accurate to think of the dynamic as risk interpretation; the term "perception" can suggest that it is possible for people to perceive the same risk, whereas the key item at issue is really how the same risk may be interpreted differently [2]. How risk is understood and responded to is not straightforward or consistent between different individuals: It is not a given that each individual, or organization, will be considering the same spatial and temporal factors when calculating probability, nor that they will be considering the same set of harmful consequences (e.g., house loss vs. specific environmental damage) in their assessment.

The result of this complexity is that there is ample evidence that recognition of a risk does not in and of itself lead to increased preparedness [12]. Numerous studies in the United States indicate that residents living in fire-prone areas are already well aware of the fire risk, that many are undertaking mitigation activities, and that a range of considerations in how the risk is interpreted can influence lack of action [13]. Studies show that the spatial scale and voluntariness of the risk exposure, as well as the benefits of the exposure (e.g., being near nature, economic opportunities), also can influence how an individual responds to wildfire risk [1]. Studies also suggest that although wildfire information can increase an individual's assessment of fire probability, the probability assessment is not associated with increased preparedness, whereas consideration of likely consequences is associated with increased preparedness [14,15]. Ultimately, recognizing a risk is a necessary but not sufficient condition for individuals to adopt mitigation measures as other factors also influence the decision process.

### 8.3.2 Experience

Although experience with a hazard is often thought to be an important influence in increased preparedness, the evidence for this is quite mixed. Studies have found that experience can both increase (generally via increased salience) and decrease (fatalism or lightning does not strike twice) risk perception and mitigation efforts, or it can have little to no effect [12,16]. The strongest relationship between experience and adoption

of mitigation measures is *frequency* of experience: The more frequent the experience, the more likely one is to have a realistic assessment of the likely occurrence and potential impact of a hazard [17,18]. Even here, it is not inherent that frequent experience will lead to mitigation; some studies have found that repeated experience with a hazard (e.g., seasonal flooding) may lead to a "disaster subculture" where people become so used to the hazard that it simply becomes part of life and mitigation is not even considered [18a]. Similar to the dynamics around risk, individuals can choose to interpret a specific experience differently. For example, research indicates that a near-miss experience can be interpreted as indicating a successful outcome (no major losses) or as a close call (disaster narrowly averted): The former interpretation leads individuals to ignore or discount the need for more protective behaviors (it worked!), while the latter interpretation makes individuals more likely to consider taking additional protective measures [19]. After the 2009 Australia Black Saturday fires, three-fourths of surveyed individuals who indicated that they evacuated late (many of whom reported encountering significant challenges including poor visibility and fallen trees) also indicated that, as they ultimately were unharmed, they would undertake the same action in the future [20].

### 8.3.3 Efficacy (response and self)

Even when risk interpretation and experience do lead individuals to explore ways to mitigate their exposure, other considerations shape the process of choosing and implementing mitigation adjustments. Access to information is an important initial item; before an individual can consider mitigation, they need to know what mitigation options are available. Once the range of potential adjustments has been identified, individuals then engage in two types of evaluation related to efficacy: response efficacy and self-efficacy. Response efficacy relates to the perceived effectiveness of the action in mitigating the risk: A belief that an action will be effective has a positive association with adoption of the practice. Self-efficacy relates to the ability to actually implement the activity; lack of necessary resources such as time, money, or physical ability is generally associated with lower implementation rates. For example, wildfire studies indicate that lack of time rather than knowledge is likely a key constraint for part-time residents undertaking mitigation activities on their property and that a common issue with vegetation management to mitigate fire risk is how easy it is to dispose of any removed vegetation [13].

### 8.3.4 Wildfire-specific considerations

Fire is relatively unique as a hazard in that although it can disrupt key social values it also plays an integral ecological role in many valued ecosystems. This fact can complicate land and fire management decisions but also appears to come into play with mitigation decisions. Multiple studies show that homeowners more readily adopt fire mitigation practices that are in line with local ecological needs [7a] and that understanding the ecological benefits of fire is often a more important consideration in acceptance of prescribed fire than recognition of its role in reducing fire risk [33].

Fire also is a somewhat unique hazard in that as a landscape scale process, effective mitigation activities generally need to take place across property lines: It is a shared risk. Studies have found that the level of fire hazard and management activities on adjacent lands can be an important consideration in mitigation decisions, albeit in an inconsistent manner that is similar to that of experience. In some cases lack of mitigation on adjacent lands can deter mitigation and in other cases landowners choose to mitigate more to compensate or find ways to work together with the adjacent landowners to mitigate the fire risk [7a].

### 8.3.5 Nonwildfire considerations

Finally, a weakness in many discussions about how to improve mitigation and preparedness is that the discussion occurs in what might be called a hazard-specific vacuum. As with the societal level, individual response to a single hazard is influenced by a range of factors external to the hazard itself. Individuals have other risks (e.g., driving to work) and concerns (economic, social, etc.) to worry about and must make tradeoffs in how they will respond to wildfire with other considerations in their daily lives. The need to secure daily livelihoods tends to be mentally more salient than risk perception related to a specific natural hazard [21]. Hence, efforts to increase preparedness that do not actively take into account potential competing interests are less likely to lead to increased wildfire preparedness [22]. It also can be useful to identify complimentary interests; in many cases individuals have implemented fire mitigation measures not to mitigate their wildfire risk but because they confer other benefits.

### 8.3.6 Evacuation decisions

Natural hazards research has extensively studied how individuals learn of and then respond to a hazard event. When an event occurs, it disrupts normal life and increases uncertainty; many actions individuals take are efforts to reduce that uncertainty and regain or maintain a sense of normality.

When considering information provision for evacuations, a belief that appears to inform decisions by emergency responders during an event is that panic is a common public response to an imminent threat. However, research clearly demonstrates that actual panic (irrational, nonadaptive, or antisocial behavior) in response to natural hazards, including wildfire, is extremely rare [23,24]. Instead, evidence indicates that although there may be heightened anxiety, fear, and more rapid action (all rational responses to impending danger), individuals tend to respond to an imminent threat by first engaging in gathering more information to determine the best course of action and then proceeding to act in a manner congruent to their situation. These actions often include helping behavior (informing neighbors, helping others evacuate) which is the inverse of panic (e.g., prosocial rather than antisocial behavior). For example, during the 2016 Fort McMurray Horse River wildfire in Canada, a number of residents who evacuated left in a vehicle of a neighbor or friend or someone they did not know before the evacuation [24]. Research has shown that behaviors seen as panic by outside observers in reality are a rational response from the actual individual's perspective [25].

Descriptions of "I panicked' appear to be less about describing irrational behavior than recognition of a moment when there is a shift to more focused and rapid thought processes. The continued belief in the panic myth may in part occur because it is an easy way to explain poor outcomes, driving toward flames to try to rescue someone is seen as panic if there is loss of life but labeled as heroic if they succeed in saving a life [25]. Scholars also argue that the media focuses on panic because of its inherent drama and that emergency response organizations focus on it because it reinforces their central role in the command and control structure [23]. However, assuming panic can be problematic as hesitance to provide warnings out of concern about causing 'panic' can lead to worse outcomes as individuals are not provided with timely information that could help them make the safest decision for their situation.

Research into warnings has identified a number of characteristics of effective warnings including that they are from a credible source; consistent in content and tone (e.g., not indicate that things are terrible but everything is under control); accurate and clear; and provide specific information about what people should do and in what timeframe [26]. Once aware of a threat, individuals tend to seek information from multiple sources to confirm and validate the initial information, make sense of the situation, reduce uncertainty, and identify their best courses of action. Official warnings are a critical information source with a clear connection to increased evacuation. Individuals also have been shown to pay attention to environmental cues (e.g., smoke, flames) as well as information from and the behavior of those around them (social cues); both types of cues have been found in studies to be associated with evacuation decisions, although the decision might not always be to evacuate [27,28]. For instance, a study of wildfire evacuation decisions found that while all respondents relied on official warnings to make a decision, and those who most relied on them were more likely to leave early, the majority of respondents also relied on environmental cues and that greater reliance on environmental cues was associated with individuals being more likely to wait and see how conditions played out rather than immediately evacuate [28]. A study of the Fort McMurray evacuation found that social cues led people to decide to just carry on with their day instead of to prepare to evacuate [24].

Self-efficacy beliefs also come into play in evacuation decisions with concerns about ability to evacuate or limited evacuation options inhibiting evacuation, items that are particularly relevant for wildfires. The response efficacy of an action, whether evacuating or not evacuating, in protecting key values (life and property) also has been shown to be influential in relation to wildfires [15]. McCaffrey et al. [28] found that respondents who felt more strongly that evacuation was an effective protective action were more likely to leave early rather than wait to see what happens, while those who had a stronger belief in the efficacy of staying and defending were much more likely to stay. Notably, the study also found an indication that those who saw mitigation actions as effective were less likely to leave early as opposed to waiting to see how the fire evolved. The study also found that risk attitudes underlay different decisions with those who were more generally risk tolerant more likely to stay and defend and those who were more financially risk tolerant more likely to leave early [28]. Other situational factors that studies have found can influence when and whether individuals

evacuate include the time of day, whether all family members are present, and the presence of children, the elderly, or animals (both pets and livestock).

## 8.4 Diffusion of innovations

The field of "diffusion of innovations" works to understand the process by which a new idea or technology is communicated and adopted. Three key aspects of this long-standing field provide useful insights into mitigation and preparedness: preventive innovations, how the attributes of a new practice influence its adoption, and the role of change agents.

### 8.4.1 Preventive innovations

Hazard mitigation is a particular type of innovation: preventive. Most innovations are adopted in the expectation that it will in some way improve one's life through improved knowledge or increased income or comfort. In constrast, preventive innovations are actions adopted primarily to *potentially* protect one's current lifestyle. As preventive innovations do little to decrease uncertainty, they tend to have a slow adoption rate as the rewards of adoption "are often delayed in time, are relatively intangible, and the unwanted consequence may not occur anyway" [29].

### 8.4.2 Characteristics that influence adoption of new practices

The attributes of an innovation are important because the risks and benefits of adopting it are unclear. Several characteristics of a new practice or tool contribute to how much uncertainty is involved in the cost–benefit calculation surrounding its adoption. Rogers [3] identifies five, often interconnected, characteristics of an innovation that play a role in its rate of adoption:

- Relative advantage—the degree an innovation is seen as superior, in economic or social terms, to existing practice. Perceived relative advantage is a key predictor of adoption rates.
- Compatibility—how well the innovation fits with the lifestyle, needs, experience, and values of the adopter.
- Trialability—how easy it is to test the innovation in a limited manner. A successful trial decreases uncertainty around the innovation's usefulness and increases likelihood of full adoption.
- Observability—how easy it is for others to see the benefits of the innovation. Seeing an innovation adopted by peers tends to influence adoption more than receiving formal information.
- Complexity—how difficult the innovation is to understand and use.

In general, the first four items are positively related to an innovation's adoption rate, whereas complexity is negatively related [29].

### 8.4.3 Change agents

Change agents are an example of a mesoscale element that diffusion of innovation has identified as playing a particularly important role in whether or not an innovation is adopted. A change agent is someone who provides "a communication link between a resource system of some kind and a client system" [3]. With wildfire such change agents or 'champions' can be fire chiefs, political leaders, forestry workers or community members [30]. The role of a change agent, who may hold a professional position but can also be less formally trained, is to provide information, create interest in, and support the adoption of an innovation by a target population. Factors that facilitate a change agent's effectiveness include: whether the change agent's attitude and the innovation itself are directed toward meeting the client's needs; frequency of contact with clients; whether the agent is of the same peer group as the client; and the degree that the change agent is seen as credible and encourages the client's ability to understand and evaluate the innovation [3].

## 8.5 Risk and crisis communication

Research has also examined how to effectively communicate about natural hazards. Risk communication has mainly focused on how to provide information about a potential hazard and mitigation options, while crisis communication has focused on how to provide information during an actual event. Over time, research in these two areas has increasingly overlapped as work demonstrated how communication during one phase in the disaster process (mitigation, preparedness, response, and recovery) can influence outcomes at another phase. An assessment of common characteristics of effective communication across this risk and crisis literature as well as wildfire social science research identified five key considerations for effective risk and crisis communication: (1) use of interactive processes and dialog; (2) use credible sources, especially appropriate authority figures; (3) take the local social context into account; (4) provide honest, timely, accurate, and reliable information; and (5) communicate about hazard response during all stages—before, during, and after an event [31]. This section elaborates on the first three of these items which have been shown to also be important considerations in the larger context of public response to wildfires.

### 8.5.1 Interactive processes

Social marketing and adult learning research have both shown that interactive processes are a critical part of efforts to shift norms and behavior. Interaction allows all parties to ask questions, clarify misperceptions (both of emergency responders and of different stakeholder groups), and identify how the topic is relevant for their particular situation and key concerns or barriers that might need to be addressed [32]. Wildfire studies have frequently found that social interactions and use of interactive processes are a key dynamic in increased preparedness with a homeowner preference for one-on-one interactions, with agency personnel as well as with neighbors and

community leaders, to learn about how best to mitigate their fire risk [33]. Wildfire studies have also shown that interactive information sources are likely to be seen as more useful and trustworthy and that agency outreach efforts, particularly personal relationships with agency personnel, can influence assessment of agency activities and whether individuals adopt protective measures [34]. During a fire, interactive communication is particularly important as affected individuals seek to decrease the uncertainty of their situation and regain a sense of control [35].

For preventive innovations, interpersonal communication networks, especially via peer networks and champions, can be particularly effective in creating localized incentives to adopt [29]. A number of wildfire studies have shown how both peer-to-peer interactions and efforts that connect fire agency staff with community members can be influential in motivating adoption of mitigation measures and that outreach programs can be a key part of fostering such interactions. Such programs can help build the social networks and relationships that facilitate information sharing and the social learning that often underlies proactive mitigation and preparedness efforts [1,14,36–39].

### 8.5.2 Trust

Interactive processes are also critical to building trust which is one of the most consistent dynamics found to shape public wildfire response. Two key aspects of trust are credibility and competence. Credibility is important in how much attention is paid to information, while beliefs about individual competence underlie acceptance of various land management practices, with trust in a manager's ability to implement a practice shown to be a key factor influencing acceptance of both thinning and prescribed fire practices [40,41]. Credibility of the information source or message provider is particularly important with preventive innovations. If the source is seen to have ulterior motives or to be contradicting past practices, it is likely to be given short shrift. Transparency of communication is critical as, particularly during an event when there is limited time to build a relationship, it can act as an indicator of trustworthiness.

### 8.5.3 Local context

Finally, studies have shown that efforts that actively take local knowledge and experience into account are more likely to be effective as they can better address local considerations that may shape the hazard and its outcomes. Communication and outreach efforts that incorporate local knowledge are more likely to be seen as relevant and trusted, positively effecting preparedness efforts [42]. Whether local knowledge and values are considered in management decisions also has been found to influence views of agency management decisions, with views of management actions, particularly response during wildfires, trending toward more negative when local knowledge and resources have not been taken into account in management decisions [1].

## 8.6 Conclusion

Wildfires have several characteristics that make them a particularly complex hazard to assess and manage, particularly in relation to effective mitigation and communication. As a critical ecological process in many ecosystems, too narrow a focus on removing fire from a system can be counterproductive in the long term. As a physical process, fire behavior can vary substantially at local spatial and temporal scales (e.g., vegetation type, topography, wind shifts), further complicating the ability to determine the most effective ways to respond to a specific event. Nor is the human relationship with wildfire simple, fire has always been an integral part of human lives and few areas in the world do not have potential for wildfires given the right conditions. Changing climate conditions are likely to exacerbate this potential in many locations. Given these factors, it is difficult to predict which dynamics will be most critical in creating the degree and type of fire risk for any given location. Therefore, care needs to be taken about overgeneralizing the global fire "problem" as no single approach will work in all locations and inaccurate assessments of the main drivers of wildfire risk in an area are likely to lead to ineffective solutions. Instead, minimizing harmful consequences of future wildfires will require careful consideration of how a range of factors, from the national to the local scale, may inform the fire risk and likely human response in a given location.

However, a number of social science research fields can provide guidance for identifying critical elements to consider in developing programs and plans to increase wildfire preparedness and mitigation in a specific country or region. Natural hazard research provides a framework for how societies and individuals perceive and respond to the wildfire hazard with specific insights on how scale, risk interpretation, experience, and views of self-efficacy and response efficacy can influence adoption of protective actions before and during a wildfire. Diffusion of innovations provides additional insights into processes that may influence adoption of fire mitigation measures, and research related to risk and crisis communication can help identify key considerations in effective outreach efforts. Research specific to wildfires provides specific examples of how key variables may come into play in individual decisions to undertake mitigation measures on their property or when and whether to evacuate.

Not all wildfires with harmful consequences occur in extreme conditions, nor will every extreme wildfire lead to significant social impacts. However, the potential for increased extreme fire behavior that overwhelms response capacity means that a focus on understanding and utilizing the full range of mitigation options becomes even more critical. Ultimately, understanding human response to wildfires that is based on empirical evidence rather than nurtured narratives will only become more critical as more communities are affected by fire.

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