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Climate change beliefs and hazard mitigation behaviors: homeowners and wildfire risk

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Downscaled climate models provide projections of how climate change may exacerbate the local impacts of natural hazards. The extent to which people facing exacerbated hazard conditions understand or respond to climate-related changes to local hazards has been largely overlooked. In this article, we examine the relationships among climate change beliefs, environmental beliefs, and hazard mitigation actions in the context of wildfire, a natural hazard projected to be intensified by climate change. We find that survey respondents are situated across a continuum between being 'believers' and 'deniers' that is multidimensional. Placement on this believer–denier spectrum is related to general environmental attitudes. We fail, however, to find a relationship between climate change beliefs and wildfire risk-reduction actions in general. In contrast, we find a statistically significant positive relationship between level of wildfire risk mitigation and being a climate denier. Further, certain pro-environmental attitudes are found to have a statistically significant negative association with the level of wildfire risk mitigation.

Keywords: hazard mitigation; climate change beliefs; wildfire risk; homeowners; environmental beliefs

Introduction

Climate change is expected to increase the scale and scope of the impacts of many natural hazards on local populations (IPCC Fifth Assessment Report Working Group II, 2014; NCA, 2014). For example, changes in temperature and precipitation are expected to increase the likelihood and severity of wildfires in the western USA (Liu, Wimberly, Lamsal, Sohl, & Hawbaker, 2015; Westerling, Hidalgo, Cayan, & Swetnam, 2006). Research on hazard mitigation consistently demonstrates the importance of social factors over hazard-specific factors as determinants of behavioral outcomes (Tierney, Lindell, & Perry, 2011). However, little is known about the relationships among climate change beliefs, environmental beliefs, and hazard mitigation actions: must individuals 'believe' in climate change and its effects in order to take action to reduce locally experienced hazards? The answer to this question can inform whether programs intended to encourage individuals to mitigate the risk of locally occurring natural hazards should focus on climate aspects of the problem, or whether such focus might be counterproductive.

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Although climate change is occurring at a global scale, related impacts are experienced locally. Downscaled global circulation models that project changes in future climate conditions at local and regional scales sharpen the focus on climate change-related impacts to human systems (IPCC Fifth Assessment Report WGII AR5, 2014; National Climate Assessment, 2014). For populations already facing natural hazards, climate change exacerbations may influence the extent to which short- and longer-term self-protective measures are needed. And while much research demonstrates physical links between climate conditions and hazard events, less research examines analogous links in social systems such as how individuals' understandings and beliefs related to the environment in general, and climate change specifically, relate to actions they undertake to reduce the impacts of local natural hazards.

Climate change social science has long sought to document and assess public perceptions of climate science and the climate-changed future (Leiserowitz, 2005; Lorenzoni & Pidgeon, 2006). Research in this area explores trends and fluctuations in the public's climate change beliefs including the certainty of and the scientific consensus on climate science (Leiserowitz, Maibach, Roser-Renouf, & Hmielowski, 2012; Nisbet & Myers, 2007). A main finding is that skepticism in climate change remains prevalent in the USA; the 2014 Gallup poll reported that one in four Americans are 'skeptical' of climate change (Gallup, 2014). Related research assesses public willingness to support climate change mitigation through legislation, policy, and planning. Perhaps not surprisingly, people who believe that climate change is human-induced tend to be more supportive of climate change mitigation actions than those who do not (Akter, Bennett, & Ward, 2012). Likewise, individuals reporting higher levels of concern report higher levels of behavioral change related to climate change including reducing energy usage and gasoline consumption (Semenza et al., 2008). Less research attention, however, has been paid to public support for actions associated with reducing adverse local impacts related to climate change. While it may be imperative that the public understand climate change in order to garner public support for policies and programs for mitigating anthropogenic climate change, it is not a priori clear that 'belief' in climate change is a prerequisite to individual hazard mitigation behavior in response to natural hazards that are exacerbated by climate change. Indeed, considering the politicization of the climate change debate and significant portions of the population who do not accept climate science it is possible that framing hazard mitigation as climate adaptation could discourage hazard mitigation behaviors, especially among those who are climate change deniers.

In this article, we examine survey data from homeowners living in the wildland–urban interface (WUI) – the place where natural and human-made fuels for wildfire (e.g. homes) intermix (Radeloff et al., 2005; United States Department of Agriculture [USDA], 2001) – within a part of the US state of Colorado. The WUI is the area where wildfire hazards are most acutely felt, as it represents the zone where human lives and properties face the greatest likelihood of losses due to wildfire. We examine these data for insight into whether conceptually linking hazard mitigation to climate change is likely to encourage wildfire risk mitigation behaviors. Specifically, we explore beliefs about wildfire risk and climate change among studied homeowners at risk of facing climate-exacerbated wildfire risk and ask: Are those at risk attuned to the climate change aspects of the natural hazard they face (i.e. that their risk will increase over time)? Is there a relationship between climate change or climate-fire beliefs and wildfire risk mitigation behavior? For further insight, we also investigate the relationships between general environmental attitudes and climate beliefs and wildfire risk mitigation behavior.

Background

Exploring human behavioral responses at the intersection of natural hazards and climate change exacerbations brings together a broad range of literatures. In order to orient this exploration, we

provide background by briefly reviewing the literature on forests, wildfire that affects human developments, and climate change, and then we clarify our use of the term *mitigation* for the purposes of this paper.

Forests, wildfire at the WUI, and climate change

Land-use history has often been cited as a major contributor to the current wildfire dilemma including increased development of the WUI and the exclusion of fire, particularly in the areas where fire puts populations at risk (Moritz et al., 2014). However, research on climate change and wildfire risk also indicates that 'the broad-scale increase in wildfire frequency across the western United States has been driven primarily by sensitivity of fire regimes to recent changes in climate over a relatively large area' (Westerling et al., 2006).

Research on global wildfire potential finds that significant increases in fire potential in the USA are related to warming (Liu, Stanturf, & Goodrick, 2010). Summaries of historical records of fires demonstrate 'an order of magnitude increase in the annual number of fires' from 1970 to 2006 (Litschert, Brown, & Theobald, 2012). Climate models suggest that this pattern is likely to continue as changes in temperature, humidity, and the timing of precipitation and snow melt will likely lengthen and intensify the fire season (Westerling et al., 2006). Further, Liu et al. (2015) recently projected that fire regime change will have a stronger influence on increases in the amount of burning that will likely be experienced along the Front Range of the Rocky Mountains in the state of Colorado (USA) than will the influx of individuals living in this area.

Research demonstrates the need for natural hazard and natural resource management to account for a climate-changed future, including effects that manifest at small scales (Colorado State Forest Service, 2009a, 2009b, 2010; Melillo, Terese, Richmond, & Yohe, 2014). Climate change-exacerbated environmental conditions will affect public land management related to pests, diseases, and species shifts (National Roadmap for Responding to Climate Change, 2011), water availability (Barnett et al., 2008; Georgakakos et al., 2014; Hamlet & Lettenmaier, 2007; Litschert et al., 2012), and fire risk (Westerling et al., 2006). Such research demonstrates the need for natural hazard and natural resource management to account for a climate-changed future that attends to the ways in which climate change effects manifest at smaller scales (Colorado State Forest Service, 2009a, 2009b, 2010; Melillo et al., 2014). Despite obstacles to climate-informed resource management, including sometimes static management paradigms; public/stakeholder acceptance; limits to funding that affect staffing and training; and ongoing science, research, and monitoring needs (Smith & Travis, 2010), evidence of steps toward this end is apparent (National Roadmap for Responding to Climate Change, 2011). Indeed, climate-informed management includes fuel reduction and fire suppression planning that incorporate climate forecasts (Corringham, Westerling, & Morehouse, 2008).

Collectively, these findings indicate that current and future forest management practices, particularly where human developments intermix with wildland fuels, must take into account a climate-changed future in order to restore and maintain healthy forest stocks (Westerling et al., 2006) and to promote resource management and disaster prevention and recovery (Liu et al., 2010).

Mitigation in climate and hazards research

Response to climate change-exacerbated natural hazards can occur along two pathways. *Mitigation* is a term that is used in both (1) climate change and (2) natural hazards literature, though used differently. To avoid confusion, we distinguish between the meanings of 'mitigation' as used in

both literatures, a distinction that reflects differences in orientation between the two research areas. Generally, *mitigation* refers to actions that seek to change the processes that contribute to creating a problem.

Climate research focuses on the dynamics of the global climate system. Direct human contributions on global greenhouse gas (GHG) cycles (e.g. industrial and vehicular emissions) are small relative to the size of natural flows but cumulatively have significant impacts on the balance of GHG in natural reservoirs like the atmosphere. These changes in the balance of GHG stocks contribute to changes in climate, which in turn alter the local environmental conditions that can exacerbate existing hazards. Accordingly, *mitigation* in this context refers to actions, such as changing consumption behaviors or energy policies that aim to change anthropogenic forcing of the climate system (e.g. IPCC Fifth Assessment Report WGII AR5, 2014; National Climate Assessment, 2014).

Hazards research, on the other hand, focuses on the confluence of biophysical processes and human systems that create hazards. It emphasizes the interactions and feedbacks across different types of processes that produce the circumstances that turn amoral natural variability into harmful-to-humans disasters. Accordingly, *mitigation* from the hazards perspective refers to actions that reduce the potential impact of hazards on people (National Research Council, 2006).

Though *mitigation* in both hazards and climate research reflects some aspects of risk reduction, the reduction of impacts to people occurs only indirectly in the climate arena, by reducing human influence on the global climate system. In contrast, mitigation in the hazards arena focuses on reducing not only the likelihood and severity but also the consequences of potential hazard events, which may or may not be exacerbated by climate-related changes to the environment. Thus, the intersection of the two approaches occurs where climate-related environmental changes influence the likelihood or severity of hazards.

Literature review

Climate change beliefs and hazard mitigation

Most of the research on public perceptions of climate change has focused on climate change beliefs. An ongoing project to track American's climate beliefs and attitudes found that 66% of Americans believe that global warming is happening, though less than half (46%) believe that it is mostly caused by human activities (Leiserowitz et al., 2012). In fact, only 35% of Americans believe that most scientists agree that global warming is happening and 41% believe there is a lot of disagreement among scientists (Leiserowitz et al., 2012).

A state-wide telephone survey in Colorado found that the majority of respondents (70%) indicated that they agree that 'global warming' is happening and 48% agree that 'if global warming is happening, it is caused mostly by human activities'. Half of Colorado respondents (50%) indicate that they believe that scientists disagree that global warming is happening while 41% indicate that they believe that scientists agree (Leiserowitz, Feinberg, Howe, & Rosenthal, 2013).

However, research offers limited insight into public understanding of *local* effects related to climate change, and as reviewed above, climate change will most acutely be felt by the American public through local effects, including exacerbated hazard events (e.g. more frequent or severe wildfires, longer fire seasons, higher storm surge, wider flood zones). For example, Leiserowitz et al. (2013) indicate that almost half (48%) of Colorado respondents indicate that 'they have personally experienced the effects of global warming', but the study did not ask participants to identify in what form those effects were experienced (Leiserowitz et al., 2013).

Two studies address the crossover between climate change beliefs, hazard impacts, and risk-reduction actions. Whitmarsh's (2008) comparison of residents who have and have not suffered

the effects of flooding and air pollution is one of the few studies that links climate change attitudes, hazard impacts, and risk-reduction actions. Whitmarsh found that:

> [r]espondents who believe the environment is delicate, resources are limited, and non-human life has intrinsic value are more likely to believe anthropogenic climate change is real, to consider it personally very important and threatening, and to be taking action in response to it. In this study, environmental values are the strongest predictor of personal importance, belief, and action; experience is only a more salient influence in the case of perceived threat from climate change. (p. 365)

In relation to wildfire risk, Schulte and Miller (2010) surveyed households in fire-prone areas and found that '[t]he most striking findings are that awareness of climate/weather impacts was high among these respondents even before the recent spike in media coverage on climate change'. This awareness, however, had distinctly different effects on risk perception, concern, and mitigation effort. Climate/weather impacts are positively related to risk perception and concern about wildfire. While many people list climate/weather impacts as mitigation motivation, this variable is only marginally significant as a determinant of high mitigation effort. Further, while Schulte and Miller's determinants of risk perception and concern relate primarily to climate change factors, 'the determinants of mitigation are related to other measures that are best characterized as tangible and community-oriented - amenities, influence of mitigation on neighboring lands, and community effort' (p. 432).

In other words, the little research examining this crossover appears to indicate two things: (1) broader environmental values play an important role in shaping action related to hazards (Whitmarsh, 2008) and (2) the primary determinates of hazard mitigation action are not climate-related beliefs but rather are local and contextually important factors (Schulte & Miller, 2010).

Politicization of climate debate

A recent edition of the *American Behavioral Scientist* (Dunlap, 2013) reviewed social science research of climate change denial and skepticism, and highlighted that plenty has been written in recent years about the varied beliefs. The issue editor, Dunlap, points out, ' … a significant portion of the American public remains ambivalent or unconcerned (Leiserowitz et al., 2012) and many policy makers, especially in the United States, deny the necessity of taking steps to reduce carbon emissions' (Brownstein, 2010).

Differences across demographic characteristics remain notable in studies on public opinion (Dunlap & McCright, 2010; McCright & Dunlap, 2011); however, differences in core values (e.g. individualistic, communitarian, or egalitarian) appear to 'explain disagreements in environmental-risk perceptions more completely than differences in gender, race, income, education level, political ideology, personality type, or any other individual characteristic' (Dunlap, 2013, p. 296). This is likely the result of the convergence of core values orientations (Kahan, 2010), sources of social influence (Dunlap, 2013, p. 296), and 'organized disinformation campaigns' (Dunlap, 2013, p. 692).

Debate that contrasts believers and deniers highlights political cleavages evident in many other controversial issues (e.g. abortion) and implicitly suggests that holding such climate beliefs (believer/denier) has specific implications. However, early work on factors related to willingness to take action to address climate change cautions that the simplistic comparison of 'believers' and 'nonbelievers' may obscure nuance in factors associated with willingness to address climate change (O'Connor, Bord, & Fisher, 1999).

While it is well reasoned that such beliefs have implications for climate change mitigation policy, it has yet to be determined whether or not such beliefs similarly have implications for

policies and practices intended to mitigate impacts from hazards exacerbated by climate change. Nor has it been established whether or not belief in anthropogenic climate change is required to move households or communities towards being more responsive to climate change-exacerbated hazards. There are accounts, however, that denial of climate change and its related impacts has driven local resistance to planning efforts intended to alleviate local flooding related to sea-level rise (Tierney, 2014), demonstrating that the link between climate change beliefs and hazard mitigation behaviors is important to address when public support and participation is required to reduce the likelihood or severity of potential impacts.

In other words, it appears that climate change beliefs are largely socially determined and research continues to demonstrate cleavages in beliefs. The implications of these cleavages on public support for climate mitigation constitute one important avenue of inquiry. Distinct, however, is the extent to which climate change beliefs are related to attitudes, beliefs, and behaviors to contend with climate change-exacerbated hazards.

Study context

In this study, we focus on the Front Range of the Colorado Rocky Mountains where forests are complex in topography, forest type, and conditions. As noted previously (Liu et al., 2010; Westerling et al., 2006), in addition to climate change and land management, wildfire risk is also exacerbated due to substantial development of and population growth in the WUI. Recent models suggest that future growth is likely to occur in areas with higher potential fire intensity and likelihood of crown fire (Platt, Schoennagel, Veblen, & Sherriff, 2011). The study area ranges from lower montane, where private properties mix and intermingle with forested lands and where management goals to restore forests to historical conditions and fire hazard mitigation goals converge (Sherriff, Platt, Veblen, Schoennagel, & Gartner, 2014), to higher-elevation ponderosa pine forests, where fire incidence more consistently reflects historical trends, and where thinning will not effectively prevent severe fires or 'return the fire regime to historical conditions' (Sherriff et al., 2014). In Colorado, the increased frequency of wildfires over the last 10 years has had an impact in terms of lives lost, houses and properties damaged or destroyed, and acres of private and public lands charred (State Task Force Report, 2013).

The WUI areas of the two Front Range counties included in this study, Larimer and Boulder, are ranked 3rd and 11th in the state for fire risk, respectively, based on the number of square miles of developed land (Gude, Rasker, & van den Noort, 2008; Headwaters Economics, 2013). The intersection of the increased social exposure to wildfire risk and climate change exacerbation of the hazard makes the examination of the relationship between climate change beliefs and hazard mitigation behavior opportune.

Data description

Sampling and recruitment

Data for this study were collected at two points of time. The first data collection effort was undertaken in 2007 in the fire-prone portions of two Colorado Front Range counties. Using geo-coded data from Boulder and Larimer County Assessor's Offices, fire hazard maps were used to generate a sampling frame of private residential parcels in the counties fire-prone areas. A random sample of 3500 residents was sent an invitation to complete a paper survey by mail or an electronic survey online. A standard three mailing approach was used for recruitment (Dillman, 2000). The survey produced 421 observations in Boulder County and 326 observations in Larimer County or an overall response rate of 36%.

In September 2010, the Fourmile Canyon Fire burned through portions of the study area resulting in 169 homes lost and over 6400 acres burned. Two months after the fire, a follow-up survey was administered to previous study participants ($n = 747$) (***Brenkert-Smith, Champ, & Telligman, 2013a, 2013b; Champ & Brenkert-Smith, 2015; Nawrotski, Brenkert-Smith, Hunter, & Champ, 2013). Again, a standard three mailing approach was used for recruitment. Among those invited to participate via mail or Internet in the 2010 survey, 428 responded for an overall response rate of 64.5%.[1]

Survey description

The household survey administered included questions regarding wildfire risk beliefs and attitudes, sources of information about wildfire risk, neighbor and community interaction, environmental and climate beliefs, and wildfire mitigation behaviors undertaken (Brenkert-Smith, Champ, & Flores, 2012; Brenkert-Smith et al., 2013a, 2013b; Champ, Brenkert-Smith, & Flores, 2011a, 2011b).[2] The surveys were largely identical across the two years. However, there were two slight modifications between the years. First, the 2007 survey included a set of questions to assess participants' environmental attitudes (Dunlap, Van Liere, Mertig, & Jones, 2000). As values undergird environmental attitudes, they tend to be fairly stable (Schultz & Zelenzy, 1999); therefore, these questions were not included in the 2010 survey. This decision allowed a battery of climate statements to be added to the 2010 survey. The questions were developed to assess basic beliefs about climate change including the anthropogenic nature of climate change, scientific consensus on climate change, and perceptions of the relationship between climate change and wildfire. These two sets of statements and their relationships to reported wildfire risk mitigation behaviors are the primary focus of the data analyzed and presented here.

Descriptive statistics and analyses

In this section, we first describe responses to the environmental belief questions that were an adapted battery of New Ecological Paradigm (NEP) questions (Dunlap & Van Liere, 1978; Dunlap et al., 2000) and generation of a two-factor representation of the NEP variables. Next, we present descriptive statistics for responses to the climate questions and discuss their relationships with demographic variables. Then we construct a factor representation from the climate variables that demonstrates the multidimensionality of climate beliefs and suggests that they lie on a continuum, rather than exist as a dichotomy. After that, we investigate relationships between responses to climate questions and NEP factor variables. Finally, we use the NEP factor variables as proxies for environmental attitudes and examine to what extent climate change beliefs and environmental attitudes correlate with reported participation in wildfire risk mitigation actions.

Environmental attitudes and NEP measures

The NEP is a set of statements designed around five dimensions: (1) beliefs about humanity's ability to upset the balance of nature, (2) the existence of limits to growth, (3) anti-anthropocentrism, which is characterized as the rejection of exemptionalism, (4) anti-exemptionalism, which is 'the idea that humans – unlike other species – are exempt from the constraints of nature', and (5) ecocrisis which includes 'items focusing on the likelihood of potentially catastrophic environmental changes … besetting human kind' (Dunlap & Catton, 1994; Dunlap & Van Liere, 1978; Dunlap et al., 2000).

Due to survey space constraints, a truncated version of Dunlap et al. (2000) NEP statements was used that included 10, rather than 15, questions to capture respondents' environmental

attitudes. In order to ensure that each of the five dimensions was captured, two statements from each dimension were used to construct the battery of 10 statements (shown in Table 1). Limits to growth (nep1, nep5), anti-anthropocentrism (nep2, nep7), balance of nature (nep3, nep8), ecocrisis (nep4, nep10), and anti-exemptionalism (nep6, nep9) were measured with two statements each.

Table 1 shows descriptive results for the NEP statements organized from highest to lowest agreement. Results show that most respondents agree that humans are subject to the laws of nature (nep6), and the vast majority believe that the balance of nature is easily upset (nep8) and humans are severely abusing the environment (nep4). Likewise, most respondents agree that human interference with nature often results in disastrous consequences (nep3). Conversely, respondents had low agreement with statements about human's right to rule over nature (nep7) or to modify nature to suit their needs (nep2), and low agreement with the statement that humans will eventually learn enough to control nature (nep9).

Factor analysis was conducted to estimate the variance among the NEP variables. Table 1 also shows polychoric factor loadings[3] for a two-factor solution[4] for concisely describing the collective variation in responses to the NEP statements. The last three columns of the table show the factor loadings created from a two-factor solution (nep_ecocrisis and nep_exempt) and the remaining variation in each variable not represented by the two-factor solution (i.e. uniqueness). For each factor loading, positive scores correspond to that factor solution representing stronger agreement with the represented NEP question, negative to stronger disagreement, and 'zero' scores to the average level of represented agreement in the sample. Ex-post investigation of the patterns of factor loadings suggests that the first factor (nep_ecocrisis) represents an expectation of environmental catastrophe, as shown by the dominance of the 'ecocrisis' NEP questions in that factor, whereas the second factor (nep_exempt) represents a belief in the (rightful) power of humans over nature; we label the factors accordingly. Although the uniqueness statistics reflect that the two-factor solution ignores variation in each individual statement's responses, we use these factor scores as a concise representation of the dominant two dimensions of environmental attitudes in subsequent analysis.

Climate change beliefs

The first five columns of Table 2 show the text and descriptive results for the nine climate change statements.[5] Responses to the climate statements (Table 2) were provided on five-point Likert scales with 1 labeled 'strongly agree' and 5 labeled 'strongly disagree'. We recoded the Likert scales into indicator variables[6] such that 1 = agree (corresponding to reported values 1 [agree] & 2 [strongly agree]) and 0 = do not agree (corresponding to reported values –2 [strongly disagree], –1 [disagree], or 0 [neutral]) (see Table 3 and the 'Agree' column of Table 2). Overall, we see a strong agreement that climate change is real, anthropogenic, and that there is scientific consensus about both. We see a small portion of 'climate change deniers' who believe climate change is a hoax (rclimate3; 10.7%) or are skeptical about the existence of climate change (rclimate4; 14.5%). We see the overall agreement that climate change has increased Colorado wildfire risk (rclimate6; 54.9%), less agreement that it may affect risk in the future, and only a small portion that believe that climate change and wildfire risk are not related (rclimate10; 8.9%).

Climate change statements and demographics

Statistical analyses help investigate the relationships between demographic characteristics of survey respondents and responses to the climate change statements. We find that respondents'

Table 1. NEP statements, responses, and factor loadings.

Variable name	Category	Statements	*n*	Median[a]	Agree[a]	Polychoric factor loadings		
						nep_ecocrisis	nep_exempt	Uniqueness
nep6	Anti-exemptionalism	Despite our special abilities humans are still subject to the laws of nature	376	2	96%	0.40	–0.45	0.64
nep8	Balance of nature	The balance of nature is very delicate and easily upset	377	1	77%	0.57	–0.19	0.64
nep4	Ecocrisis	Humans are severely abusing the environment	377	1	75%	0.86	–0.21	0.22
nep3	Balance of nature	When humans interfere with nature it often produces disastrous consequences	377	1	72%	0.72	–0.23	0.43
nep1	Limits to growth	We are approaching the limit of the number of people the earth can support	376	1	60%	0.68	–0.20	0.50
nep10	Ecocrisis	If things continue on their present course, we will soon experience a major ecological catastrophe	376	1	49%	0.77	–0.21	0.36
nep5	Limits to growth	The earth has plenty of natural resources if we just learn how to develop them	377	0	36%	–0.35	0.31	0.78
nep9	Anti-exemptionalism	Humans will eventually learn enough about how nature works to be able to control it	375	–1	25%	–0.20	0.61	0.58
nep2	Anti-anthropocentrism	Humans have the right to modify the natural environment to suit their needs	376	0	22%	–0.34	0.41	0.72
nep7	Anti-anthropocentrism	Humans were meant to rule over the rest of nature	376	–1	13%	–0.47	0.58	0.44

[a]Scored from –2 (strongly disagree) to 2 (strongly agree); 'Agree' shows percentage > 0 (i.e. agree or strongly agree).

Table 2. Climate change-related statements, responses, factor loadings, and correlations with NEP factors.

					Polychoric factor loadings		Spearman rho correlations	
		n	Median[a]	Agree[a]	cc_belief	Uniqueness	nep_ecocrisis	nep_exempt2
climate1	Climate change is real	366	2	79%	0.92	0.16	0.49 ***	–0.28 ***
climate8	Most scientists agree that climate change exists	364	1	76%	0.86	0.26	0.42 ***	–0.18 ***
climate2	Humans are largely responsible for climate change	365	1	63%	0.88	0.22	0.54 ***	–0.21 ***
climate9	Most scientists agree that climate change is caused by humans	361	1	63%	0.84	0.30	0.51 ***	–0.16 **
climate6	Climate change has increased the risk of wildfires in Boulder and Larimer Counties	364	1	55%	0.78	0.39	0.45 ***	–0.10
climate5	I know a lot about climate change	363	0	48%	0.32	0.89	0.16 **	–0.10
climate4	I am skeptical about the existence of climate change	359	–2	14%	–0.89	0.22	–0.48 ***	0.23 ***
climate3	Climate change is a hoax	363	–2	11%	–0.91	0.17	–0.47 ***	0.22 ***
climate10	Climate change and wildfire risk are not related	361	–1	9%	–0.77	0.41	–0.45 ***	0.21 ***
cc_belief		n/a	n/a	n/a	n/a	n/a	0.55 ***	–0.23 ***

[a]Scored from –2 (strongly disagree) to 2 (strongly agree); 'Agree' shows percentage > 0 (i.e. agree or strongly agree).
*$p < .05$.
**$p < .01$.
***$p < .001$.

Table 3. Climate change statements and demographics.

			Correlation with agree[a]				
		Agree[a]	Gender[b]	Age[c]	Education[d]	Married[e]	Race[f]
Rclimate1	Climate change is real	0.79	0.04	–0.23 ***	0.16 **	0.01	–0.04
Rclimate2	Humans are largely responsible for climate change	0.63	0.13 *	–0.16 **	0.10 *	0.07	0.00
Rclimate3	Climate change is a hoax	0.11	–0.05	0.13 *	–0.06	–0.06	–0.01
Rclimate4	I am skeptical about the existence of climate change	0.14	–0.09	0.11 *	–0.04	–0.03	–0.03
Rclimate5	I know a lot about climate change	0.48	–0.03	–0.03	0.21 ***	0.03	–0.01
Rclimate6	Climate change has increased the risk of wildfires in Boulder and Larimer Counties	0.55	0.06	–0.10	0.03	0.05	–0.01
Rclimate8	Most scientists agree that climate change exists	0.76	0.10	–0.19 ***	0.12 *	0.07	–0.09
Rclimate9	Most scientists agree that climate change is caused by humans	0.63	0.12 *	–0.18 ***	0.17 **	0.07	–0.06
Rclimate10	Climate change and wildfire risk are not related	0.09	–0.01	0.09	–0.09	0.02	0.02

[a]See Table 2, footnote a.
[b]Spearman rho (1 = female, 0 = male).
[c]Pearson coefficient (age in years).
[d]Spearman rho (categories increasing in education level).
[e]Spearman rho (1 = currently married, 0 = other).
[f]Spearman rho (1 = white, 0 = other).
*$p < .05$.
**$p < .01$.
***$p < .001$.

gender, age, and education levels relate to responses to some of the climate change statements (see Table 3). Other demographic characteristics (i.e. race, marital status) do not significantly relate to any of the statements.

Gender differs significantly for two items. Women are more likely than men to agree that climate change is anthropogenic, with 70% of women agreeing that humans are largely responsible for climate change compared to 57% of men (rclimate2). Women are also more likely to agree that there is scientific consensus regarding the anthropogenic nature of climate change, with 69% of women agreeing with the statement compared to 58% of men (rclimate9).

Age of respondents significantly relates to responses to six of the nine climate change statements. We find that respondents who agree that climate change is real (rclimate1) tend to be younger; likewise, respondents who are skeptical about the existence of climate change (rclimate4) or believe it is a hoax (rclimate3) tend to be older. In regard to scientific consensus, we see that younger respondents are more likely to agree with the statements 'Most scientists agree that climate change exists' (rclimate8) and 'Most scientists agree that climate change is caused by humans' (rclimate9). Finally, those agreeing that 'Humans are largely responsible for climate change' (rclimate2) also tend to be younger.

Finally, we find that respondents with higher education levels are more likely to agree that climate change is real compared to those with less education (rclimate1) and the humans are largely responsible for it (rclimate2). Being highly educated is also positively associated with reporting being knowledgeable about climate change (rclimate5). Further, higher education levels are related to agreeing that there is scientific consensus around the anthropogenic nature of climate change (rclimate9).

The finding that demographics matter is consistent with recent studies on climate change beliefs and attitudes (Dunlap & McCright, 2010; McCright & Dunlap, 2011). However, to our knowledge, the relationship between beliefs about climate change and about wildfire risk has not been investigated. Here, we do not find any demographic characteristics that are related to agreement with the statements about climate change and wildfire risk (rclimate6 and rclimate10).

Climate change beliefs: a spectrum from belief to skepticism?

In addition to the descriptive statistics, Table 2 shows a one-factor polychoric factoring solution[7] representing the majority of the correlated variation in the responses. Ex-post investigation identifies this factor (cc_belief) as representing a multidimensional belief in (anthropogenic) climate change. The left graph of Figure 1 depicts the distribution of the relative frequency of this factor's scores across respondents. Clearly, the majority of respondents are skewed toward the higher scores shown in the right-hand-side, that is, toward stronger agreement with the multidimensional belief in climate change. However, the middle 50% of respondents are between the two black lines (at 0.34 and 1.93), suggesting that although most respondents lean toward belief and there is a spike in the number of respondents receiving the highest cc_belief score, many respondents do not reside firmly in either the 'believer' or 'denier' camps. That is, the lack of a distinct second group within the data suggests that rather than sorting into a simple 'believer/denier' dichotomy, many respondents sit on the continuum between the strongest believers (i.e, those with the highest cc_belief scores) and those most likely to be identified as deniers (i.e. those with the lowest cc_belief scores).

The second graph of Figure 2 depicts the cc_belief scores for 11% of respondents who agree that climate change is a hoax (rclimate3) separately from who do not. As expected, this small group of deniers sits mostly at the bottom of the cc_belief spectrum, although the exceptions to this provide evidence that cc_belief represents a multidimensional construct more complex than mere belief/denial. This multidimensionality is further supported by the factor loadings shown in Table 2, which show that cc_belief encompasses various aspects of belief fairly consistently. Specifically, the overall belief continuum (cc_belief) is strongly loaded by nearly all

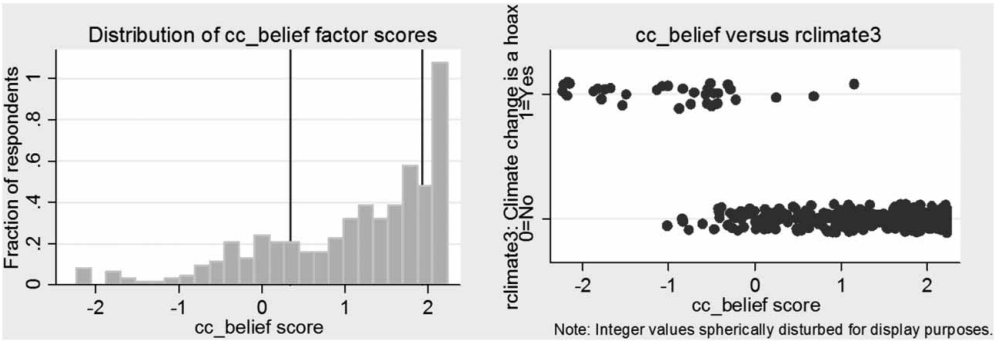

Figure 1. Distribution of climate change beliefs.

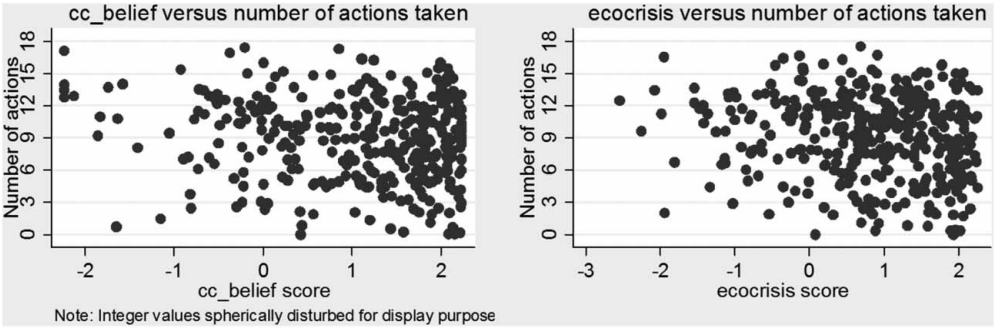

Figure 2. Climate beliefs and environmental attitudes versus wildfire hazard mitigation actions.

represented climate beliefs, including the belief that climate change is real (climate1), that humans are responsible for it (climate2), and that it is related to wildfire risk (climate10). That said, the 'uniqueness' in the factor analysis statistics also underscores the importance of viewing anthropogenic climate change beliefs as a spectrum rather than as a binary rating of believer/denier. If more of a dichotomy than a spectrum existed, the cc_belief scores would be more concentrated for each level of response to the individual climate questions.

That said, one statement, 'I know a lot about climate change' (climate5), has a particularly high uniqueness value compared to other variables, reflecting that responses to this statement vary independently from those to the other climate change statements. This statement reflects what people claim to know about climate change rather than an objective assessment of their knowledge on the subject. Thus, this result, paired with the low 48% who agree with the statement and the general leaning toward agreement with the multidimensional belief in climate change, provides evidence that those who 'believe' in climate change are not necessarily those who think they know the most about it. This matters because social science research in the hazards field has consistently found that individuals' behaviors are determined by what they believe they know (McCaffrey, 2004; McFarlane, 2005) rather than their 'actual knowledge' and what they believe they are capable of undertaking rather than their actual capabilities (Lindell & Prater, 2002; Martin et al., 2008).

Climate change beliefs and environmental attitudes

The final two columns of Table 2 present Spearman rho coefficients[8] corresponding to the correlation between the two NEP factor scores and each climate variable, including the cc_belief factor score. All climate variables have statistically significant correlations with the environmental catastrophe NEP factor (nep_ecocrisis); seven of the nine climate variables have statistically significant correlations with the 'belief that humans have power over nature' NEP factor (nep_exempt). In general, expectation of environmental catastrophe is strongly positively correlated with belief in climate change, both in terms of the cc_belief factor score and the individual questions. In addition, the belief that humans have power over nature (nep_exempt) tends to be negatively correlated with belief in climate change, although the magnitude of the correlations is not as strong for the latter as for the former.

The strong correlations between responses to climate change questions and the NEP factor variables reflect a likely relationship between climate beliefs and underlying world views pertaining to a sense of an impending ecocrisis and to a sense of humankind's non-dominion over nature.

Climate change beliefs and wildfire mitigation activity

Finally, since climate change is projected to exacerbate wildfire behavior and development in fire-prone areas is projected to increase the population at risk, it is useful to consider to what extent those facing risk understand the link between climate and wildfire. This inquiry may provide insight to what extent messages about climate change exacerbation could be useful in galvanizing hazard mitigation behaviors. This is particularly true due to the fact that despite climate-related changes in wildfire behavior, the basic steps required of homeowners to reduce risk of damages and losses due to wildfire remain the same.

Is there are a relationship between climate change beliefs and taking action to reduce the risk of wildfire hazards?

In order to assess hazard mitigation activity, study participants were asked whether they had completed 17 specific fire risk-reduction activities related to reducing vegetative fuels or improving structural conditions to reduce home ignition in the 2010 survey (see Table 4).

The first three columns of Table 4 describe the 17 actions and the percentage of respondents who reported completing and/or regularly maintaining each action. For each of the distance-related actions, more respondents reported performing the activity within 30 feet of their house and other property buildings than in the area between 30 and 100 feet from buildings on the property, although the difference ranged from 13% to 32% of respondents. Generally, yard work and maintenance-type actions (shown in the upper, 'short-run actions' panel) are more common than structural changes (shown in the lower, 'long-run actions' panel), which tend to be more permanent but also more costly, with the major exception of 60% of respondents reporting having installed or maintained a fire-resistant roof.

In addition to the 17 individual hazard mitigation actions, the final row of Table 4 shows the average number of reported mitigation actions completed or regularly maintained. On average, respondents reported performing 9 of the 17 mitigation actions.

The remaining columns of Table 4 report the Spearman rho correlations among mitigation actions (rows) with the climate belief factor score (cc_belief), agreement that climate change is a hoax (rclimate3), and the two NEP factor scores (nep_ecocrisis and nep_exempt). Most notably, the extent to which a respondent believes in climate change, as measured by cc_belief, is not significantly related with any mitigation actions except cleared leaves between 30 and 100 feet from home, for which it was weakly negatively correlated. This lack of an overall correlation between number of actions taken and the cc_belief score is visually presented in the left graph of Figure 2.

However, as Figure 1 demonstrated, respondents who agreed that climate change is a hoax (rclimate3 = 1) are also most of the respondents furthest on the negative end of the cc_belief spectrum. In contrast to the general cc_belief results, though, those who agreed that climate change is a hoax tend to report a high number of completed mitigation actions. Indeed, as Figure 3 shows, the 39 respondents who agreed that climate change is a hoax also report significantly more mitigation actions than other respondents (Kruskal Wallis test for the total number of mitigation actions, $p = .005$). Similarly, agreement that climate change is a hoax is significantly and positively associated with numerous individual mitigation actions, including mowing long grasses, clearing leaves, pruning limbs, and installing fire-resistant landscaping.

Finally, while belief in human's power over nature (nep_exempt) is not significantly related, either positively or negatively, with any mitigation actions, the expectation of environmental catastrophe (nep_ecocrisis) is significantly associated with lower levels of mitigation actions, both in terms of the overall number of actions performed and in numerous specific items, including mowing, removing dead branches, pruning limbs, and replacing wooden siding with more fire-

Table 4. Wildfire hazard mitigation actions and correlations with climate beliefs and environmental attitudes.

Mitigation actions reported completed or regularly maintained	Mean	Spearman rho correlations			
		cc_belief	rclimate3	nep_ecocrisis	nep_exempt
Short-run actions					
Mowed long grasses within 30 feet of buildings	80%	–0.09	0.11 *	–0.14 **	0.04
Mowed long grasses between 30 and 100 feet from buildings	56%	–0.09	0.13 *	–0.08	0.06
Removed dead or overhanging branches within 30 feet of buildings	79%	–0.04	0.08	–0.11 *	–0.07
Removed dead or overhanging branches between 30 and 100 feet from buildings	58%	–0.07	0.06	–0.12 *	0.04
Thinned trees and shrubs within 30 feet of buildings	75%	–0.02	0.06	–0.03	–0.03
Thinned trees and shrubs between 30 and 100 feet from buildings	60%	–0.10	0.07	–0.06	0.07
Cleared leaves and pine needles from roof and/or yard within 30 feet of buildings	75%	–0.04	0.04	–0.06	–0.10
Cleared leaves and pine needles from roof and/or yard between 30 and 100 feet from buildings	42%	–0.17 **	0.18 ***	–0.08	0.01
Pruned limbs within 6–10 feet from the ground and within 30 feet of buildings	66%	–0.09	0.12 *	–0.17 ***	0.01
Removed dead or overhanging branches between 30 and 100 feet from buildings	53%	–0.10	0.08	–0.11 *	0.08
Long-run actions					
Installed house number in clearly visible place	78%	0.02	–0.10	–0.03	0.00
Installed a fire-resistant roof	60%	0.00	0.04	–0.10	0.04
Installed fire-resistant landscaping within 3–5 feet of buildings	39%	–0.06	0.13 *	–0.09	0.05
Installed screening over roof vents	34%	–0.06	0.09	–0.06	0.03
Installed fire-resistant siding on buildings	23%	–0.02	0.07	–0.15 **	0.04
Installed fire-resistant decking	18%	0.01	0.01	–0.05	–0.03
Replaced exterior wood stairs and balconies	12%	0.08	–0.02	0.02	–0.04
(total number of actions)	9.1	–0.10	0.15 **	–0.17 ***	0.03

*$p < .05$.
**$p < .01$.
***$p < .001$.

resistant materials. As shown by the second graph in Figure 2, this negative relationship is not very strong, although significant, which is consistent with the Spearman rho of only –0.17.

Combined, these results suggest that climate change-related beliefs are not related to wildfire hazard mitigation actions, with the important exception of the small group of respondents who believe that climate change is a hoax and are also slightly more likely to report performing numerous individual mitigation actions. In contrast, the environmental world view associated with an ecocrisis (represented by nep_ecocrisis) is associated with lower levels of mitigation. Interestingly, the findings that those who believe climate change is a hoax undertake more actions and those who anticipate environmental catastrophe undertake fewer actions are counter to Whitmarsh's (2008) findings that those who believe in anthropogenic climate change and in the fragility of the environment reported undertaking more actions.

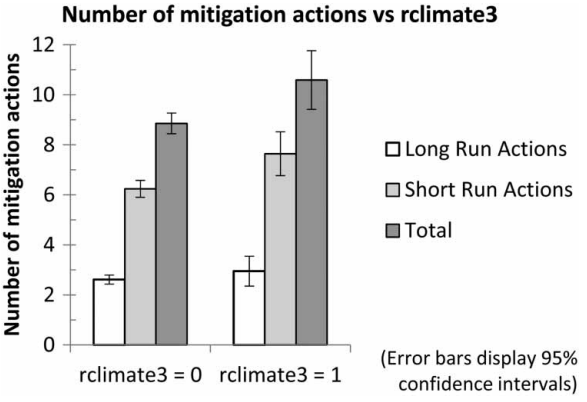

Figure 3. Wildfire hazard mitigation actions and belief that climate change is a hoax (rclimate3).

Notably, some of the specific items negatively associated with the expectation of environmental catastrophe (nep_ecocrisis) scores involve modification of trees and replacing natural siding materials (wood) with other, often human-made, materials; it is possible that an environmentally friendly world view corresponds positively with this factor (nep_ecocrisis) but may also lead to a preference for a more 'natural' property with less human intervention, with the unintended consequence being a lower incidence of wildfire risk mitigation actions being performed. In other words, although it might be tempting to make assumptions about the polarization of climate beliefs and how it might play out in hazard mitigation behaviors, the results of this study demonstrate that there is a lot more complexity involved, and indeed, climate beliefs are not well aligned with mitigation choices. Combined with Schulte and Miller's (2010) conclusions that wildfire hazard mitigation determinants are best described as tangible and community-oriented, there is some evidence that locally experienced natural hazards may best be addressed through locally relevant lenses regardless of climate change exacerbation. Further, these findings indicate that detailing climate change exacerbations of local hazards as a potential tactic to highlight the importance of taking action to reduce current and future risks may not be a route that yields increased hazard mitigation actions among those at risk.

Conclusion

Public belief in climate change may be a requirement to garner support for and investment in climate change mitigation to alter climate change trajectories, but must individuals facing climate change exacerbation of natural hazards become 'believers' to take action to mitigate the risks they face? This is an important question due to the politicized nature of climate in the public arena and because climate change is increasingly being used to galvanize support for hazard-related risk-reduction activities. While climate change will result in more frequent and severe wildfires, and longer and more intense wildfire seasons, it is important to consider whether homeowners in fire-prone areas need to be cognizant of these broader changes in order to facilitate household-level adaptive action that reduces parcel and community risk?[9]

We find that study participants are attuned to climate change and have an understanding (with caveats) of the climate change–wildfire relationship. As the analyses described above, the data from this study indicate that climate change beliefs actually rest upon a continuum between being 'believers' and 'deniers' that represents a multidimensional concept including the belief that climate change is real, that it is caused by humans, and that it is linked to increase wildfire risk. This multidimensionality disrupts the trend of categorizing the public into two

mutually exclusive and highly politicized camps. In particular, although we can identify strong believers and strong deniers among respondents, the majority of respondents lie somewhere between the two positions. This is important for several reasons. First, it highlights that the issues at hand are more complex in the public view than the dichotomy allows. Second, it challenges some of the anecdotal assumptions that may follow from this dichotomy. Placement on this believer–denier spectrum is related to certain measures of general environmental attitudes. Despite these correlations, however, we fail to find a relationship between climate change beliefs and wildfire risk-reduction actions in general. In fact, the data related to actions that reduce the risk of wildfire indicate that the small portion of the study sample that would likely self-identify as deniers are among some of the highest mitigators. Thus caution is appropriate in attending to the nuance behind the divisions. Further, these findings have potential implications related to the ways in which the risks to homeowners are characterized in light of climate change exacerbation.

As with any study, there are caveats. First, the survey questions regarding wildfire hazard mitigation actions did not ask participants to identify if their motivation for undertaking the 17 measured items were motivated for the sole purpose of wildfire risk reduction. Motivation was not included in the survey because our primary focus was on whether or not the wildfire fuel conditions that are associated with higher levels of risk had been altered by the study participants. It is possible that risk-reduction actions were undertaken for other purposes, such as aesthetics. It is also possible that such actions involve trade-offs, such as loss of privacy screening or shade. Further inquiry into property owners' motivations related to hazard mitigation actions could prove fruitful to this discussion. Second, we cannot infer results to populations beyond the study's scope. One might expect that study participants in areas in which wildfire risk is more or less visibly affected by changes in temperature or precipitation (e.g. long term drought) or even weather variability might respond differently.

With the observations from our data and these caveats in mind, we suggest that (1) the link between climate change beliefs and mitigation actions in response to climate-exacerbated hazards is an area that requires further inquiry and (2) for some portions of the population, climate change information or climate change-focused education efforts (e.g. 'it is only going to get worse due to climate change') may not be the most productive outreach and education tool. In fact, focusing on locally relevant hazards and their changing characteristics may be a useful tool for galvanizing awareness, concern, and risk-reduction actions.

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Notes

1. 428 responses/747 invitees=64.5%.
2. Access to the 2007 and 2010 survey instruments and response frequencies for each question are available, by county, via these citations.
3. Polychoric factoring (Kolenikov & Angeles, 2004) is an alternative to more conventional factor analysis methods, which assume normality of data and are appropriate for discrete (ordinal) data, such as the Likert-style responses to the NEP and climate questions.
4. The first factor (eigenvalue 4.19) explains 89% of the variation in the data; the second factor (eigenvalue of 0.50) explains an additional 11% of the variation.
5. We have omitted a 10th variable, climate7 ($n = 379$, median response = 0, 19% agree), from analysis due to its uniqueness of 0.9995 in a forced one-factor solution. This uniqueness is likely a result of ambiguous wording ("Climate change has not yet increased wildfire risk in Larimer and Boulder counties but it will in the future").
6. Recoded climate variables are identified by the prefix "r", as in "rclimate1".
7. A single factor (eigenvalue 5.98) explains the majority of the variation in the data (91%). If retained, the second factor (eigenvalue of 0.46) would explain an additional 7% of the variation.
8. Spearman rho coefficients are analogous to the more familiar Pearson correlation coefficients, but appropriate for the ordinal data.
9. This question is particularly important in light of related research that examines the crossover between climate change beliefs and hazards that highlights that broader environmental values are related to hazard mitigation (Whitmarsh, 2008) and that the primary determinants of wildfire hazard mitigations were local and contextually important factors, rather than climate-related beliefs (Schulte & Miller, 2010).

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