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The role of risk perceptions in the risk mitigation process: The case of wildfire in high risk communities

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ABSTRACT

An important policy question receiving considerable attention concerns the risk perception–risk mitigation process that guides how individuals choose to address natural hazard risks. This question is considered in the context of wildfire. We analyze the factors that influence risk reduction behaviors by homeowners living in the wildland–urban interface. The factors considered are direct experience, knowledge of wildfire risk, locus of responsibility, fulltime/seasonal status, and self-efficacy. Survey data from three homeowner associations in the western U.S. are used to estimate the direct and indirect effects of this relationship. Our results indicate that the effects of knowledge and locus of responsibility are mediated by homeowners' risk perceptions. We also find that beliefs of self-efficacy and fulltime/seasonal status have a direct influence on risk reduction behaviors. Finally, we find, surprisingly, that direct experience with wildfire does not directly influence the risk perception–risk mitigation process.

1. Introduction

The relationship between what people know about various types of risks and to what degree they will act to mitigate any given risk has been the subject of much research across numerous disciplines (Lepesteur et al., 2008; Lindell and Prater, 2002; Mulilis and Duval, 1995; Slovic et al., 1987; Weinstein et al., 1998). The objective of our research is to better understand the underlying process that motivates individuals to adopt private risk reduction strategies to protect themselves and their property from natural hazards, specifically wildfire. Understanding this process will aid decision makers in untangling the factors that directly influence the risk perceptions of various stakeholders, in developing effective communication strategies, and in influencing actual behavior on private property while designing incentives aimed at mitigating the risk to individuals and communities. This is based on the assumption that risk reduction behaviors are undertaken as part of a dynamic and adaptive process by which individuals and social factors interact (MacGregor et al., 2008). The importance of an improved understanding of these relationships in the context of wildfire was highlighted with the devastating wildfire in Australia in early 2009 and in Greece in 2008 as well as the continuing threats in the U.S.

Individuals' perceptions of risk are influenced by a variety of factors. Slovic (1987) found that people evaluate risk on the basis of controllability, voluntariness, catastrophic potential, and degree of outcome uncertainty. These risk perceptions play a critical role in how individuals choose to mitigate the risk. For example, if an individual estimates the risk from a hazard to be low, they are less likely to act to reduce their exposure to this hazard (McCaffrey, 2004). Many times, no matter how aggressive an individual is in their efforts to mitigate a risk, there is no guarantee that their actions will be sufficient to protect them against the whims of nature (Slovic, 1987; McCaffrey, 2004). Nevertheless, from a public policy perspective, a better understanding of these relationships will result in more efficient policies designed to address natural hazards such as wildfires. In other words, how well prepared residents living in flood plains are for the next flood or those living in the wildland–urban interface (WUI) of the fire-prone west are for the next wildfire season will be affected by such policy choices (Srinivas and Nakagawa, 2008).

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The role of the community is an important aspect of risk mitigation that has been addressed by a number of researchers (Cohn et al., 2008; Sturtevant and Jakes, 2008; Kumagai et al., 2004; McGee and Russell, 2003). Of particular interest is the distinction between "natural and technological (human)" disasters as discussed by Kumagai et al. The impact of such a distinction is important in the context of whether the community comes together following a hazard (to fight a common enemy) or whether the event results in a divisive community (finger pointing and assigning blame). Kumagai et al. highlight the characteristics of wildland fire that demonstrate that even a naturally caused fire (i.e. a lightening strike) can lead to a divisive outcome due to the belief that the magnitude of the disaster will be enhanced by a number of past human decisions regarding issues like fire suppression, fuel load treatment options, etc. Although community factors are of critical importance to any risk reduction strategy, our focus is on the individual homeowner's behaviors.

Achieving a balance between an individual's perceived risk of damage from a hazard and their willingness to engage in a risk mitigation strategy is a trade-off faced by individuals, communities and agencies. For example, the decision to keep shade trees close to a home involves the trade-off of the ignition/fire risk and the benefits derived from enjoying the shade and aesthetic beauty provided by the trees. We explore the impact of knowledge, experience, locus of responsibility, and self-efficacy beliefs on the risk mitigation trade-offs individuals continue to face in the WUI due to the recurring threat of wildfire. An important element of this relationship is the potential mediating influence of an individual's risk perceptions on their ensuing risk reduction behaviors. We build on past research that focuses on the correlation between these variables by demonstrating the causal and mediational relationship between these variables and risk mitigation strategies (Mileti and Sorenson, 1987; Lindell and Perry, 2000; McGee et al., 2009). We also evaluate the situational differences that exist between fulltime and seasonal residents in the three WUI communities that are the focus of this research. Both types of residents have experienced at least one catastrophic wildfire, and frequently, multiple wildfires in the vicinity of their home. Many of these residents have been evacuated numerous times due to this hazard, yet they seem to react in different ways after the fact. McGee et al. (2009) provide a qualitative analysis that highlights the diversity of reactions by homeowners following various wildfire experiences.

Specifically, our goal is to examine the process which influences risk perceptions and how these factors then affect risk reduction behaviors. The next section discusses our conceptual framework drawing on the natural hazard and the risk literatures to address the question of what motivates WUI residents to mitigate this particular natural hazard. In spite of many similarities in characteristics between wildfire and other natural hazards such as floods and earthquakes, wildfire has received much less attention in the natural hazard literature (MacGregor et al., 2008; McCaffrey, 2004; Brenkert et al., 2005; Martin et al., 2007). This is followed by a discussion of the model and the estimation methodology. The fourth section presents our empirical results followed by conclusions and a discussion of the policy implications of our findings.

2. Conceptual framework

Slovic (1987) and Mileti and Sorenson (1987) describe a process that illustrates how individuals choose to protect themselves from a natural hazard such as wildfire. These authors identify four steps in the risk mitigation process: (1) assess risk probabilities, (2) review behaviors available to mitigate the risk, (3) evaluate the expected impact of these behaviors, and (4) decide which behaviors to adopt. We investigate several dimensions of this process. Specifically, we examine the influence of direct experience, knowledge, self-efficacy, locus of responsibility, and fulltime/seasonal status on risk perception assessments and the impact of these variables on the choice of risk mitigation options. Therefore, we test the relationship that people must believe that they are personally at risk, the risk is significant and severe, and that their efforts to reduce that risk will be effective (Lepesteur et al., 2008; MacGregor et al., 2008). This modified process explains the factors that influence the formation of risk assessments that lead to actual (rather than intended) risk reduction behaviors.

Implicit in this process is the benefit–cost analysis that affects the decision making process. Research has found that behavior generally follows a rational, benefit–cost analysis of the trade-offs (Mileti and Sorenson, 1987). Mitigation options are often viewed as trade-offs between wildfire risk and preferred landscapes (Brenkert et al., 2005). We do not focus on this benefit–cost analysis since we measure actual mitigation behaviors thus making the benefit–cost analysis implicit in the actual choices that individuals make in the mitigation process. Instead, we focus on the mediational relationship between the risk assessment variables, risk perception, and actual risk reduction behaviors.

Two commonly used approaches to test the meditational effect of a particular variable are structural equation models and regression-based models. Paton (2008) uses a structural equation approach to test the role of trust as a mediating variable when considering the effectiveness of risk communication for community preparedness for a natural hazard; bushfire in this case. An alternative approach to this type of model was developed by Barron and Kenny (1986).

The mediation model presented by Barron and Kenny (1986) is used to test the conceptual framework for our empirical analysis. This causal model tests the mediating effect of a variable M on the explanatory relationship between the set of $\boldsymbol{X}$ independent variables and the Y dependent variable. Fig. 1 provides a diagram of this relationship. The total effect of the influence of the vector of explanatory variables $\boldsymbol{X}$ is presented by path C. Path C' shows the direct effect of the vector $\boldsymbol{X}$ and the mediating variable M (paths A and B) on the dependent variable Y. The essence of the mediating model is to test the difference between paths C and C'. When the paths are the same, then the variable M does not mediate the relationship. The amount of mediation that exists in the relationship (or the indirect effect) can be determined using the Sobel test (Sobel, 1982; Preacher and Leonardelli, 2004). Our model defines the elements of the vector $\boldsymbol{X}$ as experience with wildfire, subjective knowledge of wildfire, efficacy in risk mitigation, locus of responsibility, and fulltime/seasonal status in the WUI. The mediating variable M is risk perception and the dependent variable Y is the number of risk reduction actions undertaken (MacKinnon et al., 2002). The results of implementing the mediation model are reported below. First, we discuss the theoretical foundation for the variables included in the model and the expected direction of the effect on the decision to implement risk reduction behaviors.

2.1. Direct fire experience

The evidence that direct experience with a hazard can influence behavior to mitigate the effects of the hazard has mixed support in the literature (McGee et al., 2009, p. 310). In our research, we differentiate between two dimensions of expertise for individuals consistent with the literature (Alba and Hutchinson, 1987; Mitchell and Dacin, 1996). Expertise with a category of risk is based on one's direct experience with the risk and one's subjective knowledge of

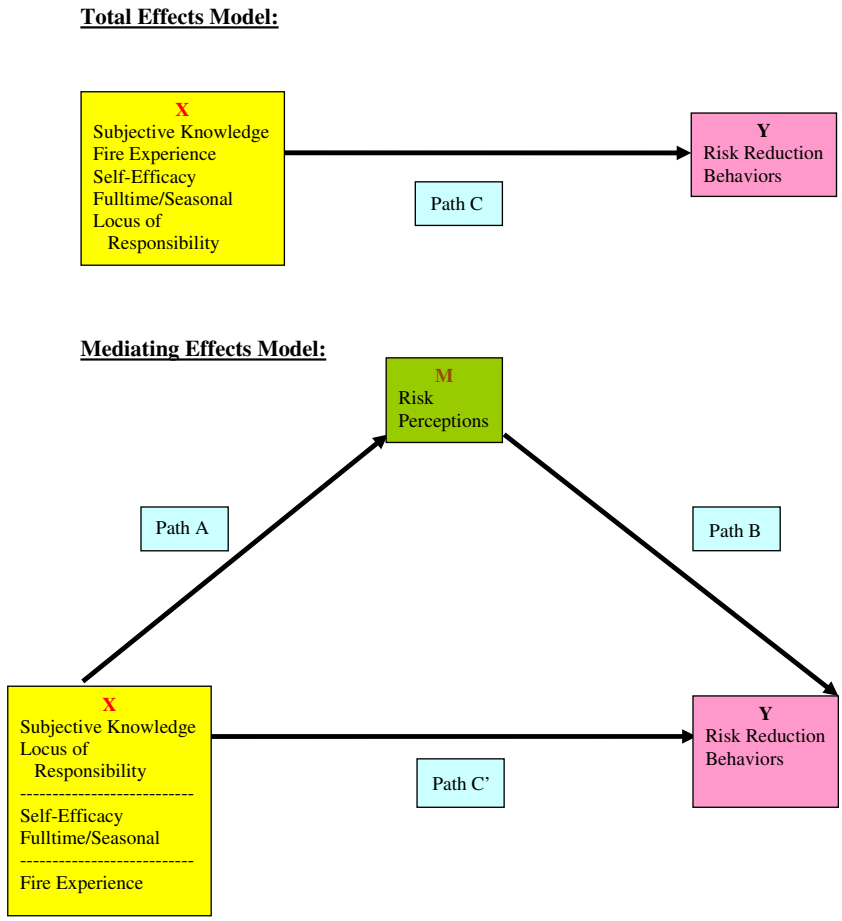

Fig. 1. Conceptual framework.

the particular category of risk. In our study, individuals' direct experience with the hazard includes being evacuated from their property, losing property, and other related experiences, all due to wildfire. Direct experiences with a domain are separate from subjective knowledge of that domain; this separation creates a stronger, direct link to engaging in risk reducing strategies (Mitchell and Dacin, 1996). Individuals' direct experience with a risky situation provides the mechanism by which they cope with the risk by making behavioral decisions that will lower the potential impact of negative consequences (Mileti and Sorenson, 1987; Mitchell and Dacin, 1996; Cho and Lee, 2006). McGee and Russell (2003) used a qualitative study of a rural community in Australia to demonstrate the importance of direct experience on wildfire risk reduction behaviors.

Personal experience can have a powerful impact on the recognition of risk and the willingness to protect oneself from that risk. Based on an extensive review of the risk literature, Weinstein (1989) demonstrates that the effects of personal experience with a hazard on protective behavior led people to see the risks as more frequent and to view themselves as potential future victims, thus increasing their motivation to engage in risk reduction behaviors. Sattler et al. (1995) found that consumers tend to base their risk mitigation choices on the psychological stress of past experiences with that risk. However, numerous researchers have found that perceived risk is enhanced immediately after an occurrence of a hazard but quickly subsides as time passes (Weinstein, 1989; Burton et al., 1993; Sims and Baumann, 1983). They found that consumers' past experiences influenced risk perceptions in the short run but not in the long term. Kaplan (2000, 1995) discusses this phenomenon in terms of attention fatigue in the context of environmentally responsible behavior. Attention fatigue could be an important variable and should be measured in future research. The three communities studied here have all recently experienced a wildfire (within the last five years).

This influence, though, has not been found consistently in the hazard literature (McCaffrey, 2004). When a natural hazard is relatively infrequent, such as an earthquake or wildfire, direct experience provides a limited, biased source of information for individuals (Weinstein, 1998). Past research in behavioral decision making has demonstrated that an individual's level of expertise is often disconnected from their decision making performance (Arvai et al., 2008). For example, Winter and Fried (2000) found that a wildfire in Michigan left residents with the belief that the hazard is uncontrollable and random, resulting in feelings of futility towards the adoption of mitigation activities. Likewise, disaster subcultures, which emerge when communities face repeated occurrences of a risk (e.g. wildfires or earthquakes in southern California), accept this hazard as part of life and do not readily adopt risk mitigation strategies (Tierney, 1994).

It could be that the best time for individuals to integrate their direct experience with a hazard into their knowledge and have this translate into action is immediately following the occurrence of the event, the so-called "*teachable moment*" (Mileti and Sorenson, 1987). Also of relevance is the finding of De Young (2000) that individuals are affected by indirect experience as well. For example, the willingness of an individual in the U.S. to act following the

media coverage of the devastating wildfires in Australia during early 2009 may be enhanced based upon this indirect experience. Given this mixed set of findings in the literature, we do not expect risk perceptions to mediate the impact of direct experience on risk mitigation behaviors. However we do expect a direct influence of experience on risk mitigation behaviors.

2.2. Subjective knowledge

Homeowners in fire-prone areas have accumulated information about the hazard that is stored in memory and accessed when needed (Alba and Hutchinson, 1987). What individuals believe they know about a risk domain is their subjective knowledge of the risks of wildfire. The extant literature in expertise has consistently demonstrated that experts (those more experienced) in a category have a greater awareness and knowledge about a particular risk and alternative strategies to deal with the risk (Lindell and Perry, 2000). The hazard literature has found that knowledge is correlated with the adoption of risk reduction behaviors (Lindell and Whitney, 2000).

Specific information that is acquired can alter an individual's perceived risk leading to feelings of discomfort (Dowling and Staelin, 1994). When consumers are in this distressed state, they are motivated to get more information on the risk and to engage in problem solving activities. The wildfire hazard literature provides support for the influence of subjective knowledge in risk perception formation and behavior mitigation (McCaffrey, 2004). For example, McFarlane (2005) found that knowledge of relevant biodiversity policies and issues impacts individuals' risk perceptions associated with various hazards to an ecosystem. Consistent with this, we expect that subjective knowledge of wildfire risks is mediated through the relationship between risk perceptions and risk reduction behaviors.

2.3. Self-efficacy

Whether or not a homeowner feels they have the means to deal with a hazard will affect the types of behaviors they are willing to engage in to reduce the threat from that hazard. Self-efficacy is defined as one's perception of how competent he or she is in organizing and executing actions needed to manage a risky situation (Bandura, 1977). Individuals with high self-efficacy perceive themselves as capable of processing, analyzing, and making optimal choices from limited information (Mitchell and Dacin, 1996). Cho and Lee (2006) found that when individuals believed they had the ability to make investment decisions, they made behavioral choices that would lower their feelings of vulnerability to the potentially negative outcomes. Individuals' self-efficacy can positively influence their choice in risk mitigation strategies as they feel more certain as to their ability to face a given risk situation. Research has consistently demonstrated that risk mitigation is likely to be undertaken when individuals are confident in their ability to protect themselves and their property (Lindell and Prater, 2002; Martin et al., 2008). The long tradition of research in Protection Motivation Theory (PMT) also provides support for this hypothesized relationship (Rogers, 1983).

Research in the risk literature demonstrates that individuals' belief in the efficacy of the risk reduction behaviors and in one's ability to perform those behaviors provides the impetus for engaging in them (Martin et al., 2007; Mulilis and Lippa, 1990; Duval and Mulilis, 1999). Thus, we expect a direct impact of perceived self-efficacy on the number of risk reduction behaviors undertaken by homeowners in order to protect themselves from the risk of wildfire.

2.4. Locus of responsibility

The hazard literature has demonstrated repeatedly that individuals' belief in personal responsibility to protect themselves and their property is correlated with their adoption of risk reduction behaviors (Weinstein, 1989; Lindell and Whitney, 2000; Mulilis and Lippa, 1990; Duval and Mulilis, 1999; Mulilis and Duval, 1997). In a qualitative study on wildfire risk perceptions among homeowners, Winter and Fried (2000) found that focus group participants believed strongly that homeowners are responsible for fireproofing their property and for taking precautions related to using fire on their property. In addition, the western culture of individuality and self-reliance means that there is a strong sense of resistance towards government actions that can impact private property. Although individuals consistently state that it is the responsibility of the public sector to reduce the risk of wildfire on public lands, they strongly believe in an individual sense of responsibility to protect oneself and one's property. McGee and Russell (2003) find that "…most residents accepted initial responsibility for protection against wildfire." (p. 7). Therefore, we expect that a strong sense of personal responsibility to protect oneself and one's property from wildfire will indirectly influence (i.e. will be mediated by risk perceptions) the degree to which residents adopt risk reduction behaviors.

2.5. Fulltime versus seasonal status in the WUI

An important situational variable that has not been discussed at length in the natural hazard literature is the seasonality of residents in a high risk zone. Unlike other traditional communities, the WUI communities are differentiated by the type of residents that populate their area – year around or fulltime residents and seasonal or vacation residents. This situational variable can impact the type of risk responses that particular residents have a potential future natural hazard. Preliminary findings in the wildfire literature (Winter and Fried, 2000) suggest that fulltime homeowners view seasonal homeowners as "*ignorant about fire and likely to pose a hazard by their carelessness and lack of concern*." (p. 47). Despite this negative perspective, seasonal residents can have direct experience and knowledge of the hazard albeit at a more rudimentary level than those residents whose primary home is in the path of this natural hazard.

Seasonal residents may tend to attach less intrinsic value to their vacation homes given that their 'family treasures, valuable belongings, and so on' are less likely to be kept in these residences. McGee and Russell (2003) discuss this in terms of being "socially linked with a community" (p. 3) and Mitchell et al. (1993) talk about an "attachment to place" in a recreation context. Along with this difference, seasonal residents frequently have the attitude that their vacation homes are there for relaxation, enjoyment and, that spending these short periods of time engaged in defensible space activities is of less importance than to fulltime residents (McCaffrey, 2004). Therefore, we expect that seasonal residents will undertake fewer risk mitigation behaviors than fulltime residents (Martin et al., 2008; Winter and Fried, 2000).

2.6. Risk perceptions

The adoption of risk mitigation strategies is influenced by the perceived degree of certainty surrounding anticipated outcomes (Slovic, 1987). A predominant finding in the risk literature concerns actions adopted by individuals to reduce or avoid risk when their perception of risk increases (Lepesteur et al., 2008; Slovic et al., 1987; Slovic, 1987). Despite differences in how individuals perceive risk, the probability of engaging in risk reduction behaviors is

a positive function of the amount of risk they perceive. O'Connor et al. (1999) demonstrated that risk perception was an important factor that contributed to the explained variance of behavioral intentions related to climate change. Additionally, Setbon et al. (2005) demonstrated that there is a direct causal link between [food-safety related] risk perceptions and actual [eating] behavior. McGee and Russell (2003) indicate that personalization of the risk is an important link between awareness of a hazard and mitigation actions. We test the relationship that when homeowners in the WUI have a high level of perceived risk, they are more likely to engage in risk reduction behaviors (Lepesteur et al., 2008; O'Connor et al., 1999; Setbon et al., 2005).

3. Methodology

Understanding the factors that influence individuals' decision of whether or not to engage in risk reduction behaviors provides homeowners with important information that increases their likelihood to protect themselves and their property from the risk (Slovic et al., 1987). In this research, we present a framework that places risk perceptions, direct experiences with risk, responsibility beliefs, self-efficacy, subjective knowledge of a risk, and fulltime/seasonal status as critical motivators to encourage risk reduction behaviors. Based upon the discussion above, the degree to which knowledge and the locus of responsibility influence risk mitigation is mediated by one's level of risk perception.

A mail survey was conducted in three communities located in the 'wildland–urban interface' (WUI) in the western U.S., each with an extensive and recurring history of wildfire risks. The three communities are located in the front-range in Colorado and in central Oregon. None of the communities are part of a larger urban area. These communities primarily are home to retirees and part-time residents that plan to move to the community full-time upon retirement. These are communities that are typically targeted by public agencies for risk mitigation efforts since they are well organized, have an easily identified contact person, their proximity to public lands, and a history of wildfire.

Respondents living in these communities were asked what type of actions they had undertaken, if any, to reduce the risk of wildfire. The set of possible actions is based on the most effective risk reduction behaviors (see Appendix A) identified by the Firesafe Council of California (www.firesafecouncil.org). The survey was sent out with a cover letter explaining the project and a self-addressed, stamped envelope for residents to return the completed survey. A reminder postcard was sent out about three weeks after the first mailing with a second mailing including a new survey two weeks later. In total, we received 251 completed and usable surveys out of 506 surveys from all the communities for a response rate of 49%, which is above the average response rate for mail surveys (Alreck and Settle, 1995).

Prior to sending out the survey, we conducted a set of focus group meetings in these communities. The participants were asked a set of questions to provide some context for the study and at the end of each discussion, we administered the survey. The results from the survey for this group were treated as a hold-out sample and analyzed separately from the mail respondents. We compared the results with those of the mail survey respondents to determine if there was any non-response bias (Dillman, 2000). A set of *t*-tests was run to test for possible differences between the hold-out sample and the mail respondents on a subset of the measures including risk perceptions, self-efficacy, knowledge, and locus of responsibility. We confirmed that there were no significant differences between the two groups providing support for our belief that we had minimized non-response bias.

3.1. Sample

The sampling frame was the population of fulltime and seasonal residents on the membership lists of the three homeowner associations. These lists were obtained for all the communities after the series of focus groups described above were conducted. The input of the "vocal" members in these communities (those surveyed) can be used by the USDA Forest Service and other management agencies to gain insight on what they can do to persuade a broader array of stakeholders to join in creating a more comprehensive plan to mitigate wildfire risks (Tierney et al., 2001). It also ensures that local knowledge is incorporated into plans to create a stronger set of policies to mitigate risks.

Socio-demographic characteristics were also measured to determine if these correlates could explain whether members of these communities were more or less likely to undertake risk mitigation strategies. We collected information on gender, age, education, length of tenure in the community, and income (see Appendix B for the basic demographic profiles of the three communities). The basic socio-demographic characteristics of the respondents provide a picture of a set of well-established, affluent and well educated residents living in the WUI communities.

Research has shown that at times, socio-demographic correlates can explain risk reducing behavior among various types of individuals when faced with a natural hazard (Lindell and Whitney, 2000; Tierney et al., 2001). For this study, we included the socio-demographic variables in the initial analysis of the model to determine their influence on risk mitigation strategies. The results found that none of the socio-demographic variables were significant. Although this is contrary to some of the natural hazard literature, it can be explained by the fact that these three communities, although located in different parts of the western U.S., are retirement communities with very similar socio-demographic characteristics (see Table 1 for socio-demographic characteristics of the sample). In Tierney et al. (2001), the authors provide a discussion of the increased heterogeneity of American communities faced with various types of hazards such as flooding, earthquakes, and tornadoes, but this is not as relevant for these WUI communities. Given these results, the socio-demographic variables are not included in the discussion and final analyses. Instead, community level differences are captured through the use of dummy variables for the communities.

3.2. Independent measures

Individuals have been found to be poor at assessing their own knowledge of a domain. Therefore, using both direct experience

Table 1
Descriptive statistics: all measured variables.

Variable name	Mean/mode	Standard deviation	*N*
Model variables			
Subjective knowledge	5.83	0.92	251
Fire experience	0.41	0.19	251
Self-efficacy	4.88	1.16	251
Responsibility	6.58	0.72	251
Risk perception	5.24	1.23	251
Risk reduction behaviors	5.99	2.62	251
Socio-demographic variables (entire sample)			
Age	55–64 years old		34%
Gender	Male		56%
Education	College degree		39%
Length of residency	12.1 years		
Income	$75,000 and up		45%
Fulltime/seasonal	126 seasonal		50%

and subjective knowledge of a risk is a robust way of measuring their level of expertise with a risk as well as their proclivity to engage in risk reducing behaviors. The first independent variable included *direct experience* with the risk as measured by "What type of experience have you had with catastrophic wildfire". The categories for the responses ranged from loss of property to experiences shared by friends. We created an index of direct experience based on the values that were assigned to each type of wildfire experience. Individual respondents were asked to rank the various sources of direct experience with wildfire. The ranking resulted in assigning a value to each of the experiences as follows: house, structures, and/or property destroyed (6); evacuated from the home (5), fires occurred less than 5 miles from the property (4), 5–50 miles from the property (3), more than 50 miles from the property (2), and heard about wildfire experiences from neighbors, family, and friends (1). Based upon these rankings we were able to weigh the importance of a more direct experience such as losing property to a less direct experience such as hearing about a friend's experience. We created an index based on the level of fire experience that each respondent had while living in their respective community. The resulting index ranged from 0 to 1; with values closer to 1 signifying that the individual had more direct personal experience with various aspects of the wildfire hazard (Dowling and Staelin, 1994).

The second independent variable was *subjective knowledge* of the risk. Likert scales were used to measure self-rated subjective knowledge, by asking respondents "how well informed do you consider yourself to be about wildfire and wildfire risks", "to what extent do you find information about wildfires to be personally relevant", and "how motivated are you to learn more about the connection between wildfire risks and undertaking behaviors to create defensible space" anchored by 1 = not at all informed/not at all relevant/not at all motivated to 7 = very informed/very relevant/very motivated. These three variables were formed into a composite measure of subjective knowledge ($\alpha = .84$). Keeping in mind that these WUI residents had varying degrees of extensive fire experience over the last 10 years, their subjective knowledge ratings tended to be on the high end of the 7-point Likert scales. This is supported by the knowledge calibration literature that demonstrates that individuals (residents in the WUI) tend to think that they know more about the hazard than they actually do and their knowledge many times is not accurate (Alba and Hutchinson, 2000). Additionally, the low correlation between fire experience and subjective knowledge provides additional support for these two variables as separate constructs in the model ($r = .18$, $p < .0001$; see Table 2). Also of importance with this measure is the finding by De Young (2000) that "conceptual familiarity" can be a relevant predictor of behaviors separate from direct experience given that "…what people can become familiar with is not limited to what they directly experience." (p. 513)

The third independent variable investigated respondents' *beliefs in the efficacy* of undertaking risk reduction behaviors measured using the following five Likert scales – "by undertaking risk mitigating behaviors on your property, how effective can you be at preventing wildfires from impacting your personal property", "by undertaking risk mitigating behaviors on your property, how effective can you be at preventing wildfires from impacting your personal life", "for people like myself, the risk of wildfire is relatively easy to avoid", "how confident are you in your ability to protect your property from the risk of wildfire", and "how confident are you in your ability to protect yourself from the risk of wildfire" anchored by 1 = not at all possible/not at all possible/very difficult/not at all confident/not at all confident to 7 = very possible/very possible/very easy/very confident/very confident. These five variables were formed into a composite measure of self-efficacy ($\alpha = .87$).

The fourth independent variable, *fulltime/seasonal status*, is measured by asking respondents how many months on average in a typical year that they live in their respective community. The respondents entered the number of months and it was determined that any resident living in a community six or more months would be considered a full-time resident and those living in the community less than six months per year were categorized as part-time residents of the particular community. As a check to confirm that this was a reasonable categorization approach, we asked a subset of the residents of each of the communities if they considered themselves 'fulltime' or 'part-time' residents and how many months each year they spent in their respective community.

The fifth independent variable measured one's *locus of responsibility* for mitigating the wildfire risks. This composite measure asked respondents "how responsible should you be for protecting yourself from the impact of wildfire" and "how responsible should you be for protecting your property from the impact of wildfire" anchored by 1 = not at all responsible and 7 = very responsible ($r = .88$). We also tested to determine if *location* of the particular community had an impact on the hypothesized relationships. The location of each community was treated as a dummy variable to determine if such unmeasured factors as forest conditions, home values, and age of the community captured regional differences.

Finally, an important factor in determining how people perceive risk is how they calculate the probability of a hazard occurring and how much damage will occur. The construct of *perceptions of risk* includes the assessment of both probability and consequences of impacts. We measured this construct using the following five Likert scales: "to what extent do you feel concerned about the effects of wildfire", "how serious do you feel the negative consequences of wildfires are to you personally", "how vulnerable do you feel about the possibility of wildfire physically affecting you or your family", "how vulnerable do you feel about the possibility of wildfire affecting your property and/or possessions", and "how severe will the impact of a wildfire be where you live". These five Likert scales were anchored by 1 = not at all concerned/not at all serious/not at all vulnerable/not at all vulnerable/no harm at all to 7 = very concerned/extremely serious/extremely vulnerable/extremely vulnerable/extremely devastating and formed into a composite measure of risk perceptions ($\alpha = .91$).

These composite measures were the basis for the analysis to investigate the direct effects of experience, subjective knowledge,

Table 2
Correlation matrix.

	Risk perceptions	Fire experience	Subjective knowledge	Self-efficacy	Beliefs in responsibility
Behaviors	.38*	.17*	.41*	.26*	.33*
Risk perceptions		.18*	.41*	.07	.08*
Fire experience			.16*	−.03	.10
Subjective knowledge				.41*	.45*
Self-efficacy					.20*

*$p < .001$.
Note: Collinearity is not likely to be a problem given the low to moderate correlations (Greene, 1990).

fulltime/seasonal status, locus of responsibility, and self-efficacy with the indirect or mediating effect of risk perceptions on risk reduction behaviors (see Fig. 1). In addition, the mediation model allowed us to test if any of the independent measures are mediated by one's risk perceptions.

3.3. Dependent measure – risk reduction behaviors

The dependent variable of interest is the number of *risk reduction behaviors* these residents had undertaken. Unlike other studies in hazard adjustments, these respondents had actually adopted a subset of the possible risk mitigation strategies so the question of whether resource-related attributes were correlated with behavioral intentions was not relevant for this study (Lindell and Prater, 2002; Lindell and Whitney, 2000). We focus on actual risk reduction behaviors that the individual had undertaken which is expected to provide a stronger test of what directly and indirectly influences these risk reduction behaviors. We asked each resident to indicate which behaviors they had completed on their property based on a list of defensible space behaviors (see Appendix A). The 11 behaviors were summed into a behavioral index using '1' if the behavior had been performed and '0' if it had not yet been undertaken resulting in a summed measure ranging from 0 to 11.

4. Analyses and results

First, correlations were run to determine if there was any evidence of collinearity between the independent variables (see Table 2 for the correlations). The second step was to run a set of regressions on the total and mediation models using direct experience as the dependent variable on the remaining independent variables. It is evident from both the correlations and the regression analyses that collinearity is not an issue. The correlations between the independent variables and the dependent variable, behaviors, are also included to provide partial support for the relationship between these variables. This pattern of correlations is also supported in the risk and hazards literature (Lindell and Prater, 2002; Lindell and Perry, 2000; Lindell and Whitney, 2000). This initial correlational support is then tested in a causal framework, discussed in detail below. Next, a series of multiple regression analyses were run to test the mediation model (Barron and Kenny, 1986).

4.1. Overall regression results (Fig. 1 – Path C)

In order to assess whether, in the total effects model, subjective knowledge, direct experience, self-efficacy, locus of responsibility, location, and fulltime/seasonal status impact the number of risk reduction behaviors undertaken, a multiple regression analysis was conducted. The results from the regression demonstrate that knowledge, efficacy, responsibility, and fulltime/seasonal status directly impact the number of risk reduction behaviors ($t = 2.93$, $p < .004$; $t = 1.62$, $p < .058$; $t = 2.85$, $p < .005$, $t = -5.51$, $p < .0001$, respectively). Surprisingly, fire experience was not a significant explanatory variable in the total effects model ($t = 0.88$, $p < .38$). This could be explained by the concept of disaster subcultures that tend to have a fatalistic approach to a prevalent hazard. Often, the shape of disaster response depends on the individual's previous experience with similar events. Thus, a previous disaster provides some 'residue' of learning that is applied to subsequent situations. When the 'residues' are preserved, the community is believed to possess a disaster subculture (Wenger and Weller, 1973). One possible 'residue' could be that no matter what you do to protect yourself from a hazard it will never be enough. This perspective is found in communities where repeated experiences with a hazard are integrated into their "constructed reality" – "*this is the tip of the iceberg – the next big one is coming!*". An alternative 'residue' could be the "constructed reality" that – "*lightening won't strike twice!*". This result is supported in a study that found that young adults who had experienced a natural disaster or engaged in a particular risk behavior estimated their chance of experiencing a negative outcome resulting from that event as less likely than do individuals without such experience (Halpern-Felsher et al., 2001).

As knowledge about wildfire risks, the belief in their ability to reduce the risk, and their feelings of responsibility all increase, there is a corresponding increase in the number of risk reduction behaviors undertaken by homeowners (see Table 3 for the means, beta coefficients, standard errors and the *t*-values for the respective parameters). As expected, we also find that fulltime residents undertake a greater number of risk reducing behaviors as compared to seasonal homeowners.

In addition to these variables, we also used dummy variables to determine if the location of these communities had an impact on their risk perceptions as well as the degree to which they undertake risk reduction behaviors. We found that the two newer communities were more likely to undertake risk reduction behaviors ($t = 3.06$, $p < .002$; $t = 1.60$, $p < .10$, respectively). The third community was an older community with older, lower-valued homes. In addition, the two newer communities had been built with a greater awareness of the fire risks in their respective areas, therefore, fire protection strategies are an integrated part of their homeowners' association (HOA) covenants. Anecdotal evidence, through interviews in these communities, also found that the two newer communities had HOAs that were more proactive about fire preparedness.

Although, these results establish that there is an effect of the independent measures on risk reduction behaviors, the next step is to determine the influence of residents' risk perceptions on this relationship through a mediation analysis.

4.2. Mediation results

4.2.1. Path A (Fig. 1)

We followed the guidelines for assessing mediation developed by Barron and Kenny (1986) to determine if risk perceptions mediate the effects of knowledge, experience, responsibility, and efficacy on risk reduction behaviors. The relationship between the independent measures and the risk reduction behaviors is confirmed as described above. A second multiple regression analysis (Table 4) demonstrated that there is a significant effect for subjective knowledge, self-efficacy, and fulltime/seasonal status on

Table 3
The relationship between independent variables and risk reduction behaviors (Path C).

Variable	Mean	Beta coefficient	Standard error	*t*-Value	*p*-Value
Subjective knowledge	5.84	0.590	0.201	2.93	.004
Fire experience	2.36	0.696	0.795	0.88	0.381
Self-efficacy	4.88	0.226	0.138	1.84	0.058
Responsibility	6.58	0.627	0.220	2.85	0.005
FT/seasonal[a,b]	0.50	−1.81	0.330	−5.51	.0001
Location1[a]		1.351	0.441	3.06	0.002
Location 2[a]		0.756	0.474	1.60	0.112
Risk reduction behaviors: 5.99 (2.62)					

$n = 251$, $R^2 = .33$.
[a] Dummy variables.
[b] Fulltime/seasonal status.

Table 4
The relationship between independent variables and risk perceptions (Path A).

Variable	Mean	Beta coefficient	Standard error	*t*-Value	*p*-Value
Subjective knowledge	5.84	0.307	0.077	3.98	0.0001
Fire experience	2.36	0.024	0.304	0.08	0.936
Self-efficacy	4.88	−0.096	0.053	−1.86	0.065
Responsibility	6.58	−0.061	0.084	0.73	0.467
FT/seasonal[a,b]	0.50	−1.317	0.127	−10.45	.0001
Location1[a]		−0.519	0.169	−3.08	0.002
Location 2[a]		−0.633	0.181	−3.49	0.001
Risk perceptions: 5.24 (1.22)					

$n = 251$, $R^2 = .55$.
[a] Dummy variables.
[b] Fulltime/seasonal status.

risk perceptions ($t = 3.98$, $p < .0001$; $t = -1.86$, $p < .06$; $t = -10.45$, $p < .0001$, respectively). The actual fire experiences of homeowners again, did not have a significant impact on risk perceptions ($t = .087$, $p < .936$). In addition, the beta coefficient for locus of responsibility was not significant. We will address this in the next section. In addition, the location dummy variables continue to be significant, as the two newer communities had lower risk perceptions than the third community ($t = -3.08$, $p < .003$; $t = -3.49$, $p < .0005$, respectively). In this regression result, homeowners' risk perceptions are treated as the dependent variable with the seven independent measures serving as explanatory factors (Table 4 presents the means, beta coefficients, standard errors and the *t*-values).

4.2.2. Path B (Fig. 1)

To confirm that risk perceptions are a significant indicator of undertaking risk reduction behaviors (Fig. 1 – Path B), we ran a simple regression with risk perceptions as the independent variable and risk reduction behaviors as the dependent variable. The results confirm that risk perceptions do indeed influence risk reduction behaviors ($t = 6.26$, $p < .0001$). Based on these results, a regression was run with risk perceptions, fire experience, subjective knowledge, self-efficacy, responsibility, fulltime/seasonal status, and the location dummy variables to test their impact on risk mitigation strategies (Fig. 1 – Path C′). The results confirmed that the independent variables, except direct fire experience, were significant (Table 5).

4.2.3. Path C′ (Fig. 1)

The Sobel test provides a statistic that measures the mediating effects of the independent variables on risk reduction behaviors (Preacher and Leonardelli, 2004). First, consistent with prior results, the Sobel tests confirm that fire experience did not have a direct or an indirect effect on risk reduction behaviors (Sobel, 1982; MacKinnon et al., 2002). Second, we verify that risk perceptions do not mediate the relationship between self-efficacy and risk reduction behaviors, thus, self-efficacy has a direct influence on risk reduction behaviors consistent with the Protection Motivation Model (Rogers, 1983).

Finally, we confirm that the partial mediation effect of risk perceptions is driven by homeowners' knowledge of what they believe they know about wildfire hazards and their sense of responsibility directed towards protecting themselves and their property from the impact of the wildfire hazard (see Table 5 for the beta coefficients, standard errors, *t*-values and the corresponding Sobel test of significance).

Table 5
The relationship between independent variables and risk reduction behaviors (Path B and Path C′).

Variable	Beta coefficient	Standard error	*t*-Value	*p*-Value	Sobel test
Risk perceptions	0.359	0.171	2.10	0.037	
Fire experience	0.690	0.789	0.87	0.383	0.81 ($p < .21$)
Subjective knowledge	0.480	0.207	2.32	0.020	1.55 ($p < .05$)
Self-efficacy	0.260	0.138	1.87	0.059	1.24 ($p < .10$)
Responsibility	0.649	0.219	2.96	0.003	1.72 ($p < .04$)
FT/seasonal[a,b]	−1.34	0.398	−3.38	0.001	
Location1[a]	1.54	0.447	3.44	0.001	
Location 2[a]	0.983	0.483	2.04	0.040	
Risk reduction behaviors: 5.99 (2.62)					

$n = 251$, $R^2 = .34$.
[a] Sobel tests are not calculated for dummy variables.
[b] Fulltime/seasonal status.

5. Conclusions and policy implications

Our analysis verifies that beliefs in one's ability to deal with the hazard and whether one is a fulltime or seasonal resident both have a direct effect on risk reduction behaviors undertaken by homeowners while subjective knowledge and locus of responsibility have a mediated impact on risk reduction behaviors. These latter effects are mediated through the risk perceptions of individuals. Finally, as homeowners' risk perceptions increased, they were more likely to undertake risk reduction behaviors to protect themselves and their property, supporting our hypotheses. This finding is consistent with the research reported in O'Connor et al. (1999) regarding climate change and Setbon et al. (2005) concerning food safety.

Various stakeholder groups (e.g. policymakers, homeowner associations, county, state and federal fire organizations, insurance companies) have a difficult task when communicating risk to diverse constituent populations. It is critical to understand what influences an individual's perception of risk, and how these perceptions influence the type of risk reduction behaviors they undertake. This understanding can influence choices of how to effectively communicate risk information and then to have that lead to the desired action or outcome. Policymakers need to know the factors that are most effective as policy tools to motivate risk reduction behaviors on private lands because of the potential negative externalities or spillover effects created by individual actions or lack thereof. Our results provide support for the premise that educating people (by influencing their subjective knowledge) on the risks associated with a natural hazard will in turn affect their perceptions of vulnerability and the severity of the risk, thus encouraging them to protect themselves, their property, and by default, their community (Bandura, 1977).

In addition, individuals' sense of responsibility to protect themselves influences their decision to undertake risk reduction behaviors as mediated by their risk perceptions. In contrast, their belief that particular risk reduction behaviors are efficacious directly impacts the degree to which they engage in these behaviors. Therefore, the belief that "*If only they knew!*" is not sufficient to persuade individuals to protect themselves from the impact of natural hazards. It is also important to consider *what* they know (or think they know!), their sense of personal responsibility, and their *belief* in their ability to do something about the risk. Each of these measures was statistically significant, however the characteristics of the targeted populations need to be considered. For example, these communities are older, more affluent retirees that may not have the physical ability to undertake many of the mitigating actions which may explain the lower rating on the self-efficacy measure.

Surprisingly, direct experience with wildfires did not significantly influence homeowners' decisions to mitigate the risk. This result is consistent with the qualitative results reported by McGee et al. (2009). The authors' examine the role that experience plays in explaining mitigation efforts following wildfires. They use personal interviews following two major fires in western Canada and find that experience was not a significant factor in explaining mitigation efforts. A question that needs to be addressed in future research is whether little or no experience with wildfire would be a significant explanatory variable. In this research, all residents had experienced some form of wildfire activity including evacuations. Future research should compare communities with large proportions of "novice" WUI residents to determine if this disaster subculture mentality has not permeated their risk assessment process. Also, the time since the wildfire experience should be included in future analysis.

This study used a survey of homeowner associations in three wildland–urban interface communities in the western U.S. In order to increase the generalizability of the results from this study, future research should consider more diverse WUI communities. The population studied was confined to a very homogeneous yet representative sample of WUI communities found in this part of the U.S. This type of community is frequently targeted by the management agencies in their wildfire risk mitigation efforts. Another limitation is the focus on what risk mitigations homeowners had done as a one-time action. Future studies should also consider the dynamic aspects of the planned maintenance and continuation of these behaviors to ensure improved hazard adjustments and to minimize wildfire risks in the long run.

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Appendix A. Risk reduction behaviors

- Creating a minimum 30-foot defensible space around your home
- Planting low-growing, fire resistant plants around your home
- Putting a fire resistant roof on your home
- Putting fire resistant undersides to any decks and balconies on your home
- Removing any dead branches from your home's roof and around the chimney
- Making sure that your home is easily identifiable and accessible from a main road
- Making sure that all the trees on or near your property are away from structures
- Making sure that all the trees on or near your property are away from overhead utility lines
- Working with neighbors to clear common areas and prune areas of heavy vegetation
- Stacking firewood and scrap wood piles at least 30 feet from any structure
- Getting local fire department to do a fire safety inspection at your home and property.

Source: Firesafe Council of California website: www.firesafecouncil.org.

Appendix B. Socio-demographic variables (percent).

	HOA 1	HOA 2	HOA 3
Respondents' age (yrs):			
18–24	0	0	0
26–34	0	5	1
35–44	11	7	9
45–54	33	28	27
55–64	35	35	33
65 & over	20	25	30
Gender (male)	58	54	58
Education:			
Some high school	0	1	4
High school degree	9	1	9
Some college	22	11	5
College degree	29	51	41
PostGrad work	22	25	24
Graduate degree	14	10	16
Length of residence[a]	11.35 (7.3)	12.46 (11.37)	12.48 (11.14)
Income level:			
Less than $15,000	0	0	4
$15,000–24,999	2	3	7
$25,000–34,999	2	4	5
$35,000–49,999	12	13	20
$50,000–74,999	39	29	24
$75,000 & ↑	44	50	40

[a] Mean and standard deviation of the number of years respondents have lived in their respective HOA. Years of residence ranged from 6 months to 50 years.

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