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Place, proximity, and perceived harm: extreme weather events and views about climate change

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Abstract Advances in event attribution have improved scientific confidence in linking climate change to extreme weather severity and frequency, but this confidence varies by event type. Yet, scholars and activists argue that extreme weather events may provide the best opportunity to raise awareness and prompt action on climate change. We focus on four cases of extreme weather with low attribution (tornado outbreaks in Laurel County, Kentucky, and Winston County, Mississippi; wildfires in Yavapai County, Arizona, and Lake County, California). We survey county residents to examine the role of event proximity, community- and event-specific characteristics, and reported harm in shaping climate change views post-event. Using multilevel regression analysis, we find that reported personal and community harm aligns with event proximity and larger community damages. For our respondents' climate change views, however, political ideology dominates, suggesting the importance of motivated reasoning in individual interpretations of extreme weather events. At the same time, while event proximity is irrelevant, we find reported harm to be related to climate change views. Thus, while respondents appear to be making connections between extreme weather events and climate change among our four cases, these connections seem to be most likely to occur in communities where belief in climate change is already high, the event caused significant impacts and is more attributable to climate change, and elites frame the event in these terms—as in Lake County. Our findings are particularly relevant for policymakers and activists looking to such events as catalysts for climate change mitigation and adaptation efforts.

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1 Introduction

The emerging field of event attribution has advanced our understanding of how anthropogenic climate change is connected to the frequency, intensity, and duration of extreme weather events. However, for weather events that are not directly related to temperature, this connection is more complex and uncertain, particularly for individual occurrences of extreme weather (National Academies 2016). Though attributing climate change to extreme weather events is an ongoing scientific debate, some scholars and activists have argued that these very events might provide the best opportunity to raise public awareness and prompt collective action on climate change (Renn 2011; McAdam 2017). To examine when and where extreme weather experiences may impact public views about climate change, we employ a comparative case approach, conducting post-event surveys and fieldwork in four communities recently impacted by extreme weather events with relatively low scientific attribution to climate change—tornadoes (Laurel County, Kentucky, and Winston County, Mississippi) and wildfires (Yavapai County, Arizona, and Lake County, California). In particular, we focus on understudied aspects of personal experience: the role of respondent proximity to the event, community- and event-specific characteristics, and perceptions of harm from the event in shaping climate change views post-event.

Our work fills an important gap in the existing literature on the link between personal experience of extreme weather and climate change perceptions. Recent work has examined the impact of numerous different types of extreme weather events on climate change views (Marquart-Pyatt et al. 2014; Konisky et al. 2016), issue attention and engagement (Lang 2014; Sisco et al. 2017), policy support (Ray et al. 2017), and residential energy use (Ogunbode et al. 2017). Others have exploited pre- and post-event surveying and/or media analysis in a particular geographic area to understand an event's impact on attitudes and discourse (Carlton et al. 2016; Cody et al. 2017). Results have been mixed. Some studies find no impact, often emphasizing the role of other factors like political ideology in determining individual interpretations of specific events (Marquart-Pyatt et al. 2014; Hamilton et al. 2016). To the extent attitudinal changes are found post-event, they are often small and short-lived (Konisky et al. 2016; Sisco et al. 2017; Ray et al. 2017). Our study is unique from these approaches because we utilize case study comparisons, allowing examination of what individual characteristics and contextual conditions may be relevant for influencing climate change views post-event.

Research on the social psychology of risk perception provides some theoretical expectations of the role that personal experience with extreme weather may have in shaping climate change views. The oft-cited construal level theory argues that those events that are more "psychologically" close (e.g., in space, time, social circles) are more concrete (Trope and Liberman 2010). Thus, those who perceive climate change impacts to be more proximal (e.g., because of personal experience with extreme weather) should also express more concern about climate change because its effects are more tangible (McDonald et al. 2015). Yet, "psychological" proximity does not necessarily align with perceptions, resulting in an ongoing debate about the role of experiential learning versus motivated reasoning in shaping climate change views (Spence et al. 2012; Myers et al. 2013; Borick and Rabe 2017). Does personal experience, through experiential learning, shape climate change views or do pre-existing climate change views color perceptions of extreme weather events, through motivated reasoning? As shown above, empirical evidence supports both perspectives, and perhaps both are true, in that differential experiences with different types of events in different contexts impact people in varying ways—a phenomenon which we explore here given our comparative case approach.

To better understand the complex interplay between experience, psychological distance, and climate change views, we use a formulation of psychological distance described in construal level theory, spatial distance (McDonald et al. 2015). While spatial distance is relatively straightforward to define, measuring extreme weather experience, as a construct, varies substantially in the literature (Akerlof et al. 2013; Reser et al. 2014; Van der Linden 2015; Lujala et al. 2015). We address this ambiguity using a similar approach to Demski et al. (2017), who argue that self-reported measures of experience that include "direct physical experience and material impacts of an event, well-defined in terms of personal effects and damage, are less susceptible to biased reporting, providing the best proxy available for objective experience" (p. 152). Following a similar line of reasoning, we conceptualize experience in terms of self-reported harm at both a personal level (i.e., impacts to property, finances, and physical and mental health) and at a community level (i.e., impacts to infrastructure, economy, public safety, and community well-being). Applying these two conceptualizations of harm to our measure of proximity (spatial distance to the event), we offer the following hypotheses:

H1: Respondents more proximate to the extreme weather event will be more likely to report that:

H1a. They were harmed personally by the event.
H1b. The community was harmed by the event.
H1c. The event was made more severe by global warming.[1]
H1d. They are more concerned about global warming based on their experience.

We also consider how event type could influence the connection between extreme weather experience and climate change views. Attributing a single extreme weather event to climate change—in terms of either its increased intensity and/or frequency—is challenging. Scientific confidence in the ability to attribute the effects of anthropogenic climate change is highest for extreme heat and cold events and lowest for tornadoes and wildfires (National Academies 2016). For both wildfires and tornadoes, the event attribution science is limited by inconsistent data records, poor capability to simulate events, and a low understanding of how physical mechanisms relate climate change to events. Furthermore, for wildfires, a multiplicity of confounding factors (e.g., forest management practices) can contribute to the magnitude of these events, thus reducing confidence in attribution. Although scientific confidence in attributing climate change to the intensity and frequency of tornadoes and wildfires is relatively low compared to other types of extreme weather (National Academies 2016), confidence can increase for wildfires associated with a heatwave and/or drought. We do not know whether the scientific community's confidence in event attribution aligns with general public opinion, so we offer the following research question:

RQ1: To what degree does the public attribute single weather events to climate change? How is this similar, or dissimilar to, scientific confidence in attribution?

[1] We use the term *global warming*, rather than *climate change*, for comparability to downscaled national surveys (Howe et al. 2015).

While many studies have examined the connection between individual experience with climate change and climate change views (Akerlof et al. 2013; Blennow et al. 2012; Broomell et al. 2015; Reser et al. 2014; Myers et al. 2013), another related topic of inquiry is how personal experiences of harm from an extreme weather event influence climate change views. For example, Lujala et al. (2015) found that Norwegians who experienced personal damage from climate change-related weather events expressed increased concern about climate change and its future impacts on their local community. This effect, however, was not observed for those living in at-risk areas who did not report personal damage. With a similar focus on direct experience with extreme weather, Demski et al. (2017) explored the 2013/2014 flood events in the UK, using these events as a natural experiment to compare climate change views between those who experienced flooding and those who did not. Those reporting direct flood experience ranked climate change as having higher issue salience and were also more likely to support climate mitigation policies and climate impacts adaptation strategies that were unrelated to the flooding event. Following this line of inquiry, we consider how perceived harm resulting from event experience, both personally and to the community, shapes climate change views with the following hypotheses:

H4: Respondents with higher levels of *personal* harm will be more likely to report that:

H4a. The event was made more severe by global warming.
H4b. They are more concerned about global warming based on their experience.

H5: Respondents with higher levels of *community* harm will be more likely to report that:

H5a. The event was made more severe by global warming.
H5b. They are more concerned about global warming based on their experience.

With these hypotheses in mind, we now turn to a description of our methods.

2 Methods

2.1 About the cases

Selected from a larger research project exploring community reactions to extreme weather, we focus on four cases, two wildfires and two tornadoes, occurring in the Western and Southern USA between 2012 and 2015: a 2012 tornado outbreak in Laurel County, Kentucky; a 2014 tornado outbreak in Winston County, Mississippi; a 2013 wildfire in Yavapai County, Arizona; and a 2015 wildfire in Lake County, California. In this section, we first provide a brief description of each case, generated from newspaper sources, government documents, and in-person interviews, and then summarize some key similarities and differences across the cases.

2.1.1 Tornado outbreak (Laurel County, KY)

After several days of heavy rain throughout the state, an EF2 tornado touched down in Laurel County, Kentucky, on March 2, 2012, near the community of East Bernstadt. The tornado traveled just over ten miles, with a maximum width of 310 yards and maximum wind speeds of 125 mph. The tornado crossed through a mix of rural and residential lands, killing six individuals, destroying 68 homes, and damaging 245. While minor tornadoes and straight-line winds are a normal occurrence in the area, residents agreed that this storm was unprecedented in terms of its magnitude, impact, and timing (i.e., tornadoes typically occur in the fall). Due to the devastation of the event, President Obama issued a major disaster declaration for the county.

2.1.2 Tornado outbreak (Winston County, MS)

On April 28, 2014, an EF4 tornado touched down in Winston County, Mississippi. This tornado was part of an outbreak, including 23 tornadoes that affected 20 counties across the state of Mississippi. Governor Bryant described the tornado outbreak as "one of the most devastating events we have had in Mississippi. Not since Yazoo County or Katrina have I ever seen this type of devastation" (Winston County Journal 2014). While Winston is the least populous of our four counties, the tornado hit its most populated areas. It resulted in ten fatalities and damaged or destroyed more than 400 homes and 1500 buildings along its 35-mile long and half-mile wide path that intersected the city of Louisville. President Obama also issued a major disaster declaration for the county.

2.1.3 The Yarnell Hill Fire (Yavapai County, AZ)

The Yarnell Hill Fire broke out on state land near the unincorporated community of Yarnell in Yavapai County, Arizona, on June 28, 2013. An early monsoon two days later caused the wildfire to move much faster than predicted, at 12 as opposed to two to three miles per hour. Burning at temperatures as high as 2000°F, the fire overtook and killed 19 of 20 firefighters in the Granite Mountain Hotshots from nearby Prescott, becoming the deadliest wildfire in Arizona's history. While the fire also struck Peeples Valley, the small community of Yarnell, with a population of 649, was the hardest hit. Due to the fast-moving nature of the blaze, evacuation times were short. The fire damaged or destroyed 141 homes, causing a total of $2.2 million in property damages. The Yarnell Hill Fire is our only event for which President Obama did not issue a major disaster declaration—sparking significant local controversy.

2.1.4 The Valley Fire (Lake County, CA)

The Valley Fire began on September 12, 2015, and, at the time, it became the third most destructive wildfire in California's history. Over four weeks, the fire burned 76,067 acres, caused the evacuation of nearly 20,000 residents (roughly a third of Lake County's population), and destroyed 1280 homes, 27 apartments or other multifamily facilities, 66 businesses or commercial properties, and 585 other structures. The fire significantly damaged the communities of Cobb, Middletown, Hidden Valley Lake, and Anderson Springs. Four individuals were killed in the fire and four firefighters suffered second-degree burns. While Lake County has a history with wildfires, the Valley Fire was noted for its rapid rate of spread, size, and intensity: it burned 40,000 acres in ten hours, exceeding normal rates by three to four times. Presidential Obama issued a major disaster declaration for this event.

2.1.5 Similarities and differences across cases

Despite differences in event type, all four events were described by community members and local media as devastating. At least four deaths occurred in each case, and three of our four events were declared major disasters by President Obama. While the Yavapai wildfire did not receive a presidential disaster declaration, the large number of fatalities from this event exacted a high emotional toll on the community. Moreover, our fieldwork did not reveal evidence of pre-event variation across the counties in terms of climate change adaptation and/or extreme weather preparedness. Furthermore, all cases had similar levels of social vulnerability to extreme events, as demonstrated by lower levels of education and median income and higher levels of unemployment than national averages (Table 1).

Examining differences in downscaled climate opinion data and political ideology between cases (Table 1), Laurel County has the lowest level of worry about global warming (43%) and voted overwhelming Republican in the 2012 presidential election. Like Laurel, a majority in Yavapai County voted for the Republican candidate in the 2012 election. However, unlike Laurel, Yavapai has similar levels of worry about global warming (49%) compared to the national average (52%). Winston County voted slightly more Republican than Democratic in the 2012 presidential election and has lower levels of worry about global warming (46%) than the national average. Unlike the other three cases, a majority of Lake County voters supported the Democratic presidential candidate in the 2012 election. Lake is also home to those most worried about global warming. Of all the counties in our study, Lake seems the most likely place for residents to make connections between the event and climate change.

2.2 Data collection

We collected surveys from a residential address-based random sample drawn from our four counties by Marketing System Group (MSG), a commercial survey sample provider. Our goal was to achieve 100 responses per county to generate an adequate sample for analysis. We consulted Dillman et al.'s (2014) Tailored Design Method for sampling protocol, questionnaire design, and best practices. From September 2016 to May 2017, we mailed three waves of survey materials to 3488 valid addresses and received 489 completed questionnaires for an overall response rate of 14.0%. Response rates varied by county, with the tornado cases in Laurel County (8.4%) and Winston County (13.1%) having lower response rates than the wildfire cases in Yavapai County (16.1%) and Lake County (18.6%). Overall, the geographic distribution of respondents was consistent with countywide residential address distributions, with higher densities of respondent locations corresponding to more population-dense areas within each county. For a description of our survey methodology and protocol, see Supplement S1.

2.3 Measures

2.3.1 Climate change views

Public opinion polling on views about climate change has taken many shapes and forms—as one issue of many on a "most important problem" question and via direct questions about how much a respondent personally worries about climate change, how seriously they view the problem, as well as the seriousness and timing of its impacts (Brulle et al. 2012; Maibach et al.

Table 1 Case information

Case/community	Extreme weather event	Timing	County population (density per sq. mile)[1]	Education (bachelor's degree %)[1]	Unemployed (%)[1]	Median income[1]	Obama/Romney votes in 2012 presidential election (%)[2]	Worried about global warming (%)[3]
Laurel County, KY	Tornado	Spring 2012	64,158 (137.7)	12.3	12.4	$36,020	17/81	43
Winston County, MS	Tornado	Spring 2014	18,697 (30.8)	16.5	12.3	$33,202	47/53	46
Yavapai County, AZ	Wildfire	Summer 2013	215,996 (26.6)	16.0	10.0	$44,748	34/64	49
Lake County, CA	Wildfire	Summer 2015	59,751 (51.1)	25.6	14.7	$35,578	56/39	57
USA	–	–	–	29.8	8.3	$53,889	51/47	52

[1] American Community Survey, 2015 estimates (5-year) (U.S. Census Bureau 2017)

[2] National Atlas of the United States (U.S. Geological Survey 2014)

[3] Yale Climate Opinion Maps (Howe et al. 2015). Estimates generated using a statistical model of national surveys collected between 2008 and 2014. While this date range includes years after some of our events, these are the earliest available estimates that are downscaled to the county level

2011). While these existing measures have proven valuable in tracking climate change views over time and the factors (including extreme weather events) that shape these views, our specific interest in the experience of a particular extreme weather event led us to draft survey questions referencing the event. The first was a measure of perceived attribution (*severity*): "Do you think that global warming made <<event_name>> in <<county_name>> less severe, more severe, or had no impact?" with responses presented on a five-point scale from 1 = "Much less severe" to 5 = "Much more severe" ($m = 3.64$; sd = 0.79). Our phrasing of this question builds upon previous polling efforts aimed at understanding the role of nationally recognized extreme weather events (e.g., Hurricane Sandy) in shaping views on climate change (Climate Change in the American Mind 2013).

Our second was a measure of self-reported attitude change[2] (*concern)*: "As a result of your experiences with <<event_name>>, are you less concerned, more concerned or did your views remain unchanged about global warming?" with responses on a five-point scale from 1 = "Much less concerned" to 5 = "Much more concerned" ($m = 3.39$; sd = 0.69). Due to limited responses for categories indicating less severity or less concern, we dichotomized these measures as *severity* (53% more severe; 47% less severe or had no impact) and *concern* (34% more concern; 66% less concerned or views remained unchanged). See Supplement S2 for more detail.

2.3.2 Harm perceptions

We also asked participants to rate their level of *personal* harm from the event with the following question: "For each type of harm listed below, how much were you or members of your household harmed by the <<event_name>>" with four corresponding items (1) "property (such as home, yard, or car)," (2) "finances (such as lost income or time at work)," (3) "physical health (such as injury)," and (4) "mental health (such as prolonged anxiety)." For rating level of *community* harm, we asked the question "For each type of harm listed below, how much was <<county_name>> harmed by the <<event_name>>" with the following items (1) "infrastructure (such as buildings or transportation routes)," (2) "economy (such as lost revenues, recovery expenditures)," (3) "public safety (such as injuries, fatalities)," and (4) "community well-being (such as strained social services)." Each personal and community harm item was ranked on a four-point scale from "not at all" to "a great deal" and combined into two continuous mean composite indices of personal harm ($m = 1.49$; sd = 0.62; alpha = 0.68) and community harm ($m = 3.02$; sd = 0.94; alpha = 0.86). Both indices have Cronbach's alpha coefficients above 0.65, indicating they fall within a range of acceptable reliability (Vaske 2008).

2.3.3 Individual level controls

We incorporated individual level demographic controls for gender, education, income, age, and race/ethnicity (see Supplement S2 for descriptive statistics). We also included political

[2] As highlighted in Corner et al. (2012), a*ctual* attitude change would have required a "before-and-after" method, where respondents would have been asked to state their current views about climate change both before and after the extreme weather event. *Reported* attitude change is measured only once, after the event, and asks respondents to assess whether their attitudes have changed since before the event. Psychological research comparing actual to reported attitude changes in experimental settings indicates that reported attitudinal changes might show more evidence of attitude polarization (e.g., between non-skeptics and skeptics of climate change) than actual measures (Corner et al. 2012). For our purposes, *reported* attitude change was our only option given that we only conducted post-event surveys.

ideology, which has been identified in the literature as critical for explaining climate change views (Hamilton et al. 2015; McCright et al. 2016; Bohr 2017). We measured political ideology on a five-point scale from "very conservative" to "very liberal" ($m = 2.84$; sd = 1.16).

2.3.4 Proximity to event

Using geocoded street level respondent addresses, we estimated the nearest geographic distance, in kilometers, from respondent residence to extreme weather event using ESRI ArcMap 10.4. For the wildfires in Yavapai and Lake Counties, we estimated nearest geographic distance to the fire boundary polygon (see Fig. 1) (Lake County 2017; Yavapai County Sheriff's Office 2013). For residencies within the fire boundary, respondent distance is zero. For the tornadoes in Winston and Laurel Counties, we estimated nearest distance from the polyline of the tornado track to the residential address (see Fig. 1) (NOAA 2017). Respondent distance varied between 0 and 117 km ($m = 25.07$ km; sd = 27.51) and displayed wide-ranging variation within and between cases, with respondents from Yavapai having the highest average distance ($m = 62.09$ km; sd = 24.12) and Winston the lowest ($m = 7.04$ km; sd = 6.85) (see Supplement S3 and Fig. 1). To reduce the left-leaning skew of this distribution, we log-transformed the distance metric and obtained values that range between 0 and 4.76 ($m = 2.589$; sd = 1.31). We refer to this log-transformed distance-to-event measurement as *proximity.*

2.4 Analysis

We conducted our analysis in two stages. First, we considered how proximity to the extreme weather event influenced reported personal and community harm caused by the event. Next, we considered the influence that harm and proximity to the event had on our two measures of climate change views, *severity* and *concern*. We estimated analytical models using the R package lme4 for mixed effects models (Bates et al. 2014) due to the spatial, nested nature of our data. All independent variables were standardized prior to modeling. For our harm indices (a continuous dependent variable), we applied linear multilevel regression. For our climate change belief measures (a dichotomous dependent variable), we used binary logistic multilevel regression.[3]

First level, fixed effects variables were individual characteristics (e.g., demographics, proximity) and binary variables that identified cases, with Laurel County as the reference case. For the second level of this multilevel analysis, we modeled respondent ZIP code groups as random effects (intercepts). While each of the four cases included one county, 48 unique ZIP codes corresponded to respondent residential addresses within our four counties. This approach is similar to other studies that have explored phenomena that are anticipated to have strong place-based or contextual relationships (Sisco et al. 2017). Because 20–25% of respondents have missing values for our specified models, we conducted multiple imputation and included these model results in Supplement S4. We also conducted moderation analysis by including interaction terms in our multilevel framework (Supplements S5–S7) and mediation analysis using the R package lavaan[4] (Rosseel 2012), both of which did not yield statistically significant findings.

[3] Alternatively, we modeled five-point scale versions of the climate change view measures using ordinal logistic multilevel regression and found that the proportional odds ratio assumption was violated.

[4] The R package lavaan does not accommodate multilevel modeling at the time of conducting this research, so the results of this analysis are not directly comparable to the models we present throughout this article. We will provide them upon reader request.

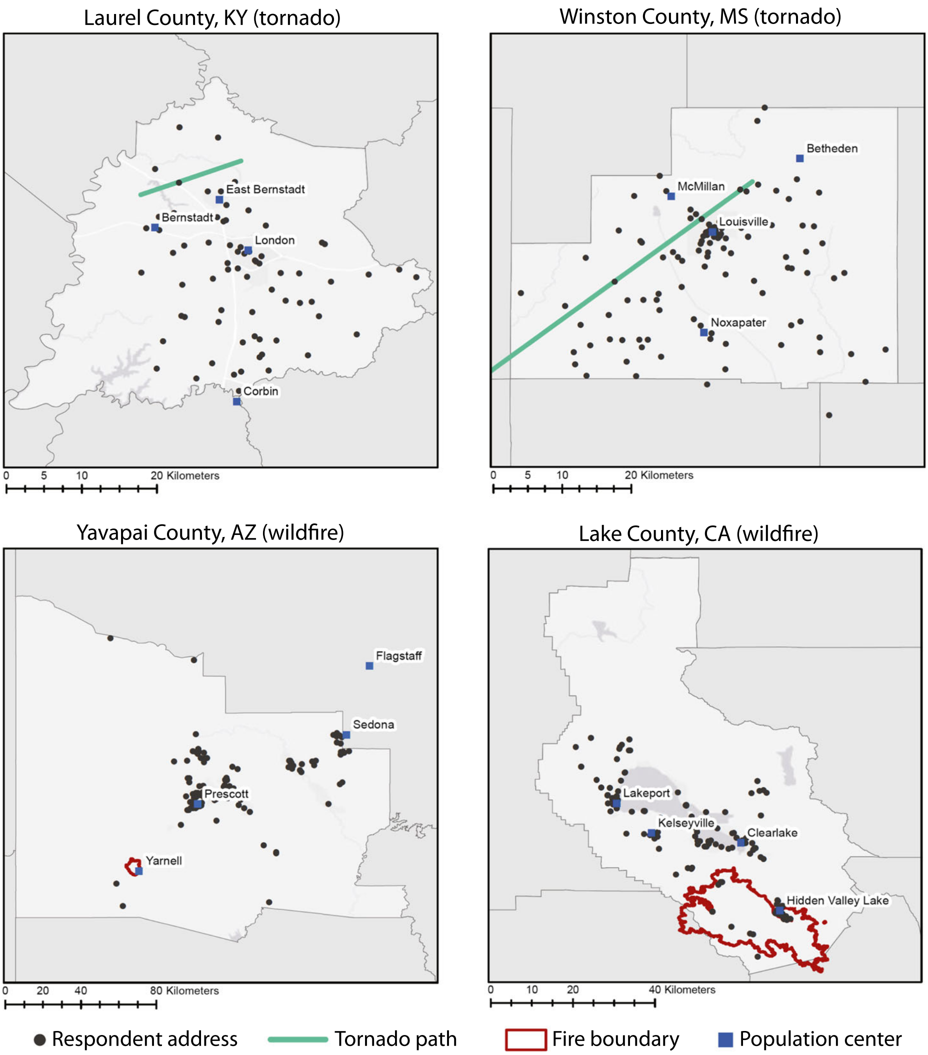

Fig. 1 Location of survey respondents and extreme weather event, per case

3 Findings

3.1 Outcomes by case

Examining our dependent variables by case reveals substantial variation (Fig. 2). When considering our two measures of harm, respondents reported more community harm than personal harm, with Lake County having the highest levels of both (personal, $m = 1.68$, sd = 0.70; and community, $m = 3.52$, sd = 0.63), similar to Winston County (personal, $m = 1.67$, sd = 0.69; and community, $m = 3.33$, sd = 0.80). Yavapai County had the lowest levels of reported personal harm ($m = 1.10$; sd = 0.24), while Laurel County had the lowest levels of reported community harm ($m = 2.40$; sd = 0.89). In terms of our severity measure, over two thirds of Lake respondents thought the wildfire was made more severe by global warming

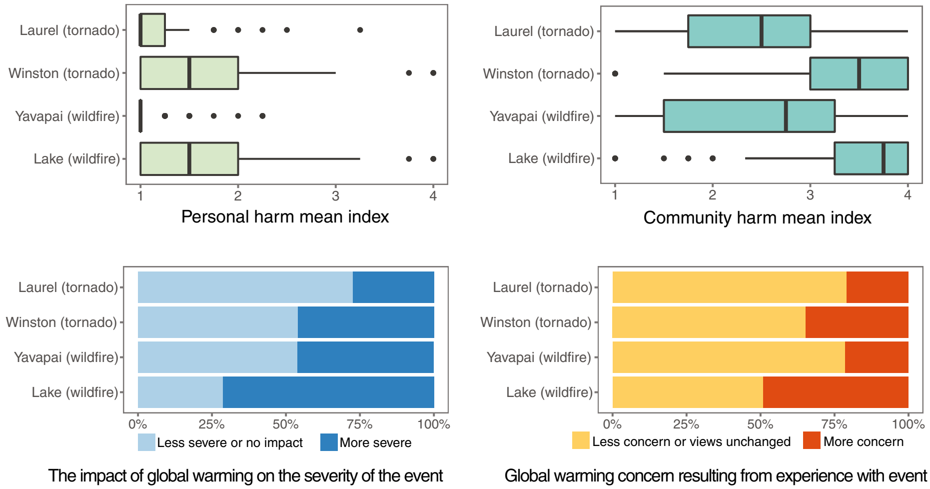

Fig. 2 Harm perceptions and global warming views, per case

(71.3%), while less than one third of Laurel respondents (27.4%) thought this about the tornado. We observed a similar pattern for increases in global warming concern resulting from an individual's experience with the event, with half of Lake respondents (49.0%) reporting more concern, compared to less than one quarter of Laurel (20.8%) and Yavapai (21.4%) respondents.

We next report two sets of models for explaining harm (models 1A and 2A) and climate change views (models 1B and 2B). Both sets of models include the same demographic variables, proximity measure, and case controls. The dependent variables for the first set of models, personal and community harm, are included as independent (fixed effects) variables in the second set of climate change belief models.

3.2 Proximity to event

We first consider the relationship between our two measures of harm, community and personal, to respondent proximity to the event (Table 2). For the personal harm model (1A), respondent proximity to the event is statistically significant: those located closer to the extreme weather event reported more personal harm. The effect of proximity on a respondent's personal harm has a higher magnitude effect than all other standardized individual level factors (model 1A). Unlike the personal harm model, proximity to the event is not significant when modeling community harm (model 2A). Similarly, when modeling our climate change belief variables, severity and concern (model 1B and model 2B), we found no significant relationships between respondent proximity to the event and climate change views. Therefore, we accept the hypothesis that respondents more proximate to the event reported more personal harm (H1a) and reject all other hypotheses related to respondent proximity (H1b-d).

3.3 Community- and event-specific characteristics

We next consider community-specific factors that contributed to the variation in the models for harm and climate change views (Table 2). For modeling personal and community harm (models 1A and 2A), case-specific characteristics are important, with those from Lake County

Table 2 Multilevel regression models of harm and climate change views

	Multilevel linear regressions[1]				Multilevel logistic regressions[1]			
	Personal harm		Community harm		Severity		Concern	
	Model 1A		Model 2A		Model 1B		Model 2B	
	Estimate[2]	*P* value	Estimate[2]	*P* value	Estimate[3]	*P* value	Estimate[3]	*P* value
Demographics								
Female (vs. male)	0.118*	0.037	0.030	0.716	− 0.028	0.916	− 0.082	0.742
White (vs. nonwhite)	− 0.108	0.185	0.272*	0.024	− 0.753	0.060	− 1.081**	0.002
Age	− 0.142*	0.012	0.131	0.113	− 0.519*	0.049	0.007	0.978
Income	− 0.001	0.991	− 0.005	0.954	− 0.666*	0.013	− 0.774**	0.005
Bachelor's or higher	0.011	0.849	0.150	0.084	− 0.235	0.41	0.154	0.553
Political ideology (conservative → liberal)	0.029	0.619	0.106	0.221	1.797***	0.000	0.862**	0.001
Perceived harm								
Personal harm	–	–	–	–	0.621	0.052	0.643*	0.021
Community harm	–	–	–	–	0.608*	0.044	0.493	0.103
Geographic and case controls								
Proximity	− 0.487***	0.000	− 0.046	0.682	0.333	0.458	0.417	0.233
Winston (vs. Laurel)	0.338*	0.020	1.001***	0.000	0.451	0.449	− 0.092	0.847
Yapavai (vs. Laurel)	0.224	0.054	0.056	0.698	0.798	0.136	− 0.424	0.359
Lake (vs. Laurel)	0.396**	0.002	1.056***	0.000	1.520**	0.006	0.485	0.269
Intercept	1.463***	0.000	3.032***	0.000	0.164	0.311	− 0.719***	0.000
Random effects	Variance	Std. dev.	Variance	Std. dev.	Variance	Std. dev.	Variance	Std. dev.
ZIP codes (intercept)	0.004	0.066	0.000	0.000	0.155	0.393	0.000	0.000
Akaike Information Criterion	679.413		986.675		430.291		456.532	
N	398		401		374		384	

Corresponding significance levels are $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

[1] Fixed effects variables were standardized by centering and dividing by two standard deviations

[2] Estimates are linear coefficients

[3] Estimates are logit coefficients

and Winston County reporting more perceived personal harm than the reference case, Laurel County. As with our models of personal harm, respondents from both Lake and Winston Counties reported higher levels of community harm. For these harm models, case controls had the highest magnitude effect compared to other standardized variables.

For the influence of case-specific characteristics on whether a respondent believed the event was made more severe by global warming (*severity*) and whether experience with the event made the respondent more concerned about global warming (*concern*), we only observed one significant relationship: Lake County respondents were more likely to report that global warming made the event more severe. No significant relationships between case identification and concern about global warming were found.

3.4 Personal and community harm

Finally, we considered whether there was an association between our measures of personal and community harm and our climate change belief measures of severity and concern. Higher reported levels of community harm were associated with a belief that global warming made the event more severe, while personal harm was not significant (model 1B). The opposite effect was observed for concern about global warming, with those reporting higher levels of personal harm having more concern about global warming, whereas the effect of community harm was not significant (model 2B). Therefore, we accept the hypothesis that global warming concern is positively associated with perceptions of harm, but only for two of the four proposed hypotheses.

H4: Respondents with higher levels of perceived *personal* harm will be more likely to report that:

H4a. The event was made more severe by global warming. **(REJECT)**
H4b. They are more concerned about global warming based on their experience. **(ACCEPT)**

H5: Respondents with higher levels of perceived *community* harm will be more likely to report that:

H5a. The event was made more severe by global warming. **(ACCEPT)**
H5b. They are more concerned about global warming based on their experience. **(REJECT)**

4 Discussion

In terms of personal and community harm, our descriptive results, somewhat unsurprisingly, show that those events that hit populated areas in Lake and Winston Counties resulted in more reported personal and community harm by respondents. From our models, the importance of respondent proximity—and the insignificance of political ideology—in shaping reports of personal harm indicates that motivated reasoning may not be influencing responses about perceived harm in our cases. Moreover, the significance of our place-based controls in shaping reporting about community harm in Lake and Winston Counties also seems apt given what we know about the widespread impact of these two events on populated areas compared to the other two cases. These results suggest that our respondents seem to be quite good at both placing themselves correctly in the "shadow of experience" of an extreme weather event (Howe et al. 2014), as well as assessing overall community harm resulting from an event. We note, however, that these two events are also the most recent, so higher levels of reported harm may also be related to their temporal proximity.

Translating reported harm into changes in climate change concern, however, appears to be less straightforward and more event and context dependent. Again, from our descriptive results, only a minority of respondents in each of our cases reported being more concerned about climate change post-event. Even for Lake County, the case where the most respondents reported that their experience with the wildfire made them more concerned about climate change, only slightly less than half (49%) did so. A case study of changes in climate change concern post-flooding in Boulder County, Colorado, also found little self-reported change in concern post-event—in that case largely because respondents there were already concerned about climate change pre-flood (Shepard et al. 2018). In contrast, a higher percentage of respondents in each case were more willing to attribute the severity of the event to climate change, even in our more conservative counties. This finding suggests that climate change communicators may want to focus on the connection between climate change and event severity.

Moving beyond descriptive results to our models of whether respondents thought climate change made the event more severe (*severity*) and whether their experience made them more concerned (*concern*), political ideology dominates; event proximity is irrelevant. These findings suggest the importance of motivated reasoning in individual interpretations of extreme weather events (Myers et al. 2013; Hamilton et al. 2015; Borick and Rabe 2017). Yet, despite ideologically motivated interpretations of events, for the cases that we examined, harm also matters for our measures of *severity* and *concern*, indicating a potential theoretical model in which the impact of personal experience of extreme weather on changes in climate change concern is mediated and/or moderated by the personal harm caused by the event. While our mediation and moderation analyses did not uncover significant relationships, this finding may be related to sample size. Future research should further examine these relationships between harm, political ideology, and climate change views with larger samples and more varied settings and contexts.

In terms of the role of event- and context-specific factors, our descriptive results seem to suggest that event type matters less than its harm and community context for climate change views, though we cannot specifically test this without additional cases. For example, if we compare our survey results in Lake and Yavapai Counties, both of which experienced wildfires, we find vastly different responses to our questions about *severity* and *concern* post-event. Unfortunately, with only four cases, we cannot say whether this difference is related to community context, the event's impacts, or some other place-based factor. What we can say is that two different communities can experience the same type of event and interpret it—in terms of its relationship with climate change—very differently. Worth highlighting is the exceptional nature of our Lake County respondents—our place-based control for this location is significant in three of the four models.

In sum, while we find evidence that personal experience with an extreme weather event can impact views about climate change, these findings were not uniform across the four cases. Respondents in some counties readily made connections, while those in others did not. We showed that while being closer to an extreme weather event resulted in higher levels of reported personal harm, this proximity measure did not translate to altered climate change views, suggesting that proximity alone was not a crucial factor in the cases we studied. Somewhat paradoxically, we found that harm was related to increased attribution of the severity of the event to climate change *and* increased reporting of being more concerned about climate change post-event. Thus, harm from the event could be important for connecting extreme weather experience with views about climate change.

As previously noted, the extreme weather event types that we examined in this study have relatively low scientific attribution compared to other extreme weather events, such as extreme heat or cold events (National Academies 2016). In terms of how scientific event attribution aligns with respondent perceptions (RQ1), in only one of our cases, the Valley Fire in Lake County, did scientists connect a pre-fire drought to climate change, with some in the scientific community arguing that these drought conditions increased the severity of the wildfire (Magill 2015). However, while Lake County respondents readily connected event severity to climate change, any apparent alignment of the scientific community with Lake respondents' perceptions is challenging to assess given our limited cases. Moreover, it is also possible that survey participants in our other three cases could be reflecting the relatively low levels of scientific attribution for wildfires and tornadoes in their responses.

Our selection of wildfire and tornado events was in many ways a practical one: while extreme heat and cold events have greater scientific confidence in attribution to climate change, these events are usually distributed across time and have less discrete impacts associated with them. Indeed, previous research on self-reports of personal experience of extreme weather has found that the public is better able to recall and report the experience of a discrete event like a hurricane or tornado, as compared to an event that evolves across a longer time scale and larger geographic extent, like a drought (Howe et al. 2014). This potential disconnect between an extreme weather event's memorability and its attribution to climate change could present obstacles for climate change communication post-event and deserves further study.

As opposed to other research that considers many distributed events of varying magnitude, we focused on events that resulted in substantial community losses. This distinguishes our work from prior research that includes weather events that might not have a perceptible or impactful effect on the individual or community. What this research was unable to address is a respondent's view prior to the event, although we utilize downscaled climate opinion estimates for comparison. Additionally, some of our findings may be driven by the time dependency of the event (Deryugina 2013), with the most recent cases (Lake and Winston) reporting the highest levels of change in climate change concern. Socio-demographic composition of the communities could also be driving this, with relatively higher percentages of Democrats—a strong explanatory factor in climate change views—in both these locations.

If policymakers and scholars are looking to turn extreme weather events into teachable moments, the educational window appears to be context dependent, at least for the cases explored in this study. In only one of our cases, a 2015 wildfire in Lake County, California, did we detect a discernable influence on climate change concerns from the event. From our fieldwork, we know that this was a community that had already experienced multiple extreme wildfires, drought, and heat events, where belief in climate change was already high, where the most populated areas of the county were particularly impacted by the event, and that was located in a state with a Governor willing to explicitly describe the event in terms of climate change. So while extreme weather events are predicted to become more frequent and more severe across time, connections might only be made in "most likely" communities—where an event attributable to climate change causes significant harm, belief in climate change is already high, and elites frame the event in those terms. Although we agree that extreme weather can provide policy-focusing events for mitigating and building adaptive capacity to future climate change (Shepard et al. 2018), this impact appears to be heterogeneous and limited to certain community contexts, namely, those with a higher propensity to believe in climate change and those where climate-related extreme weather events cause substantial harm to individuals and the community.

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