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Risk perception and response to changing wildfire hazards: Evidence from family forest owners in the western US Pacific Northwest

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A B S T R A C T

Climate models predict future increases in the frequency, magnitude, and duration of natural hazard events, including heat waves, droughts, and wildfires. People may be aware of these natural hazards but unfamiliar with new patterns expected under climate change. Ideally, people would take action to protect themselves from natural hazard events—even those with which they have limited prior experience. Doing so would likely reduce the public costs of later assisting individuals impacted by events when they occur. Although a large body of research has examined how people perceive and protect themselves from the risks of natural hazards, fewer studies have focused on risk behavior in the context of changing hazard conditions. In such contexts, people's past experiences may not be indicative of the future so they may rely more on their beliefs and information gained through their social networks when making decisions. Focusing on the western Pacific Northwest, USA–where a growing number of wildfires, including extreme wildfires, may signal changing hazard conditions–we examined the influence of wildfire hazard experiences, beliefs about environmental change, and information networks on family forest owners' wildfire risk perceptions and risk mitigation intentions. We found strong correlations between family forest owners' wildfire experiences and their wildfire risk perceptions. We also found strong correlations between owners' risk perceptions and their beliefs about environmental change and information networks. Owners' wildfire risk mitigation intentions were also correlated with their perceptions of risk, perceived capacity to reduce risk, beliefs about environmental change, and information networks. Our findings provide evidence that in the context of changing wildfire hazards, people rely on their experiences when making decisions about risk mitigation behavior in addition to their beliefs and social networks.

1. Introduction

Natural hazard events are expected to increase in severity, frequency, and duration under climate change. When these patterns differ greatly from historical conditions, natural hazards can be considered novel, and when they cause substantial disruption to the functioning and well-being of human and natural systems, they can be considered extreme (AghaKouchak et al., 2020; Balch et al., 2020; McPhillips et al., 2018). Wildfires, in particular, are becoming much larger, more frequent, and more damaging around the world (Ellis et al., 2022; Rocque et al., 2021; Senande-Rivera et al., 2022; Xu et al., 2020). Changing natural hazard conditions require people to make decisions about phenomena with which they may have limited experience, even as the potential consequences may be substantial. People may already be aware of a hazard, and perhaps even have experienced a version of it, but now face it in new patterns. This complex and uncertain decision-making environment around changing hazards can pose particular challenges when

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policymakers expect risk-reduction activities to be carried out by individuals who might be affected.

Prior research has investigated factors that influence how individuals protect themselves from natural hazards. Much of this research has drawn on Protection Motivation Theory (PMT) (Rogers, 1975), which posits that people's perceptions of risk and their perceived capacity to reduce risk influence whether they take action to protect themselves, and that these perceptions themselves are shaped by their experiences of hazards as well as their beliefs and the information they obtain through their social networks about hazards, among other cognitive and social factors (Gifford et al., 2011; Grothmann and Patt, 2005; Lindell and Perry, 2012; Paton, 2003; Paton, 2019; Reser and Swim, 2011; Rogers, 1975; Rogers and Prentice-Dunn, 1997). Less research has investigated how people perceive and respond to changing natural hazard conditions, including increasingly extreme or novel natural hazard events, although there are exceptions (Andrade et al., 2019; Eusse-Villa et al., 2024; Lindell et al., 2019; Rodríguez-Cruz and Niles, 2021; Veloso et al., 2024). The paucity of such research may limit efforts to design effective policies and programs that promote mitigation actions by individuals.

We investigated the influence of people's experiences, beliefs, and social networks on their risk perceptions and responses to changing wildfire hazard conditions. We focused on family forest owners in the western US Pacific Northwest (PNW). Wildfires have recently become more common in this region, in some cases burning with substantial size and severity in areas that historically experienced wildfires only rarely. Given this dynamic wildfire hazard environment, we expected that family forest owners' beliefs about environmental change and information gathered through their social networks would have greater influence on their wildfire risk perceptions and risk mitigation intentions than their experiences with wildfire hazards. Conversely, we found that owners' wildfire hazard experiences were correlated with their risk perceptions, and their risk perceptions were correlated with their risk mitigation behavior, as were their climate change and wildfire trend beliefs and social networks. Our research can help answer theoretical questions about how people adapt to climate change and inform practical approaches to aid and encourage family forest owners in adapting to changing wildfire hazards.

2. Conceptual framework

2.1. Risk behavior theory

Psychosocial frameworks based on the PMT posit that people's decisions to protect themselves from natural hazards are primarily a function of their subjective appraisals of risk and their ability to respond (Rogers, 1975) (Fig. 1). Risk appraisal refers to perceptions of the likelihood of being affected by an adverse event and the potential severity of consequences (Paton, 2003; Rogers, 1975). Response appraisal refers to people's perceptions of their capacity to respond to risk as a function of the effectiveness of their response options (response efficacy), their capacity to implement those options (self-efficacy), and whether they feel it is worth the effort (perceived costs) (Ajzen, 1991, 2002; Grothmann and Patt, 2005; Paton, 2003; Paton, 2019; Rogers, 1975; Rogers, 1983a,b). Some studies have found risk appraisal and response appraisal to be equally important influences on risk mitigation behavior (Botzen et al., 2019; Esham and Garforth, 2013), while other studies have found that response appraisal explains behavior better than risk appraisal (Floyd et al., 2000; Koerth et al., 2013; Milne et al., 2000; Truelove et al., 2015; Zheng and Dallimer, 2016).

Theories about how individuals appraise risk generally acknowledge the influence of people's experiences and observations of natural hazards, which people make sense of through experiential processing, and people's preexisting beliefs, values, social norms, formed on the basis of information gathered through their networks through the process of social construction (Fownes and Allred,

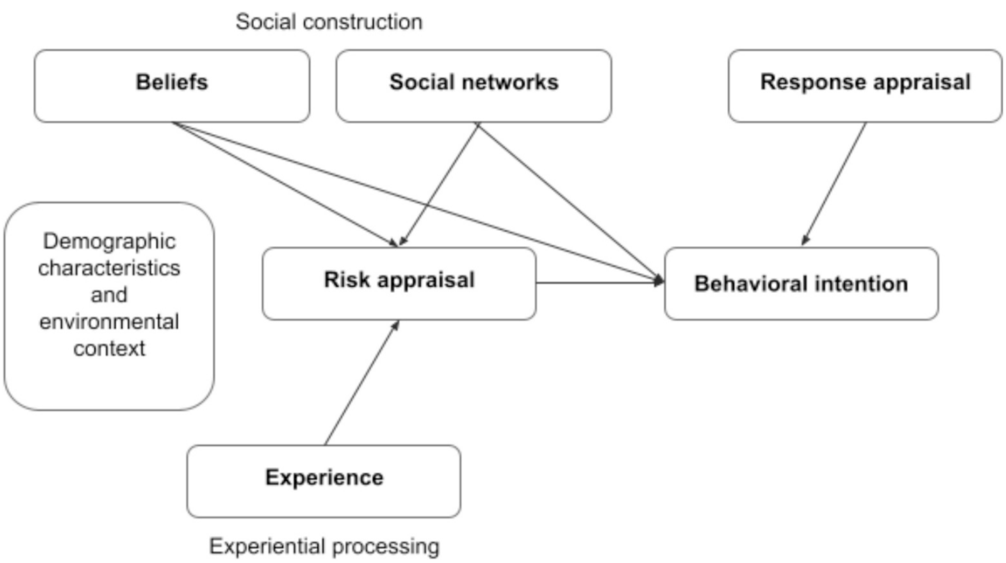

Fig. 1. Conceptual framework with the focal constructs in bold font in rectangles and relationships between the constructs represented with arrows.

2019; Howe, 2018, 2021; Reser et al., 2014; Sisco, 2021; Zanocco et al., 2018). Broader structural conditions are also important, as rules, regulations, markets, and other institutions influence people's access to information about risk and resources for responding (Gifford, 2011; Grothmann and Patt, 2005; Tierney, 1999, 2007; Wisner et al., 2004).

2.1.1. Experiential processing

Experiencing natural hazards can involve various interactions between people and their environment, including observations (Lindell and Perry, 2012; Risbey et al., 1999) and physical experiences of material impacts (Cutler, 2015; Demski et al., 2017; Lujala et al., 2015; Shao et al., 2017; van der Linden, 2015; Xia, 2024; Zanocco et al., 2018; Zhang, 2022). Research generally acknowledges the influence of experience on risk appraisal (Bronfman et al., 2020) (Fig. 1), although evidence of the strength and direction of this influence is mixed. Some studies find that experience can increase risk perception (Bronfman et al., 2020; Cutler, 2015; Kellens et al., 2013) and risk mitigation efforts (Denny and Fischer, 2023; Eusse-Villa et al., 2024; Harvatt et al., 2011; Koubi et al., 2016; Lindell et al., 2019; Mertens et al., 2018; Rodríguez-Cruz and Niles, 2021; Xia, 2024; Zhang, 2022), and other studies find that experience has minimal effects or can decrease risk perception and risk mitigation. In their *meta*-analysis of determinants of climate change adaptation, for example, van Valkengoed and Steg (2019) found that experience had small-to-moderate effects.

Cognitive biases help to explain inconsistencies in the influence of experience on risk perception and response. The "availability" heuristic leads people to prioritize information that is easiest to recall (e.g., more recent, more vivid) when making decisions (Tversky and Kahneman, 1973). The "affect" heuristic leads people to prioritize emotionally charged information (Slovic, 1997). Affective dimensions such as dread and familiarity also lead people to perceive risk regarding recent, vivid, and nearby hazards more readily (Keller et al., 2012). Other aspects of affect, however, such as high anxiety, can lead people to succumb to fatalism (Dillon et al., 2014; Sims and Baumann, 1983). Similarly, cognitive biases associated with probabilities and prediction (Tversky and Kahneman, 1974) can lead people to believe it is unlikely to experience repeated adverse events or associate a near-miss with successful prevention (Dillon et al., 2014; Harvatt et al., 2011; Krasovskaia et al., 2001; McCaffrey, 2004; McGee et al., 2009). These cognitive biases also make it difficult for people to react to psychologically distant risks, such as those that are highly variable, complex, or uncertain (Gifford, 2011; Liberman et al., 2007; McDonald et al., 2015; Reser and Swim, 2011; Trope and Liberman, 2010). They also explain people's strong affective responses and why people are more concerned about events with faster onset and termination speeds and greater visibility (Carolan, 2004; Chen and Cong, 2022; Denny and Fischer, 2023; Dessai et al., 2004; Konisky et al., 2016; Rosa, 1998; Staupe-Delgado, 2019; Staupe-Delgado and Rubin, 2022; Tosun and Howlett, 2021). A desire to minimize cognitive dissonance often leads people to perceive risk more readily in contexts where they can take action to mitigate it (Festinger, 1957; Slovic, 1997; Tversky and Kahneman, 1973). In a context of environmental change, people who lack sufficient information and resources may perceive themselves as incapable of responding (Kasperson et al., 1988), potentially making response appraisal a more important determinant of response than risk appraisal.

2.1.2. Social construction

Social construction refers to the process of making sense of phenomena through social interaction (Berger and Luckmann, 1967). Social networks facilitate this social process through which people form risk appraisals (Gifford et al., 2011; Grothmann and Patt, 2005; Kasperson et al., 1988; Lindell and Perry, 2012; Reser and Swim, 2011; Slovic, 1997, 1987; Tierney, 1999, 2007) (Fig. 1). The size and composition of social networks affect risk perception and risk mitigation behavior. People with larger and more diverse networks (i.e., greater bridging capital) are arguably exposed to broader knowledge, information, and resources than people with smaller and more homogeneous networks (Berardo and Scholz, 2010; Burt, 2000; Granovetter, 1973; Reagans and McEvily, 2003; Rogers, 1983a,b; Ruef, 2002). Therefore, people seeking information from larger networks may be more knowledgeable and concerned about natural hazards and more informed and proactive about managing risk. People's beliefs are also thought to be socially constructed rather than based on direct experience. Theories of motivated reasoning and, specifically, confirmation bias, explain that people, in fact, interpret their experiences through the lenses of prior belief. In other words, people can appraise risk based on their beliefs without experiencing hazards firsthand (Fig. 1). Studies find that people who believe in anthropogenic climate change are more likely to believe they have personally experienced climate change or natural hazard events (Akerlof et al., 2013; Hamilton and Stampone, 2013). Research also finds that people who believe in anthropogenic climate change are more likely to support and undertake protective actions against natural hazards (Arbuckle et al., 2013, 2015; Osberghaus and Fugger, 2022; van Valkengoed and Steg, 2019).

2.2. Research questions

We tested the conceptual framework's ability to explain family forest owners' intentions to manage their forests to reduce the risk of wildfire as a function of their perceptions of wildfire risk—shaped by their wildfire hazard experiences, as part of experiential processing, and their beliefs about environmental change, including climate change and wildfire trends, and their information networks, as part of the process of social construction—as well as their perceptions of their capacity to reduce wildfire risk. We also accounted for the influence of climate change beliefs and information networks directly on owners' behavioral intentions, recognizing that owners who believe in anthropogenic climate change and who have broad networks for obtaining forest management information may think it's a good idea to mitigate wildfire risk on their properties even if they do not perceive risk or believe that wildfire hazard is changing.

We investigated four research questions:

(1) *Do family forest owners who have wildfire hazard experiences, either in the form of direct experience with wildfire events or exposure to wildfire hazard (*e.g.*, flammable vegetation that serves as fuel), perceive greater risk of a wildfire occurring on their property?*
(2) *Do owners who believe in anthropogenic climate change and that wildfire hazards are getting worse perceive greater wildfire risk on their property?*
(3) *Do owners with broader information networks perceive greater wildfire risk on their property?*
(4) *Are owners with greater risk perception and greater perceived capacity to reduce risk (either the probability or the severity of wildfires on their properties) more likely to intend to undertake forest management activities?*

3. Materials and methods

3.1. Study area

Our study area was the western Pacific Northwest (PNW), the portions of Oregon and Washington that are west of the Cascade Range. This area can be classed into three ecological areas: The North Cascades and Coast Range (NCCR) ecoregions, the Willamette

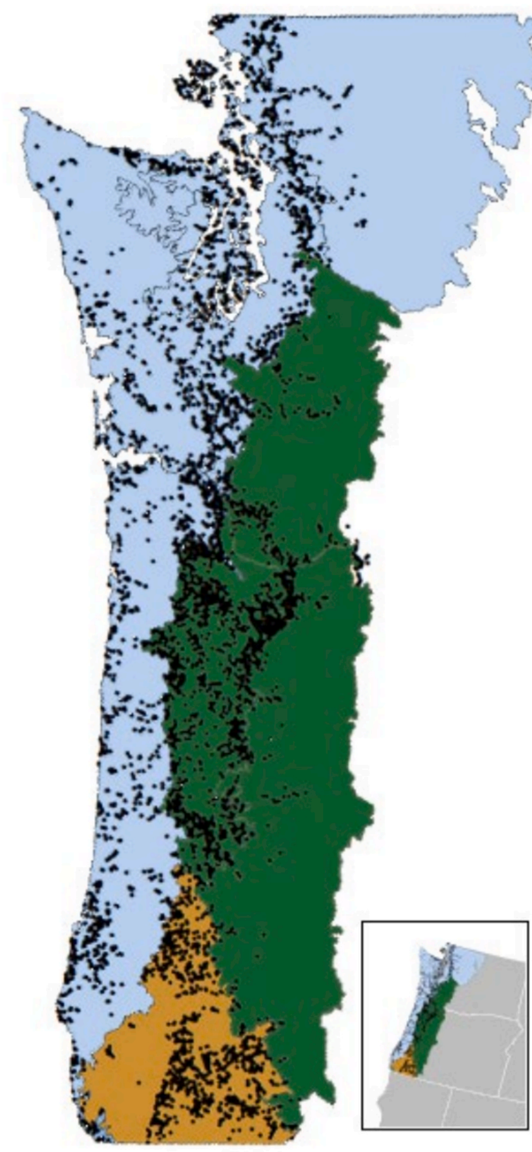

Fig. 2. Study area with the North Cascades and Coast Range ecoregions in blue, the Willamette Valley and western Cascades ecoregions in green, and the Klamath ecoregion in yellow. Black dots indicate approximate locations of survey respondents' parcels. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Valley and western Cascades (WVWC) ecoregions, and the Klamath (KLAM) ecoregion (Environmental Protection Agency, 2016) (Fig. 2). Running north to south, the region's temperate rainforests become drier and more fire-prone, eventually transitioning at the very south to a dry mixed conifer forest type. The Klamath ecoregion historically supported frequent, mixed-severity, moderately sized wildfires (<35 years average recurrence interval) (Agee, 1991), but over the past 25 years, several large wildfires burning in this ecoregion, including the 202,169 ha Biscuit Complex fire in 2002, the 77,346 ha Chetco Bar Fire in 2017, and the 95,431 ha Klondike/Taylor Creek fire in 2018 (Abatzoglou et al., 2021).

Conversely, the North Cascades and Coast Range and Willamette Valley and western Cascades ecoregions (except for the oak woodlands, savannas, and prairies in the valleys) are characterized by dense, productive conifer forests that historically burned infrequently but, under dry, windy conditions, can fuel extremely large wildfires. Since the 1100 s, these forests have experienced large fires every 100–300 years, with the 52,000 ha Columbia Burn in 1902 and the 140,000 ha Tillamook Burn in 1933 being the most recent large wildfires before 2020 (McEvoy et al., 2021; Reilly et al., 2017). In September 2020, multiple large wildfires (the "2020 Labor Day fires") burned over 400,000 ha (>988,000 acres) in Oregon's WCCR ecoregions, including suburban areas outside the city of Portland and rural communities along river valleys in the western Cascades (Reilly et al., 2022). Unexpected in their scale and location, the wildfires were declared a federal disaster, exposing hundreds of thousands of people to smoke (Burke et al., 2023) and prompting the evacuation of 90,000 people, with over 500,000 people on alert. Climate models suggest more frequent and larger wildfires in the region (Davis et al., 2017; Dunn et al., 2020; Dye et al., 2024; Halofsky et al., 2020), because of increasing drought, heat, insect and disease incursions, and resulting tree mortality (Davis et al., 2017; Kitzberger et al., 2017; Stavros et al., 2014; Westerling et al., 2006). The 2020 Labor Day fires were an extreme example of the changing wildfire hazard conditions in relation to which we investigated the influence of owners' experiences of wildfire hazard, beliefs about environmental change, and social networks on their behavior. Although we assumed that respondents were generally aware of the 2020 Labor Day wildfires, and some experienced the fires, we did not confirm these experiences. We therefore did not include the 2020 Labor Day fires as a variable in our analysis.

3.2. Study sample population

We focused on family forest owners–defined here as individuals and families owning four or more hectares of forestland (Butler et al., 2021). Family forest owners are important ownership group because the extent and location of their forest parcels can potentially enable them to influence landscape-level wildfire hazard. Collectively, these owners—44,000 in Oregon and 48,000 in Washington—own and manage 15% of the forestland in the western PNW (B. Butler et al., 2016), much of it concentrated at the interface of wildland and populated areas at lower elevations, which both increases their vulnerability to wildfire while also offering a potential buffer between larger forested areas and population centers (Ager et al., 2012; Stein et al., 2009).

3.3. Sampling

We randomly selected 5,000 owners from a sample of tax lots four hectares or greater in size, created from a forest parcel dataset from the Oregon Department of Forestry (Hubner, 2021) and the Washington State Forestland Database (NRSIG, 2019). We excluded parcels owned by government, school, non-profit, and private corporate owners, as well as families owning greater than 2,024 ha. Of the 4,735 eligible owners to whom we sent surveys, 976 returned surveys with more than half of the questions answered, yielding a 22% response rate. This sample size is sufficient for a 95% confidence interval with a 5% sampling error, assuming a 50/50 split on most survey questions (Dillman, 2011).

3.4. Data collection

We administered the survey in collaboration with Oregon State and Washington State Universities, beginning in February 2022, with the expectation that owners in the vicinity of the 2020 Labor Day fires would have had one full season (May 2021-November 2021) to undertake any management practices in response to the fires. We used a mixed-mode paper-digital format. The survey included 28 questions in six sections. The paper survey was eight pages long. Following the Dillman (2011) method, we first mailed a paper pre-survey announcement card that provided a digital link for those who preferred to complete the survey online, followed by two waves of paper surveys, each offering the digital link, and then a final postcard reminder. The author's university institutional review board reviewed the research design and determined that it posed minimal risk to participants and was exempt from ongoing review (study number HUM00184837).

3.5. Variables and measurement

3.5.1. Dependent variables

We operationalized the risk appraisal construct using the variable RISK PERCEPTION (Table 1, Fig. 3), which summed respondents' subjective appraisals of the probability that a wildfire would start on or spread onto their parcel from a neighboring property. We operationalized behavioral intention with the variable PLANNED RISK MITIGATION (Table 1, Fig. 3), which indicated whether respondents planned to conduct at least one of the risk mitigation actions listed in the survey. We expected that the extreme 2020 Labor Day fires may have prompted many forest owners to plan wildfire risk reduction activities, though they may not have yet had time to conduct them by the time of the survey.

Table 1
Variables developed for inclusion in regression models of risk appraisal and risk mitigation activities. Categories of variables are indicated by italic font and constructs are bolded.

Variable name	Variable definition	Sample statistics N = 726			
		Mean	SD	Min	Max
Risk appraisal					
RISK PERCEPTION	Sum of respondent's perceived probabilities of a wildfire starting or spreading onto their forest parcel	28.02	30.31	0	100
Behavioral intention					
PLANNED RISK MITIGATION	Variable equals 1 if respondent intended to undertake at least one of eight forest management practices in the next five years because of wildfire concerns; 0 otherwise. Practices included: Harvest all or most trees in a stand; Thin trees from a stand; Remove trees of a particular species; Remove brush or understory vegetation; Remove dead trees (standing or fallen); Plant tree species better suited to conditions; Create or maintain breaks in vegetation; and Apply prescribed fire.	0.32	0.46	0	1
Wildfire hazard experience					
SMOKE EXPERIENCE	Variable equals 1 if respondent experienced wildfire smoke or ash on their parcel in the past ten years; 0 otherwise.	0.69	0.46	0	1
NEIGHBORING BURN	Variable equals 1 if respondent experienced a wildfire burning on a neighboring parcel in the past ten years; 0 otherwise.	0.21	0.41	0	1
PARCEL BURN	Variable equals 1 if respondent experienced a wildfire burning on their parcel in the past ten years; 0 otherwise.	0.05	0.22	0	1
STRUCTURE BURN	Variable equals 1 if respondent experienced loss or damage to a home or building on their parcel from wildfires in the past ten years; 0 otherwise.	0.008	0.09	0	1
FUEL-BURN PROBABILITY	Likelihood of a wildfire on parcel based on surface and canopy fuel	0.004	0.011	0	0.06
FUEL-CONDITIONAL FLAME LENGTH	Potential severity of a wildfire on parcel based on surface and canopy fuel	2.36	1.67	0	9.39
Beliefs about environmental change					
CLIMATE CHANGE BELIEF	Level of agreement on five-point Likert scale with statement: "Human activities are the main cause of climate change"	3.68	1.26	1	5
WILDFIRE BELIEF-FREQUENCY	Variable equals 1 if respondent agreed that wildfire events had become more frequent in the ten years prior to the survey; 0 otherwise.	0.67	0.47	0	1
WILDFIRE BELIEF-DAMAGE	Variable equals 1 if respondent agreed that events had become more damaging in the ten years prior to the survey; 0 otherwise.	0.67	0.46	0	1
WILDFIRE BELIEF-SEASON	Variable equals 1 if respondent agreed that wildfire seasons had become longer in the ten years prior to the survey; 0 otherwise.	0.8	0.4	0	1
WILDFIRE BELIEF-SIZE	Variable equals 1 if respondent agreed that wildfire events had become larger in the ten years prior to the survey; 0 otherwise.	0.7	0.46	0	1
Social networks					
INFORMATION NETWORK	Count of up to seven types of actors (University extension; Natural resource or forestry agencies; Non-profit organizations; Forestry consultants; Loggers or other contractors; Other forest landowners in local area; Fire department or district) from which respondent sought information in the five years before the survey about forest management, how to manage wildfire risk, or future forest conditions	2.29	1.89	0	7
Response appraisal					
PERCEIVED CAPACITY-PROBABILITY	Variable equals 1 if respondent agreed or strongly agreed with statement "How I manage my forest affects the chance of a wildfire burning on my property"; 0 otherwise.	0.76	0.43	0	1
PERCEIVED CAPACITY-SEVERITY	Variable equals 1 if respondent agreed or strongly agreed with statement "How I manage my forest affects the chance of a wildfire burning on my property"; 0 otherwise.	0.81	0.39	0	1
Control variables					
PAST RISK MITIGATION	Variable equals 1 if respondent intended to undertake at least one of eight forest management practices (listed above) in the next five years because of wildfire concerns; 0 otherwise.	0.36	0.48	0	1
LIMITATIONS	Variable equals 1 if respondent perceived at least one of six management factors (time, money, labor, equipment, market access, cost-share assistance, knowledge and skills, and laws or regulations) as imposing significant or severe limitations on efforts to reduce wildfire risk on their parcel in the past ten years; 0 otherwise.	0.59	0.49	0	1
PARCEL SIZE	Total hectarage of the parcel associated with the tax lot to which the survey referred	25.91	60.29	1.24	890.31
MANAGEMENT LENGTH	Number of years respondent had been involved with management of the parcel	25.72	16.53	1	83
AGE	Respondent's age in years	67.26	12.14	25	97
GENDER	Variable equals 1 if respondent identified as female; 0 otherwise.	0.3	0.46	0	1

(*continued on next page*)

Table 1 (*continued*)

Variable name	Variable definition	Sample statistics N = 726			
		Mean	SD	Min	Max
EDUCATION	Variable equals 1 if respondent reported attaining a bachelor's degree; 0 otherwise.	0.67	0.47	0	1
INCOME	Variable equals 1 if respondent reported earning an average annual income of $100,000 or more; 0 otherwise.	0.54	0.5	0	1
WVWC	Variable equals 1 if respondent's parcel was in the Willamette Valley or western Cascades ecoregions; 0 otherwise.	0.4	0.49	0	1
KLAM	Variable equals 1 if respondent's parcel was in the Klamath ecoregion; 0 otherwise.	0.18	0.38	0	1
NCCR	Variable equals 1 if respondent's parcel was in the North Cascades or Coast Range ecoregions; 0 otherwise.	0.42	0.49	0	1

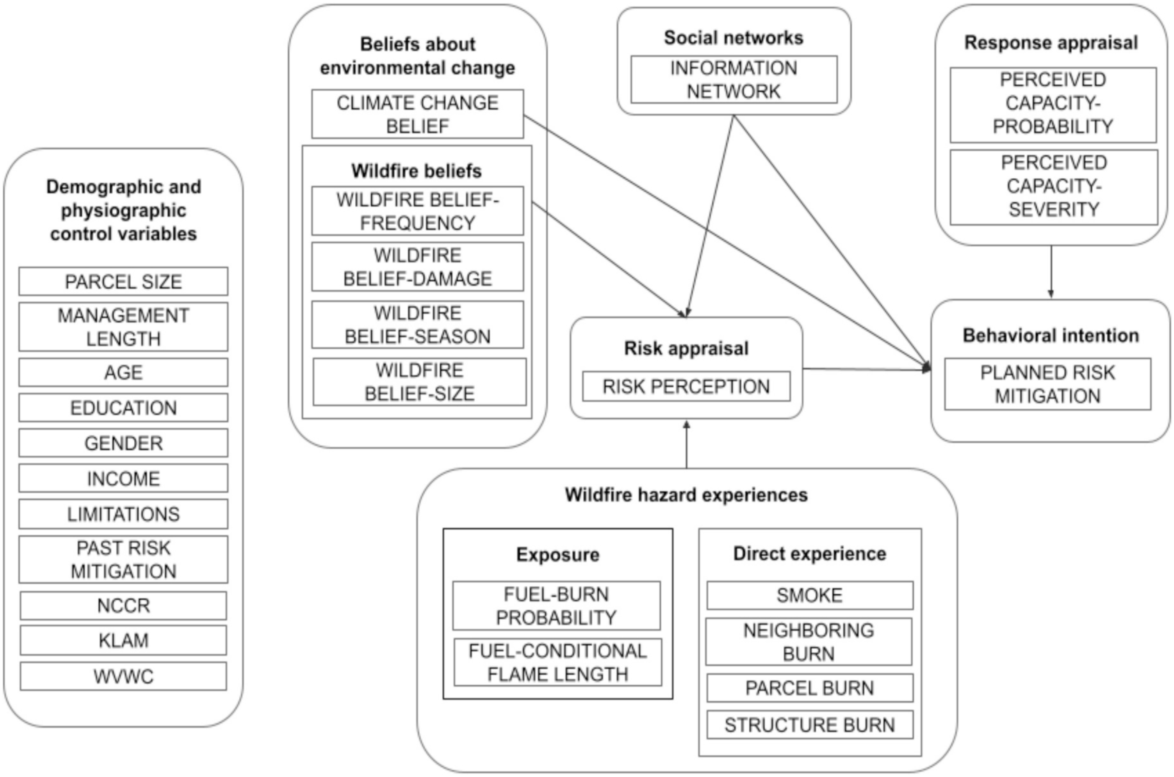

Fig. 3. Empirical model. Constructs are in bold font and variables are in all capitals. Arrows indicate hypothesized relationships.

3.5.2. Independent variables

We operationalized the experience construct using wildfire hazard experience variables indicating direct experience with four types of wildfire hazards (SMOKE EXPERIENCE, NEIGHBORING BURN, PARCEL BURN, and STRUCTURE BURN) and exposure to two measures of flammable fuel conditions (FUEL-BURN PROBABILITY and FUEL-CONDITIONAL FLAME LENGTH) (Table 1, Fig. 3). FUEL-BURN PROBABILITY and FUEL-CONDITIONAL FLAME LENGTH (Ager et al., 2012; Cruz and Alexander, 2010) were produced with the wildfire simulation model FSIM (Finney et al., 2011), which generates wildfire scenarios for many hypothetical wildfire seasons incorporating fire and weather history data and data about fuel loads from the national LANDFIRE data grid (Rollins, 2009). We incorporated the exposure variables following Fischer et al. (2013) and Olsen et al. (2017).

We operationalized the response appraisal construct using the two variables, PERCEIVED CAPACITY-PROBABILITY representing their perceptions of their capacities to reduce the probability of a wildfire igniting on their forestland, and PERCEIVED CAPACITY-SEVERITY, in recognition that forest owners may feel capable of influencing wildfire severity through thinning and other forest management practices even when they feel unable to control wildfire ignitions (e.g., from lightning, arson, or human negligence) (Table 1, Fig. 3).

To account for the beliefs construct, we created variables representing respondents' beliefs about environmental change, including belief in anthropogenic climate change (CLIMATE CHANGE BELIEF) and beliefs about wildfire trends (WILDFIRE BELIEF-DAMAGE, −FREQUENCY, −SIZE, and −SEASON) (Table 1, Fig. 3). To account for the influence of social networks, we created a variable representing the breadth of information sources relevant to wildfire risk mitigation (INFORMATION NETWORK) (Table 1, Fig. 3).

We included several demographic variables: AGE, GENDER, EDUCATION, INCOME, PARCEL SIZE, and MANAGEMENT LENGTH to control for varying respondent characteristics (Table 1). We also included variables indicating respondents' parcel location within the North Cascades and Coast Range ecoregions (NCCR), Willamette Valley and Cascades ecoregions (WVWC), and the Klamath ecoregion (KLAM) to account for broad physiographic and climatic heterogeneity across the study region that can influence site productivity and wildfire hazard conditions on respondents' parcels and their propensities for active management (Table 1, Fig. 3).

We created the variable PAST BEHAVIOR to test for correlation between reported behavioral intentions and past behavior. We created the variable LIMITATIONS to account for constraints that owners reported facing in their efforts to mitigate wildfire risk on their parcels. A reliability analysis of these factors, rated on a 5-point Likert scale from "No limitation" to "Severe limitation," yielded a Cronbach's alpha of 0.7816, indicating good internal consistency. We collapsed the scale variables into binary variables to indicate whether any factors presented at least some level of limitation (Table 1, Fig. 3).

3.6. Data analysis

We developed a two-staged regression model as an empirical representation of our conceptual model (Fig. 1) to examine the potential influence that various explanatory variables might have on both response variables, RISK PERCEPTION and PLANNED RISK

Table 2
Estimated explanatory variable coefficients of regression models describing wildfire risk perception and planned risk mitigation activities. Categories of variables are indicated by italic font and constructs are bolded.

Variables	RISK PERCEPTION LOGIT				PLANNED RISK MITIGATION			
	Estimated Coef.	Std. Err.	95% Confidence Interval		Estimated Coef.	Std. Err.	95% Confidence Interval	
			Lower	Upper			Lower	Upper
Risk appraisal								
RISK PERCEPTION LOGIT	–	–			1.094 *	0.616	−0.114	2.302
Behavioral Intention								
PLANNED RISK MITIGATION	–	–			–	–		
Wildfire hazard experience								
FUEL-BURN PROBABILITY	−6.091	18.405	−42.226	30.044	–	–		
FUEL-CONDITIONAL FLAME LENGTH	0.196 **	0.08	0.039	0.354	–	–		
SMOKE	0.085	0.265	−0.436	0.605	–	–		
NEIGHBORING BURN	1.132 ***	0.305	0.533	1.732	–	–		
PARCEL BURN	−0.043	0.65	−1.319	1.233	–	–		
STRUCTURE BURN	2.328	1.582	−0.778	5.434	–	–		
Beliefs about environmental change								
CLIMATE CHANGE BELIEF	0.244 **	0.097	0.053	0.434	0.147 *	0.086	−0.022	0.315
WILDFIRE BELIEF-FREQUENCY	−0.431	0.435	−1.285	0.423	–	–		
WILDFIRE BELIEF-DAMAGE	0.044	0.474	−0.886	0.975	–	–		
WILDFIRE BELIEF-SEASON	1.132 ***	0.37	0.406	1.857	–	–		
WILDFIRE BELIEF-SIZE	1.026 ***	0.38	0.280	1.772	–	–		
Social networks								
INFORMATION NETWORK	0.19 ***	0.064	0.064	0.315	0.101 *	0.052	−0.001	0.203
Response appraisal								
PERCEIVED CAPACITY- PROBABILITY	–	–			−0.019	0.288	−0.583	0.546
PERCEIVED CAPACITY- SEVERITY	–	–			1.143 ***	0.368	0.422	1.863
Control variables								
PAST RISK MITIGATION	–	–			1.06 ***	0.192	0.683	1.438
LIMITATIONS	–	–			0.643 ***	0.186	0.279	1.007
PARCEL SIZE	0.0002	0.001	−0.001	0.002	0.0005	0.001	−0.001	0.001
MANAGEMENT LENGTH	0.021 ***	0.008	0.005	0.036	−0.014 **	0.007	−0.028	0.000
AGE	−0.043 ***	0.012	−0.066	−0.020	−0.004	0.01	−0.023	0.015
GENDER	0.214	0.256	−0.29	0.717	−0.074	0.201	−0.467	0.319
EDUCATION	−0.634 **	0.262	−1.149	−0.12	0.138	0.215	−0.283	0.559
INCOME	−0.138	0.241	−0.612	0.336	−0.469 **	0.191	−0.844	−0.094
WVWC	0.167	0.247	−0.318	0.652	0.004	0.202	−0.391	0.400
KLAM	1.303 **	0.568	0.187	2.419	−0.292	0.348	−0.974	0.390
Constant	−2.391 ***	0.849	−4.058	−0.724	−2.845 ***	0.703	−4.224	−1.466
Model statistics:	N = 726; F = 9.40; P < 0.01; R^2 = 0.22				N = 726; Chi-sq = 118; P < 0.01; Pseudo R^2 = 0.15			
Note: *** p < 0.01, ** p < 0.05, * p < 0.10								

MITIGATION. We used a two-stage regression model because our RISK PERCEPTION variable is endogenous within the decision system described by our conceptual framework (see, for example, Olsen et al. 2017). The first equation characterized survey respondents' perception of the likelihood of a wildfire occurring on their parcel (RISK PERCEPTION LOGIT), and the second equation characterized survey respondents' planned risk mitigation behavior (PLANNED RISK MITIGATION). We estimated the RISK PERCEPTION equation as a logistic regression model as a function of several explanatory variables, including respondents' direct experiences with wildfire, exposure to wildfire hazard, beliefs about wildfire hazard trends and climate change, information networks, and other variables (Fig. 3). We estimated the PLANNED RISK MITIGATION as a logit model, with explanatory variables including predicted values for each respondent from the RISK PERCEPTION equation, as well as variables describing respondents' wildfire risk response appraisal, climate change belief, and information network variables, and other non-theoretical variables (Fig. 3). We estimated the two-stage regression model with Stata 17.0 (StataCorp, 2021). We also conducted a detailed sensitivity analysis to evaluate the magnitude of the impact of each explanatory variable on the predicted values of risk perception and planned risk mitigation behavior.

4. Results

4.1. Sample characteristics

Our final sample consisted mostly of males, those of retirement age, who were educated, and middle-income earners (Table 1). Respondents were slightly older, more educated, and wealthier than the average family forest owner in the US West (B. J. Butler et al., 2016a,b). Seventy-six percent of respondents reported living on the parcel referenced in the survey, similar to the proportion of family forest owners who live on or within a mile of their ownerships in the region (Butler et al., 2021). Their parcels ranged from 4 to 890 ha, with a 26-ha mean—smaller than the Oregon average (38 ha) and larger than the Washington average (17 ha) (Butler et al., 2021). Respondents were involved in the management of their parcel for 26 years, on average, similar to family forest owners reported by Butler et al. (2021). The sample was well distributed across the ecological regions of the study area and the PNW, with 67% of respondents in Oregon and 33% in Washington. See Tables S1–S4 and Figs. S1 & S2 for summary statistics of all variables.

4.2. Regression analysis

4.2.1. Wildfire risk perception model

The estimated equation for RISK PERCEPTION LOGIT was statistically significant ($F = 9.40$, $P < 0.01$, adjusted R^2 0.22, Table 2). As expected, RISK PERCEPTION (mean 26%, Table S1) was correlated with direct experiences with wildfire hazard. Specifically, experiencing a wildfire on a neighboring property (NEIGHBORING BURN) (21% of respondents) was positively and strongly correlated with RISK PERCEPTION LOGIT. Other direct experience variables were not associated, including SMOKE EXPERIENCE (perhaps because most respondents—69%—had experienced it) and PARCEL BURN and STRUCTURE BURN (perhaps because so few respondents had experienced these—5% and < 1%, respectively (S2). Respondents' exposure to wildfire hazard, specifically FUEL-CONDITIONAL FLAME LENGTH, was also correlated with RISK PERCEPTION LOGIT (Table 2).

Respondents' beliefs that wildfires were becoming bigger (WILDFIRE BELIEF-SIZE) (70% of respondents), and that wildfire seasons were becoming longer (WILDFIRE BELIEF-SEASON) (80% of respondents) were positively and strongly correlated with RISK PERCEPTION LOGIT. Whether respondents believed the frequency of, or damage from, wildfires was increasing in their area, however, was not significant (Table 2), even though 67% reported these trends (Table 1). Respondents' perceptions of the chance of wildfire burning on their parcels were also positively and strongly correlated with CLIMATE CHANGE BELIEF (Table 2). Most respondents believed the climate was changing, human activities were the leading cause of climate change, and climate change was exacerbating wildfire hazard (S3).

Respondents' perceptions of the chance of wildfire burning on their parcels were also positively and strongly correlated with their INFORMATION NETWORK (Table 2). While about one-quarter of respondents did not report seeking information, many respondents sought such information from more than one source, with the most common sources being fire departments, fire protection districts, and natural resource and forestry agencies (S3).

Several demographic variables were associated with respondents' wildfire risk perceptions. AGE and EDUCATION were negatively and strongly associated with risk perception, indicating that younger and less educated owners perceived a greater chance of a fire burning on their parcel. We suspect that younger owners may be more receptive to information about wildfire risk, and less educated owners may more often manage for timber, making them concerned about potential losses to their assets. Respondents who were involved with the management of their property for longer periods (MANAGEMENT LENGTH) perceived greater risk. Location in the Klamath Ecoregion (KLAM) relative to the base case North Cascades and Coast Range ecoregions (NCCR) was also associated with greater wildfire risk perception, as expected given that fires are more common in the Klamath ecoregion (Table 2). Location in the Willamette Valley and western Cascades ecoregions (WVWC) was not associated with greater wildfire risk perception than location in the North Cascades and Coast Range ecoregions (NCCR), the base case, suggesting that wildfire risk perceptions do not vary greatly in these ecological areas (Table 2).

4.2.2. Planned wildfire risk mitigation model

The estimated equation for PLANNED RISK MITIGATION was statistically significant, Chi-squared = 117.95, $P < 0.01$, and Pseudo $R^2 = 0.15$. (Table 2). As expected, RISK PERCEPTION LOGIT was positively, albeit moderately, correlated with their intentions to undertake at least one of the eight practices we asked about (Table 2) (32% of the sample, S4, Table 1). PLANNED RISK MITIGATION was positively and strongly correlated with PAST RISK MITIGATION (Table 2), which approximately one-third of respondents had done (Table 1). The most common practices were removing brush and understory vegetation, creating and maintaining fuel breaks, removing dead trees, and thinning stands (S4). As expected, CLIMATE CHANGE BELIEF was positively and moderately correlated with PLANNED RISK MITIGATION. INFORMATION NETWORK was also positively and moderately correlated with PLANNED RISK MITIGATION, also as expected (Table 2).

As expected, whether an owner believed how they manage their forest could affect wildfire damage (PERCEIVED CAPACITY-SEVERITY) was positively and strongly correlated with PLANNED RISK MITIGATION. Whether an owner believed how they manage their forest could affect wildfire probability (PERCEIVED CAPACITY-PROBABILITY) was not significant (Table 2). Respondents' appraisals of their ability to mitigate wildfire risk were surprisingly high given their lack of experience with wildfire, especially on their parcels, with most respondents believing they could affect wildfire probability and severity (Table 1).

Several demographic variables were also associated with owners' behavioral intentions. MANAGEMENT LENGTH and INCOME were negatively and strongly correlated with PLANNED RISK MITIGATION (Table 2), indicating that less wealthy owners and owners who have been involved in the management of their property for less time are more likely to intend to undertake wildfire risk mitigation practices. Having faced LIMITATIONS in efforts to reduce wildfire risk was positively and strongly correlated with PLANNED RISK MITIGATION (Table 2), perhaps an indication that owners who had been frustrated in past mitigation efforts were even more motivated to mitigate wildfire risk in the future. Location in the Klamath Ecoregion (KLAM) or the Willamette Valley and western Cascades ecoregions (WVWC) were not associated with greater intentions to mitigate risk relative to the base case North Cascades and Coast Range ecoregions (NCCR), suggesting that physiographic context's influence on behavioral intention likely operated through risk appraisal (Table 2).

4.2.3. Sensitivity analysis

We conducted a sensitivity analysis of our regression equations to illustrate the magnitude of impacts that individual explanatory variables have on each of the dependent variables. Our sensitivity analysis of explanatory variables indicated that both RISK PERCEPTION and the likelihood of PLANNED RISK MITIGATION were fairly sensitive to several explanatory variables found to be statistically significant in our estimated models. For example, respondents who had reported experiencing a wildfire on a neighboring parcel (NEIGHBORING BURN = 1) on average perceived a 37% likelihood (0.371) of a wildfire starting on or spreading onto their parcel from a neighboring property in the next five years, whereas respondents who had not reported such an experience perceived a 16% likelihood of a wildfire starting on or spreading onto their parcel from a neighboring property. Similar effects can be seen for other explanatory variables in the risk perception equation, including CLIMATE CHANGE BELIEF, INFORMATION NETWORK, WILDFIRE BELIEF-SEASON, WILDFIRE BELIEF-DAMAGE, MANAGEMENT LENGTH, and EDUCATION. RISK PERCEPTION also appeared to be notably correlated with FUEL-CONDITIONAL FLAME LENGTH, with respondents perceiving a 12% likelihood (0.125) of a wildfire starting on or spreading onto their parcel from a neighboring property in the next five years at the minimum conditional flame length present in the sample, and a 50% likelihood (0.488) at the maximum conditional flame length present in the sample. Respondents located within the Klamath ecoregion (KLAM), with its historically warmer and drier conditions, on average perceived a 41% likelihood of a wildfire starting on or spreading onto their parcel from a neighboring property, while respondents located outside the Klamath ecoregion on average perceived just a 16% (0.160) likelihood of such a fire in the next five years.

Similarly, for PLANNED RISK MITIGATION, our sensitivity analysis indicated that the explanatory variables found to be statistically significant in the planned risk mitigation equation influenced respondents' reported likelihood that they planned to undertake risk mitigation actions in the next ten years. These explanatory variables included CLIMATE CHANGE BELIEF, INFORMATION NETWORK, PERCEIVED CAPACITY-SEVERITY, LIMITATIONS, MANAGEMENT LENGTH, and INCOME. Our sensitivity analysis indicated that the influence of RISK PERCEPTION was to increase PLANNED RISK MITIGATION from a likelihood of 23% (0.233) for respondents perceiving the lowest wildfire risk among our sample, to 46% (0.465) for respondents perceiving the highest wildfire risk among our sample. Past risk mitigation behavior (PAST RISK MITIGATION) also appeared to influence planned risk mitigation behavior, with respondents who reported no past risk mitigation activities on average reporting a 20% (0.197) likelihood of planned future activities, and respondents who reported the most past risk mitigation activities reporting a 41% (0.415) likelihood of future risk mitigation activities.

5. Discussion

5.1. Summary of findings

We investigated the influence of family forest owners' wildfire hazard experiences, beliefs about environmental change, and information networks on their risk perceptions and intended responses to changing wildfire hazard conditions. We found that family forest owners who had experienced a wildfire nearby perceived a greater risk of a wildfire occurring on their property, as did owners whose parcels were more exposed to wildfire hazard conditions (Research Question 1). Forest owners who believed that human activities were the leading cause of climate change and that wildfires were becoming more severe and wildfire seasons were becoming longer also perceived greater wildfire risk (Research Question Q2), as did owners with broader information networks (Research Question Q3). Although not a question of theoretical interest, we also found that owners holding stronger beliefs in anthropogenic climate change were more likely to intend to reduce risk, as were owners with broader information networks. Finally, we found that owners were more likely to intend to undertake risk mitigation activities when they had greater wildfire risk perception and perceived capacity to reduce risk (Research Question 4). These findings are notable because they suggest that individuals rely on their experiences as well as their beliefs and information gained through their networks to perceive risk and make decisions to protect themselves from natural hazards even in the context of changing hazard conditions.

5.2. Relationship with literature

Our findings support the relevance of psychosocial models of behavior based on the PMT for changing hazard conditions and suggest that both experiential learning and social construction are important to people's behavior in dynamic natural hazard environments. In the western PNW, where wildfires are becoming more common even in ecoregional areas that historically experienced wildfires only rarely, family forest owners' wildfire hazard experiences were positively associated with their wildfire risk perceptions, and their risk perceptions were positively associated with their intentions to undertake risk mitigation activities. This provides evidence of experiential processing. Additionally, the positive associations between owners' risk perceptions and their beliefs in anthropogenic climate change, beliefs that wildfire hazards were getting worse, and having broad information networks, and between owners' risk perceptions and risk mitigation intentions, provide evidence of social construction.

5.2.1. Risk appraisal and response appraisal as influences on risk mitigation

Our findings that family forest owners are more likely to intend to mitigate wildfire risk on their parcels when they perceive greater risk and greater capacity to reduce risk align with other literature. Risk appraisal and response appraisal are well-recognized influences on risk mitigation behavior (Ajzen, 1991; Grothmann and Patt, 2005; Paton, 2003; Rogers, 1975). Additionally, our finding that response appraisal exhibited a larger influence on behavior than risk appraisal was consistent with other studies (e.g., Floyd et al., 2000; Koerth et al., 2013; Milne et al., 2000; Truelove et al., 2015; Zheng and Dallimer, 2016), although risk appraisal was still influential. Notably, a large proportion (81%) of owners believed that how they manage their forests could reduce damage from wildfire (i.e., had high response appraisal). When individuals have limited prior experience with hazards, they typically have limited opportunity to learn how to manage associated risks and therefore may not perceive they have sufficient knowledge and skills to manage the risk (Winter and Fried, 2000). Our findings about the high level of response appraisal and its influence on behavioral intention may reflect the uniqueness of our population. Despite not having extensive experience with wildfire, many family forest owners have forest management knowledge and skills that are relevant for wildfire risk mitigation. Indeed, forest owners who had longer involvement in the management of their forests were more likely to intend to engage in wildfire risk reduction, arguably because they had the opportunity to develop forest management knowledge and skills.

5.2.2. Experiential processing

Our finding that experiencing a wildfire on a neighboring property was positively associated with forest owners' perceptions of wildfire risk on one's own parcel is consistent with other studies that find that experience of natural hazard events can be positively associated with risk perception even in an observational stage where direct physical impacts or losses are not experienced (Aslan et al., 2024; Bronfman et al., 2020; Cutler, 2015; Kellens et al., 2013; Lindell and Perry, 2012; Risbey et al., 1999). This finding is also consistent with other research suggesting that observing natural hazards through the experiences of others contributes to risk perception (McCaffrey, 2002). A mechanism for this effect of experience may be increased salience, resulting from the availability heuristic (Tversky and Kahneman, 1973) and, relatedly, reduced cognitive distance (Gifford, 2011; Liberman et al., 2007; McDonald et al., 2015; Reser and Swim, 2011; Trope and Liberman, 2010).

Our finding that experiencing loss or damage to a home or building from a wildfire was not positively associated with the perceived wildfire risk on one's parcel may have been due to the small proportion of survey respondents (~2.0%) who had experienced such impacts from wildfires on their properties. Other research on disasters and extreme events such as Weber et al. (2018) and Bronfman et al. (2020) has found that experience with disaster impacts—including personal harm or material loss during the disaster—is positively associated with preparedness behaviors, resulting from increased risk perception and increased self-efficacy gained through experience with risk mitigation.

Additionally, our finding that forest owners' risk perceptions were associated with exposure to wildfire hazard conditions reflects the findings of other studies that experiencing natural hazard events is not required for risk perception; awareness of exposure may be sufficient (Brody et al., 2008; Fischer et al., 2013; Olsen et al., 2017). This finding may suggest that some family forest owners are attuned to wildfire hazard on their properties, even in geographic areas where wildfires are uncommon. Admittedly, family forest owners may be unique. Owning forestland creates the opportunity to observe hazardous conditions and the motivation to mitigate risks to assets, especially if they live on, visit, or actively manage their parcels, and if the forest is valuable.

Nevertheless, owners of forest parcels in the Willamette Valley and Western Cascades (WVWC) ecoregions, where several large wildfires occurred the year before the survey, did not perceive more risk than owners of parcels in the Northern Cascades and Coast Range (NCCR) ecoregions, where such fires did not occur. This was despite having more wildfire experiences—25% of WVWC owners experienced a fire on a neighboring property compared to only 14% of NCCR owners (S1). In the more fire-prone Klamath (KLAM) ecoregion, on the other hand, where 29% of respondents had experienced a fire nearby, respondents did perceive greater wildfire risk than owners of parcels in the NCCR ecoregion. The lack of a greater association between risk perception and location in WVWC as compared to NCCR may be explained by cognitive biases that work against risk perception in the context of extreme or novel hazards. Even once experienced, people often assume that rare or uncharacteristic events are unlikely to happen again (i.e., the gambler's fallacy) (Burton et al., 1993; Tversky and Kahneman, 1974).

5.2.3. Social construction

Our finding that family forest owners' perceptions of wildfire risk on their parcels was associated with their beliefs in anthropogenic climate change and wildfire trends was consistent with the theory of social construction and other research on the influence of prior beliefs on risk perception (Reser et al., 2014; Reser and Swim, 2011). Preexisting belief in climate change amplifies natural hazard risk perceptions according to some studies (van Valkengoed et al., 2024). Regardless of their direct experience with wildfires, owners who believe in anthropogenic climate change may also believe that climate change makes wildfires worse (62.5% of our survey respondents agreed with this statement (S2)), and, more specifically, that hotter conditions increase the flammability of vegetation. Similarly, owners who believe that wildfires are becoming worse in their area perceive a greater probability of a wildfire on their parcels, regardless of their direct experiences with wildfire.

Relatedly, our finding that forest owners who believed in anthropogenic climate change were more likely to intend risk mitigation, accounting for risk perception, is consistent with other research findings that belief in anthropogenic climate change is associated with risk mitigation and protective action behavior (Arbuckle et al., 2013; Osberghaus and Fugger, 2022; van Valkengoed et al., 2024; van Valkengoed and Steg, 2019) Again, preexisting belief in climate change may amplify risk perception and the effect of risk perception on behavioral intention (van Valkengoed et al., 2024).

Our finding that forest owners with larger information networks were more likely to intend to mitigate risk is consistent with other research about the positive association between information-seeking and risk mitigation behavior (Mileti and Fitzpatrick, 1992) and between bridging capital, risk perception, and risk mitigation behavior (Paton, 2008). In our study context, where wildfire hazard conditions are changing, owners who sought information about wildfire and forestry from more sources may have had greater awareness about wildfire risk, in general, and the benefits of mitigating risk.

5.3. Unique contributions to the literature

Our study contributes to the research literature on natural hazard risk perception and risk mitigation behavior by taking a nuanced approach to investigating experience as an influence on risk perception and behavior. We break experience into two constructs to account for experiential processing: direct experience of various types of wildfire hazard events and exposure to wildfire hazard conditions (i.e., flammable fuel). This enables us to investigate whether owners respond to environmental cues requiring deliberate observation (i.e., hazardous vegetation conditions on their parcels that could fuel wildfires) and environmental cues that one can readily observe (wildfire events on their own properties or neighboring properties). Our use of objective measures of wildfire hazard demonstrates the potential for using measures of experience other than self-reported observations of conditions and events (Lindell and Perry, 2012; Risbey et al., 1999) or objective measures of direct physical experience and material impacts (Cutler, 2015; Demski et al., 2017; Lujala et al., 2015; van der Linden, 2015; Xia, 2024; Zanocco et al., 2018; Zhang, 2022). We also accounted for physiographic context, recognizing that people's wildfire experiences, risk perceptions, and risk mitigation behavior will vary with local ecological conditions, including wildfire regimes.

We also introduce a nuanced approach to measuring response appraisal, separating the perceived capacity to reduce the probability of a wildfire from the perceived capacity to reduce the severity of consequences. This is important for the study of extreme or novel events, resulting from an unusual combination of exogenous and uncontrollable factors. Nevertheless, with proper preparation, their damages can be mitigated to some extent. With extreme wildfires, often ignited by lightning or accidental sparks and fueled by wind and hot, dry weather, thinning to reduce flammable fuel or creating defensible space around property lines or structures can reduce damages. Similarly, extreme floods result from weather events, but impacts on individual properties can be mitigated by planting vegetation to control erosion, modifying riverbanks, and relocating or elevating structures. Distinguishing between the probability and severity of consequences of extreme events creates the possibility for more rigorous studies of risk perception and response.

Our variable regarding forest owners' information networks is also novel. While many studies account for whether people obtain information and advice from experts, we focus on the number of sources, recognizing the substantial theoretical and empirical research on the influence of social networks and bridging capital. Including a variable indicating the size and diversity of owners' information sources, we account for the richness of information that may go into their decision-making processes, a mechanism for knowledge and awareness, and motivated reasoning.

5.4. Limitations and recommendations for further research

It is worth considering several potential limitations posed by the timing of our study and how we operationalized some of the constructs. The 2020 wildfires presented an opportunity to study people's risk perceptions and intended responses to changing wildfire hazard conditions, including extreme events. However, without data regarding family forest owners' risk perceptions and behavioral intentions prior to the 2020 wildfires, we lack baseline data regarding their risk and response appraisals and behaviors. Expanding the study with a panel would enable us to determine whether respondents' risk perceptions and risk mitigation intentions were the result of short-term saliency and recency effects or a result of more durable responses to changes in their wildfire experiences, wildfire hazard exposures, beliefs in climate change, and local wildfire trends.

While our survey included questions about the second dimension of risk appraisal, perceived severity of consequences (Paton, 2003; Rogers, 1975), our focus was on the potential for loss of and damage to homes and outbuildings on the property. Incorporating this variable would have reduced the sample size dramatically because a much smaller proportion of our respondents had such structures on their properties than we expected; therefore, we omitted it. Regarding response appraisal, our survey questions focused on the distinction between owners' perceived capacity to influence the probability and severity of wildfires on their parcels rather than distinguishing between response efficacy and self-efficacy. Consequently, our variables do not capture the response appraisal construct as comprehensively as we would have liked.

6. Conclusion

As wildfires, heat waves, floods, and other natural hazards become more frequent, severe, and damaging under climate change, people face decisions about protecting themselves and their assets from risks they may be familiar with but have limited prior experience with, particularly in the locations where they live. Policy makers would benefit from a better understanding of the relative influence of people's experiences with changing hazard conditions, even if limited, on their risk perceptions and risk mitigation behaviors versus the influence of their beliefs and knowledge gained through their information networks. This understanding of the relative influence of experiential processing and social construction would shed light on the role of public policy in helping people adapt to changing natural hazard conditions, e.g., by helping them become more sensitive to signals from the environment or amplifying risk perception through social processes.

Focusing on the western Pacific Northwest, known for its wet climate more conducive to temperate rainforests than wildfires, we explored the influence of wildfire hazard experience, beliefs about environmental change, and social networks on family forest owners' wildfire risk perceptions and risk mitigation intentions in the aftermath of the historic 2020 wildfire season. Despite the dynamic nature of wildfire hazard in the western Pacific Northwest, we found that forest owners' wildfire experiences and beliefs about climate change and wildfire trends were positively associated with their risk perceptions. Moreover, their exposure to hazardous fuel conditions on their parcels was associated with their risk perceptions, indicating that they paid attention to environmental cues regarding wildfire hazard. Owners' risk perceptions and their perceived capacity to reduce risk were positively associated with their intentions to undertake wildfire risk mitigation on their properties. Our findings support the utility of behavioral frameworks based on the Protection Motivation Theory even in the context of changing natural hazard conditions, where people must adapt to natural hazards with which they have limited prior experience. Our findings also suggest that, even with limited experience, people can be sensitive to environmental signals indicating risk. An extension of these findings is that people may draw on their experiences, beliefs, and social networks when adapting to dynamic natural hazards, which are increasingly expected under climate change.

CRediT authorship contribution statement

Alexandra Paige Fischer: Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Mahmood Muttaqee:** Writing – review & editing, Formal analysis. **Riva C.H. Denny:** Writing – review & editing, Data curation. **Jeffrey D. Kline:** Writing – review & editing, Validation, Supervision, Formal analysis.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.crm.2026.100795.

Data availability

Data will be made available on request.

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