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Promoting Concern for Climate Change: A Q Method Study of Wildfire Photographs

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Abstract

Public concern regarding climate change in the United States lags far behind expert consensus that climate change is one of the most pressing issues of our time. Climate-fueled wildfire has significant negative consequences for life, property, and ecosystems in most regions of the American West. As a climate-fueled natural hazard that is heavily photographed, nationally reported, and widely discussed on social media seasonally, wildfire presents a regular opportunity to promote concern for climate change nationally. This paper uses visual framing theory to identify frames present in photos shared on social media during the 2018 Camp Fire, and uses Q method to determine which of those visual frames elicited most concern for climate change.

Keywords: wildfire, visual framing, photography, q method, climate change

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Introduction

On November 8, 2018, a wildfire started near Camp Creek Road in Butte County, northern California. Under dry and windy conditions, the Camp Fire spread rapidly. It eventually became the most destructive wildfire in California and the deadliest U.S. wildfire in a century, causing 85 civilian fatalities, burning over 150,000 acres and more than 13,000 homes (Incident Information System, 2018). As a growing natural hazard, wildfire has significant consequences for life, property and ecosystems in most regions of the American West. Wildfires negatively impact air quality, watershed function, wildlife habitat, economic livelihoods, the physical safety of residents, and the places they live (Thomas et al., 2017; Westerling, et al., 2011). These harms are accelerated by climate change. Wildfires have been found to have burned twice as much area in the western U.S. as could have been expected without human-caused climate change over the last several decades (Gonzalez et al., 2018; Harvey, 2016). Larger, more frequent, and more severe fires are expected to continue into the future due to global warming (Barbero et al., 2015; Harvey, 2016; Westerling et al., 2011). As well as being exacerbated by climate global warming, wildfires also contribute to it by emitting large amounts of carbon dioxide (Gonzalez et al., 2018). For example, the spate of bushfires in Australia over the 2019 summer has been calculated to have emitted the same amount of carbon dioxide in five months as the total human-caused carbon dioxide release in Australia over the previous 100 years.

Despite the expert consensus that climate change is one of the most pressing issues of our time, one that will inevitably wreak havoc on economic growth, food security, and social stability, climate change is of concern to a surprisingly small proportion of Americans. As climate-fueled natural hazards that are heavily photographed, nationally reported, and widely discussed on social media seasonally, wildfire events present a regular opportunity to promote

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concern for climate change among the general public in the United States. In particular, journalistic coverage of wildfires on social media presents a unique opportunity to reduce the consensus gap between scientists and the general public concerning climate change (Cordner & Schwartz, 2019). Journalists have been slow to harness this opportunity; there are a lack of climate change perspectives in media coverage of wildfires generally (Gonzalez et al., 2018). The consequence of reporting on social media about wildfires without promoting concern for climate change is that it becomes harder for policy makers and advocacy groups to harness public understanding and gain support for issue-related policy agendas (Crow et al., 2017).

Presently, the understanding of how photographs related to wildfires impact public concern for climate change is limited (Chapman et al., 2016; Duan et al., 2019). Most wildfire communication research (Lidskog, Johansson, & Sjödin, 2019) and climate change communication research (Berglez & Lidskog, 2019) focuses on information and perspectives contained within the textual portions of journalistic news coverage. This is despite the widespread acknowledgement across the interdisciplinary literature of the importance and prominence of photographs in reporting on wildfires (DiFrancesco & Young, 2011; Hopke & Hestres, 2018; O'Neill & Smith, 2014). Addressing the intersection between wildfire reporting, climate change communication and images shared on social media, our study takes an initial and important step to examine how photographs of wildfires shared on social media immediately after a major wildfire affect public perceptions of climate change. Specifically, we build upon visual framing theory (Geise, 2017) and use a Q methodology to investigate which photographs of California's Camp Fire shared on Twitter evoke most concern for climate change.

Overall, our study explains how visual photographic representations of disasters such as wildfire can be integrated into effective climate change communication research. We examine

the effectiveness of wildfire photographic frames in relation to climate change concerns, contributing to the theoretical understanding of visuals' framing effects, a relatively underdeveloped area in environmental communication (Chapman et al., 2016; Feldman & Hart, 2018). Findings could also offer practical advice regarding how to promote effective visual strategies for climate change communication and disaster coping efforts.

Literature Review

Social Media and Visual Disaster Communication

Today, visuals play a prominent role in the public information process in our society. In particular, during natural disasters, visuals create stories, and the public construe the scope, truth, implication of the disasters through them (Ali & Mahmood, 2013). Scholars have recently started to explore the power of visuals, the meanings they create, and how they influence the public's disaster responses (Bica, Palen, & Bopp, 2017). Visual communication of disasters has been examined from emotional perspectives (Jaspal & Nerlich, 2014), perspective of visual framing (e.g., flood, Ali & Mahmood, 2013), audiences' image-sharing behaviors on social media (e.g., Ebola, Seltzer et al., 2015), race in the visuals (e.g., Hurricane Katrina, Kahle, Yu, & Whiteside, 2007), as well as the differential influence of photographic versus "iconic" visual representations (i.e., maps) on disaster risk perceptions (Rickard et al., 2017). Visual communication of disasters has also been approached from the perspective of visual rhetoric, which studies the persuasive effects implicit within visual elements such as composition, color, representation, and visual framing. Overall, both visual rhetoric (Richards, 2018; Walsh, 2015) and empirical studies of similar visual materials (Kain & Covi, 2013) have found that the visual rhetoric of disasters communicates a message that is alienating, confusing, or harmful for non-expert viewers. Given

that visuals are used ubiquitously to represent natural disasters and in general produce stronger framing effects than texts (Powell, Boomgaarden, De Swert, & de Vreese, 2015), researchers increasingly call for more studies on visual disaster communication effectiveness and its subsequent influence on public perceptions of climate change (Maes, 2017; Sheppard, 2005).

In the past decade, with the rise of social media, there have also been rapid shifts in the way that visuals are communicated (Hopke & Hestres, 2018; Wang et al., 2018). Specifically, as a natural disaster was unfolding, people post photographs and streaming videos on Twitter to show how their neighborhoods are being affected; officials use Twitter to share warning messages with the public. Photographs are central to Twitter use during natural disasters, as they tell real-time impacts, reflect participants' perspectives, and disaster relief efforts. Compared to texts, photographs on Twitter have proven to be able to more deeply engage with the audience who follow the issue updates (Cooper, 2013). Despite that Twitter photographs' emotion-inducing power and their involvement of diverse frames from professional media organizations and nonprofessional tweeters fundamentally impact how people understand the disaster (Mortensen, Hull, & Boling, 2017), the majority of the visual framing studies focus on photographs in the mainstream media. We believe how people perceive disaster photography on Twitter during difficult times warrants research exploration (Bica et al., 2017; Mortensen et al., 2017), as it has broad significance for disaster coping and relief efforts. Therefore, in this study, we examine Twitter photographs of the 2018 Camp Fire.

Disaster Imagery and Concern for Climate Change

Journalistic use of wildfire visual communication

Fire professionals and scholars have acknowledged that the media are an important information source that the public rely on to collectively understand and respond to wildfire disasters (Paveglio, Norton, & Carroll, 2011). Traditionally, scholarship in the field of wildfire and media communication has primarily focused on text-based framing (Paveglio et al., 2011), event-driven issue-attention cycles (Crow et al., 2017), ignored topics (e.g., climate change) and individual voices (e.g., the perspectives of the affected residents, Cordner & Schwartz, 2019). Despite growing investigation into media coverage of wildfires, little research has been conducted to explore the efficacy of wildfire photography. And the limited available evidence suggests that citizens contribute to the reporting of wildfire by producing visual mapping information using mobile devices (Gillette et al., 2007). Maps and warning illustrations can effectively fulfill people's informational needs, providing them increased understanding of the risk (Cao et al., 2017). However, in addition to the iconic images (maps and illustrations), there are also indexical images such as photos of on-the-ground conditions (Messaris, 1994), aerial and satellite photography (Eosco, 2015). The *effects* of such photographic representations of wildfire may have important implications for visual disaster communication efforts (Bica et al., 2017) yet remain unclear, which we explore in this study.

Do disaster photographs promote concern for climate change?

Climate change is hard to visually communicate in a way that effectively mobilizes the public, since the issue, by nature, is complex, abstract and evolves slowly across time. Wang et al. (2018) have argued that photographs of the immediate disastrous impacts of climate change and the catastrophic scenes of climate-fueled natural disasters (e.g., wildfire) might significantly increase people's *climate change concern*, a desirable outcome that not only represents

successful apprehension of the risk, but also indicates more likelihood of people taking mitigative actions (Stevenson & Peterson, 2016).

To date, disaster photographs of local impacts of climate change (e.g., heatwaves) have been found to be more effective than global iconic motifs (e.g., polar bears) in encouraging concern (Baldwin & Chandler, 2010; Schroth et al., 2014). Also, composite photographs depicting "what if" scenarios (showing the future consequences of climate change) have promoted concern about climate change, at least in the short term (Hart & Leiserowitz, 2009). However, some affective disaster photographs could lead to "climate change fatigue," since individuals may become desensitized to fear appeals in the photographs (O'Neill & Nicholson-Cole, 2009). In one study, disaster imagery was found to be irrelevant to the accompanying textual information (Jerry & Atieno, 2016) and was therefore ineffective at fostering issue concern.

Considering these studies together, it is apparent that a large range of types of visual appeals are used in photos for encouraging concern for climate change. Considering the mixed evidence, and as suggested by Wang et al. (2018), we believe a more nuanced understanding of what types or elements of disaster photographic frames evoke climate change concern is warranted, as it could clarify how to most effectively use visual framing strategies to promote public concern for climate change. In an attempt to gain some clarity, our study uses the lens of visual framing theory and the exemplification theory to explore the nuances in effective visual communication of climate change and climate-fueled wildfire disaster.

Visual Framing

Framing is a communication practice whereby communicative elements are coordinated into a storyline, or frame, to "set a specific train of thought in motion, communicating why an issue might be a problem, who or what might be responsible for it, and what should be done about it" (Nisbet, 2009). Framing is also an interdisciplinary research area in which frames are both identified embedded implicitly within communications, and explicitly crafted to improve communication efficacy. Although framing theory and practice has received extensive attention in media research, the idea of *visual* framing continues to be underdeveloped (Cacciatore et al., 2016). Visual framing involves coordination of composition, content, contrast, form, light, and movement into a visual storyline or narrative "to promote a specific interpretation of events conducted either consciously or subconsciously" (Huang & Fahmy, 2013, p.195). Dahmen and Miller (2012) explain that visual frames can become iconic and representative of the totality of the event. Unlike words that require cognitive load, visual frames are less intrusive (Rodriguez & Dimitrova, 2011) and potentially more implicitly persuasive. They appeal to reason and emotion concurrently, and can thereby positively prime people viewing news stories, raising the accessibility of subsequent cognitive information processing (Erisen, Lodge, & Taber, 2014; Geise & Baden, 2014). Such "amplifying effect" implies that photographs employing considered visual frames can be more easily, quickly, and deeply integrated into people's memory, leading to greater framing effects than text (Baden & Lecheler, 2012).

In today's multimodal media reality (Coleman, 2010), visual depictions, particularly photographs, are used ubiquitously to illustrate climate change and natural disasters. Prior research has examined various visual frames of disasters, their frequency and changing patterns across time in the media (e.g., Borah, 2009). For example, Miller and LaPoe (2016) found that visual frames of the BP oil disaster on televisions changed over time as the disaster shifted from

breaking to sustained coverage. In the reporting of Hurricane Katrina, the media were found to portray the survivors and ground rescue teams most frequently (Fahmy et al., 2007). In a contradiction, on social media, the visual coverage of the 2015 South Carolina flood put more emphasis on the pragmatic frames (e.g., aerial shots, physical destruction, officials) rather than the human interest or relief work frames (Mortensen et al., 2017).

Recently, there are repeated calls for scholarship that focuses on the *effect* of these identified visual frames, especially how they help shape public perceptions of and engagement with climate change (Chapman et al., 2016; Metag et al., 2016). In this developing area, scholars have claimed that locally-framed images that featured local impacts and disasters can provide a realistic feeling and thus foster climate change concern and engagement (Bolsen et al., 2018; Retchless, 2018). Similarly, Bloodhart et al (2015) found that photographs of local extreme weather and catastrophic events could make people feel more concerned about climate change. However, humans in the visual frames such as politicians, campaigners and protesters might lead to a disconnection between the issue and the public (Corner, Webster, & Teriete, 2015). In general, different disaster visual frames might encourage different levels of concern about climate change, and which exact visual frames of disasters encourage or discourage people's climate change concerns is worth further research exploration.

Imagery has become an important framing device in climate change disaster communication. Until now, however, there has been little research that focuses on *photographs'* powerful framing effect on societal understandings of these natural hazards and their relationships with climate change, and there has been a lack of understanding of how disasters are visually framed on social media, an environment that involves both professional and non-professional photographers (Mortensen et al., 2017). To explore this new direction, our project

uses California's Camp Fire as a case study, addressing how such wildfire photographs with various frames shared on social media (Twitter) affect people's climate change concern. We proposed a Q method study to identify the typology of viewpoints toward the wildfire visual frames and their effectiveness in raising climate change concern, which contributes to the theoretical aspects of visual framing effects and the empirical research of effective visual communication of disaster and climate change. Given the important social implications, there is a need to identify visual communication strategies that effectively mobilize the public to concern for wildfire disaster and climate change. Therefore, we proposed the following research question:

Research Question: Which wildfire visual frames elicit the most concern for climate change?

Q Methodology

Q methodology empirically identifies groupings of participants' shared worldviews or social perspectives (Sneegas, 2019). In this study we employ visual Q method to gauge community perceptions, which has been used by prior researchers examining which photographs engage people with environmental issues (e.g., climate change, O'Neill et al., 2013; wind farms, Beckham Hooff et al., 2017; stream restoration, Nost, et al., 2019; water management, Schultz, Fielding, & Newton, 2018). In Q studies that bridge qualitative and quantitative approaches, participants are asked to indicate their personal point of view by rank ordering their preferences holistically (i.e., relative to one another) among a given a range of stimuli; in this case, photographs. After sorting by all participants is complete, Q factor analysis and qualitative analysis enable researchers to identify patterns or shared viewpoints between the participant's orderings on a specific topic.

Performing a Q study typically involves six steps: selection of the study concourse (identifying the appropriate stimuli related to the topic of investigation), development of the Q sample (refining the stimuli used for data collection), selection of the study participants, Q-sorting procedure (participants rank the selected stimuli), correlation and factor analysis (discovering similarities and dissimilarities among participants' viewpoints), and interpretation (participant interviews) (Watts & Stenner, 2012).

Definition of the concourse

The concourse refers to "the flow of communicability surrounding any topic (Brown, 1993, p. 94)." To search for the concourse on California's Camp Fire, we used the keywords "camp" and "fire". This case-insensitive search strategy finds image tweets that may have been posted only with the #CampFire hashtag as well as image tweets that may have been accompanied by text mentioning the Camp Fire but did not use the hashtag. A small number of unrelated tweets were retrieved and removed due to the broad nature of the search. In the cases of tweets with multiple images, only the first biggest image that was most prominently featured was harvested. The search gathered all public Tweets posted during the Camp Fire period (Nov, 8th, 2018 ~ Nov, 25th, 2018). This resulted in a collection of 1,045 images, which was further filtered in the following two ways: First, to most effectively answer our research question, only images that could be clearly identified as photographs were included, and an image was considered to be photographic only if two thirds or more of the surface area of the image contained unobscured photographic content. Second, all photographs included in the concourse contained fire-related content (e.g., fire, smoke, fire damage) or text indicating the photo was related to the fire,

regardless of whether the tweet itself explicitly mentioned climate change. Our final concourse consists of 464 photographs.

Development of the Q sample

Independent screening by four experts

Consistent with other Q research, the authors refined the concourse using their respective fields of expertise. The goal of this process is to reflect the full range of visual frames observed in the concourse. The researchers' fields of expertise included: visual communication efficacy, science communication, risk perception, and Q methodology. To initiate narrowing the concourse, each author individually selected 15-40 photographs representative of the concourse, using methods and criteria from their respective fields. One author used quantitative content analysis to search for manifest, denotative framing categorizations. Two authors used a mixed methods approach where they combined quantitative selection of manifest, denotative frames and perspective types with qualitative thematic content analysis. The remaining author used the qualitative approach of discursive content analysis to identify discourses and discursive components within the photographs. This stage of the independent selection of the Q sample allowed the experts to identify frames from the perspective of their unique expertise and disciplines without influence from their collaborators' fields.

Collective screening by experts

The authors then combined their representative photographs in one pool and used this set of 84 images as the basis for a collective decision-making process to narrow down the remaining selections. For each image in the pool, the number of times an image was selected was recorded.

Photographs selected by more than one expert were included in the final image selection automatically. Even in cases where an image wasn't selected by multiple experts, in many cases each expert had selected a similar image, so the discussion process focused on deciding which image was most representative of that particular theme in the concourse. Using this process, the Q sample was narrowed down to 49 photographs that met the collectively established inclusion criteria, which was the balanced representation of the many visual frames in the concourse combined with the experts' knowledge about which types of visual frames contained sub-frames. Deliberation also focused on representing multiple types of visual frames: not just pragmatic frames (e.g., aerial/on-the-ground photographs that show physical destruction), but valence/emotional frames (e.g., well-composed photographs, photographs that represented common culture memes). This stage of the selection of the Q sample allowed the final selection to be influenced by the methods and criteria from each field, while also being reduced to a manageable number that follows a Q method criterion.

Screening photographs for veracity and frame distribution

The 49 selected photographs were then subjected to a reverse image search to confirm that they depicted the Camp Fire, not the other fires, and to verify that they were not from any known "fake news" sources. The remaining images were also re-checked to confirm that they well represented the span of frames in the original concourse. A total of 44 photographs were finally retained as Q sample.

Selection of the study participants

Q study requires a (small) number of participants who are theoretically relevant to the topic of the study (Brown, 1980). This study included 38 participants who volunteered to participate. All recruitment took place at a public location at a mid-sized university in the western United States during September and October 2019. In an effort to protect potential participants from undue harm, participants who have been negatively affected by fire and those who indicated they would be disturbed by seeing wildfire images were excluded. A total of 38 participants completed the face-to-face Q interviews, and the sorting of 44 Q-sample photographs among 38 participants is in line with the Q study criteria (Brown, 1980).

The Q interviews

During the interviews, participants were guided through a ranking procedure leading to the arrangement of all the 44 Q set photographs onto a sorting grid (See Figure 1 for the sorting grid) labelled from "most concerned" to "least concerned." Each image was sorted according to the statement "To what extent does this photograph make me concerned about climate change?" At the end of the sorting, participants were asked to give feedback on the sorting process, why the photographs on the left and right ends made them least concerned and most concerned about climate change, respectively. Each interview took approximately 35-45 minutes to complete.

Figure 1 *here*

Results

We collected a total of 38 sorts from 38 participant interviews. Q-method typically uses small sample sizes; this does not bias the results, since the primary goal is to reveal a typology of viewpoints rather than exploring proportional sample distribution within a large population (Brown, 1993). Q factor analysis was (McKeown & Thomas, 2013) then conducted using

principal component analysis and varimax rotation in KenQ Analysis Software (Version 1.0.6) (Banasick, 2019). Each of the 38 Q-sorts were intercorrelated with all the others to identify significant differences and areas of consensus among participants. After examining several possible solutions, we decided to select the three-factor solution as it obtains the most meaningful and coherent factors and accounts for the largest number of sorts (34 out of 38 sorts, 89.5%) with the simplest structure, and it explains 53% of the variance in the Q sorts. These three divergent viewpoints (i.e., factors) included: 1) Urgent, catastrophic impacts of burning (hereafter "Catastrophic Impacts," e.g., burning house), 2) Environmental impacts of wildfire (hereafter "Environmental Impacts," e.g., smoky landscapes), and 3) Social impacts of wildfire (hereafter "Social Impacts," e.g., individual human or animal injuries, losses or suffering). Each factor represents the generalized view of a subgroup of participants (Q sorts) who reacted similarly regarding which photographs provoke the most climate change concern. Table 1 reports the details on the three factors for all the photographs. General statistics of the three factors we extracted and rotated are presented in Table 2. We summarized the three different dominant factor viewpoints below.

Table 1 *here*

Table 2 *here*

Factor 1 – Catastrophic Impacts

We labeled Factor 1 (17 participants) as "Urgent, catastrophic impacts of burning." This generalized viewpoint (i.e., factor) is characterized by defining photographs with negative-valence frames such as a burning house, burning cars, a firefighter with burning structures, a child near a burned house, and an empty street with burning. Based on the post-sort interviews,

common reasoning for these negatively-framed burning photographs being the most concerning ones was that the immediate impact was evident, threatening. Fire is an imminent threat, frightening by nature. The fire or burning related impact frames show the disaster scenes, making climate change impacts seem more obvious and powerful (e.g., "Anytime I see fire, I feel personally concerned…" Participant 1, Image 18; "This image shows nothing left. It is scary how the fires that happen can take things away so fast. There's nothing left and a lot of sadness in the picture..." Participant 27, Image 11; "The image is scary and looks like total destruction..." Participant 30, Image 42; "This shows a lot of carnage and destruction…demonstrates the scale of the problem," Participant 16, Image 36). Furthermore, for this group of people, catastrophic fires trigger concerns about the "what ifs" scenario (i.e., extreme disasters are urgent and will exacerbate if we do not take actions to address climate change) (e.g., "The image illustrates what it would be like to be in a disaster exacerbated by climate change. The risk of being trapped by a disaster like this would be very concerning." Participant 23, Image 42). Lastly, the fire burning scene was the most concerning also because the photographs clearly show evidence the burning is actively and adversely affecting the built environment such as cars, homes and other properties (e.g., "It is related to me, as the burning destroys human properties such as cars and homes," Participant 20, Image 36).

Factor 2 - Environmental Impacts

We labeled Factor 2 (11 participants) as "Environmental impacts of wildfire (i.e. smoky landscapes)" as it is characterized by defining photographic frames such as a lone burned tree on a charred landscape, a time lapse of fire smoke, and an aerial view of football stadium surrounded by smoke. For people significantly associated with this point of view (i.e., factor),

wildfire photographs that highlight the destroyed landscape, ecosystem destruction and the overall smoky air to the entire city/environment can trigger most concern for climate change. Overall, this perspective is more worried about the *pragmatic visual frame* – the long-term physical damage that wildfire might bring to the ecosystem. Many of the participants aligned with this view used the keywords such as vastness, widespread, entire ecosystem, and wiped-out landscape when describing why these photographs were the most concerning ones (e.g., "That is a barren landscape… large scale and vast devastating effects," Participant 29, Image 2; "The image makes me think of no life remaining...wiped out landscape shows the devastation…" Participant 19, Image 33). Specifically, some participants noted they were concerned about the health impacts of such widespread smoke, the health problems in relation to CO2 emissions and climate change in general ("...Smoke is a huge concern for air quality and health," Participant 26, Image 32; "Images related to air quality is the most concerning and relatable," Participant 38, Image 15). Moreover, some of these people felt concerned about climate change because these smoky landscape photographs use smoke to signify that CO2 emissions resulting from widespread wildfires could further contribute to the increased warming of the climate (e.g., "With disasters like wildfire that emit greenhouse gases and damage ecosystems, climate change will grow into a bigger issue..." Participant 38, Image 15). Last, people associated with this factor thought photographs that pragmatically framed large-scale environmental impacts of wildfire triggered most concern because they were fact-based and thus more convincing than the emotional and arousing ones ("The Time lapse of fire smoke is fact-based. It clearly presents the data on how quickly the fire/smoke expanded. I was convinced by this data...The other fire burning photos are not as informative as this one. The other people getting hurt pictures did not show me the information nor the severity of the big-picture situation." Participant 22, Image 43).

Factor 3 - Social Impacts

We labeled Factor 3 (6 participants) as "Social impacts of wildfire: Individual human and animal sufferings." For this point of view (i.e., factor), the defining photographs focused on *human interest frames*, featuring hospital workers evacuating a patient in a bed, an emotional couple in front of burned house, and people holding a cat with bandaged limbs. The people that are significantly aligned with this view were community-oriented, cared for human and animal injuries related to climate change and natural disasters (e.g., "These images involve human lives in critical condition, and I'm concerned," Participant 9, Image 21, Image 44; "This family image makes me think of other families that have been displaced by climate change," Participant 17, Image 21; "I'm concerned with how climate change affects humans and animals…" Participant 21, Image 21; "I am concerned about human-related injuries resulting from climate change," Participant 25, Image 44).

Consensus photographs

The bold entries in Table 1 are the consensus photographs for which all the groups shared the same level of concern at $p > .05$ level. Table 3 below also shows the three factors are correlated, with Catastrophic Impacts (Factors 1) and Environmental Impacts (Factor 2) exhibiting the highest correlation ($R = .5564$). Results indicate that the factor groups broadly agreed on image frames that did *not* evoke climate change concern relative to other photographs in the sample. These photographs included "UC Davis Health doctors (– 3, – 4, – 3, Image 4)," "Displaced victims getting distribution/donation (– 1, – 1, – 1, Image 31)," "Tent city in front of Walmart (– 1, – 2, – 2, Image 12)," "Search and rescue team meeting (– 3, – 3, – 3, Image 8)," etc., most of

which focused on a positive-valence frame (e.g., recovery efforts) and/or an official frame (e.g., officers' meetings or visiting the sites). Participants explained these photographs are not arousing because the charitable efforts and donation scenes promoted a sense of hope, and lacked appeals to empathy. Also, photographs of officers' meetings did not directly show the impacts of fire on local people or the damage of climate change. Participants also agreed upon some photographs that are relatively neutral which scored + 1 or 0 out of the "– 4 to +4" scale, such as "House with collapsing roof from fire (+1, +1, 0, Image 40)," "3 men with hazard suits sifting through debris (+ 1, 0, + 1, Image 6)" and "Burned car and bus (+1, +1, +1, Image 37)."

Table 3 *here*

Discussion

A growing body of climate change communication literature has used experimental approaches to investigate the effect of disaster narratives on people's attitudinal and behavioral responses to climate change (Jones et al., 2017; Schuldt et al., 2018). Complementing and extending these recent studies, we employed an image-based Q sorting method to explore the role of visual framing of wildfire disasters in influencing climate change concern in the context of California's Camp Fire in 2018.

Finding 1: Three visual frames foster concern for climate change

Views on which visual frames in wildfire photography triggered highest levels of concern were divergent; there were three different predominant viewpoints, including photographs of 1) catastrophic impacts, 2) environmental impacts, and 3) social impacts. The conceptual typology

of effective wildfire visual frames found in this paper can be replicated and further examined in future studies of the uses and effects of disaster imagery in climate change engagement. It also contributes to ongoing discussions on effective climate change visual communication by incorporating a disaster-related visual framing perspective and by responding to the recent call for more nuanced visual communication research focusing on what *specific* types and frames of image are most useful in engaging people with climate change (Wang et al., 2018).

Catastrophic Impacts photographs that had negative-valence frames were most primarily associated with the concern for climate change. These photographs showed the immediate ongoing devastation of wildfire, triggered fear, worry and thus concern about the potential exacerbating effects of climate warming in the future. This finding is in line with the broader literature in climate change disaster communication which explained that disastrous imagery and documentaries, especially those that present the consequences of future impacts of climate change, could bring the issue closer to home and therefore raising more concerns, at least in the short term (e.g., The Day After Tomorrow, Hart & Leiserowitz, 2009; Lowe et al., 2006). It also confirms the previous finding by Leiserowitz (2006) which outlined that photographs can engage people at an affective level. However, this affective fear appeal was not considered the most effective in eliciting concern among the other two factors groups, which probably explains why there are mixed findings in the literature regarding whether fear appeals promote a sense of "presence" concern or a feeling of hopelessness and discouragement (Skurka et al., 2018). Future studies may continue to explore how fear appeals in disaster imagery affect different audience groups differently.

The Environmental Impacts factor was also prominent; it focused on the pragmatic frame, showing the fire's damage to the area's air quality, landscapes, and even the entire

ecosystem. Instead of the fearful emotional appeals (Factor 1 - Catastrophic Impacts) or the human interest in the photographs (Factor 3 - Social Impacts), these participants were most convinced by fact-based visual messages, such as the bird's-eye view of the widespread smoke that truthfully presented how such a local fire was far-reaching geographically, the time lapse image of Camp Fire smoke that accurately indicated how fast the fire expanded. For this group of people, negative-valence frames might backlash due to a lack of informativeness. Future research might continue to explore how informative and emotional visual elements might interact in disaster imagery to influence public concern for climate change and how personal characteristics (e.g., numeracy, visual literacy) may impact the process.

The third factor extracted was Social Impacts. It emphasized human interest frames - families' sufferings, health impacts of climate-fueled natural disasters on individual humans and animals. This finding is consistent with the study by Van der Linden, Maibach, and Leiserowitz (2015) and Hine et al. (2016) which explained that climate change messages focusing on personally relevant stories and experiences may make the issue more tangible. It also confirms the finding that ordinary victims in the photographs of climate change could encourage more concern towards such a global issue (O'Neill et al., 2013). Overall, we found human-interest framed visuals highlighting personal relevance have the potential to affectively engage and resonate with certain audiences, presumably people with high altruistic values. How photographs of individual health and suffering emotionally affect a wide audience could be a promising avenue for future research.

This study found some agreement between certain factors on specific photographs, such as Image 38 (aerial image of smoke/fire; Figure 2) which received the highest concerning score (+ 4) among both Environmental Impacts (Factor 2) and Social Impacts (Factor 3) participants

and a positive score (+1) among the Catastrophic Impacts participants (Factor 1). This is consistent with previous Q method studies of climate change photographs that discovered aerial views of flood were among the most salient photographs across different audience groups (Metag et al., 2016). Some other commonalities in terms of photographs' perspective, time, and action were also observed when examining all three factors' ideal arrays. For example, among both Catastrophic Impacts (Factor 1) and Environmental Impacts (Factor 2) participants, photographs rated +3 or +4 were the long-distance photography that were able to capture the vastness of the wildfire disaster. Future research could continue to explore the effectiveness of different point of view visual styles. Last, both Catastrophic Impacts (Factor 1) and Social Impacts (Factor 3) participants rated active process photographs as the highest concerning ones (+3 or +4), such as photographs of rapid movement in the course of medical care or searching through built environment rubble in the aftermath of a fire. This finding could potentially relate to people needing a felt sense of climate change, and combating climate change as being an active, current time-sensitive phenomena comprised of smaller environmental and human activities (e.g., Churchill et al., 2016; Altinay & Williams, 2019). Further research could be done to ascertain whether this concept of "active processes (either human or man-made)" could be replicated in other studies of climate change visual communication.

Finding 2: Confirming prior findings on photographs that seldom elicit concern for climate change

We found evidence that people reached consensus on which visual frames in photographs of wildfire disaster elicited weakest levels of concern for climate change. The finding on the consensus photographs was in line with previous work on which photographs depicting climate change were not engaging (Chapman et al., 2016; O'Neill et al., 2013). This finding shows that

participants across the three subgroups widely agreed on the least concerning photographs of wildfire, which were those that had positive-valence and official frames, showing helping scenes, charity efforts, protesters, and rescue officers. Unexpectedly, although hope is considered as equally important as fear in encouraging active social actions on climate change (Clingerman & Ehret, 2013), in our study's context of eliciting concern for climate change in natural disaster communication, hope was not arousing; it was even viewed as a distraction that disengaged the participants. The result that photographs of officials and campaigners did not resonate is in close accord with climate change communication research. This literature suggests that overusing photographs of protesters and activist campaigns may lead to a reduction in their effectiveness (Chapman et al., 2016) and that politicians featuring prominently in climate change related photographs may make lay audiences feel climate change is less relevant to them (O'Neill et al., 2013).

Implications for visual communication of natural disasters and climate change

These findings have important implications for visual communication of climate-fuelled natural disasters, as outlined below.

Finding 3: Photographs of ordinary people that evoke empathy

The consensus photographs suggest that when professional communicators want to highlight the relationship between a natural disaster and climate change in communication to a broad audience, their message will likely be strengthened by including photographs that depict ordinary people (as opposed to officials, emergency workers, or pets) and that evoke empathy (as opposed to hope, anger, or despair). Professional communication contexts where this finding is relevant

include: current events journalism, science journalism, climate change advocacy, climate communication, and public-oriented science education (for example, museum programs and). will be positively and natural disasters about climate change advocates could feature ordinary people (vs. officials) and highlight empathy (vs. hope) when visually framing climate-fueled natural disasters to resonate with broad audiences.

Finding 4: Depictions of active processes using image compilations

Given the three different ways of thinking about wildfire imagery, to make visual disaster frames more widely engaging and raise climate change concern among diverse audience groups, future visual wildfire communication practitioners could make climate change more salient by using photographs that depict active processes, long-distance perspective, and *combinations* of photographs that depict negatively-framed catastrophic impacts, pragmatically-framed environmental devastation, or human interest frames.

Limitations and opportunities

Our study is not without limitations. First, in Q-method, the study comprehensiveness is achieved primarily through the careful selection of image concourse and representative Q sample photographs rather than the selection of participants. Therefore, the nature of our study is non-representative and applies only to demographics within a western, mid-sized University campus. It is possible that when replicating the study in another cultural or demographic context (e.g., rural community, coastal area), findings on the Q-sorts (i.e., viewpoints) of wildfire imagery and climate change might be different. Future research could continue to replicate the findings with other representative samples using experimental methods to increase the research ecological

validity and take culture, social demographics and other personal factors into account. Furthermore, this study measured climate change concern rather than behavioral intentions. It is likely that even though some types of fear-appeal photographs trigger greater climate change concern, they lead to less self-efficacy and thus less motivation to act. Future studies of visual communication of disasters and climate change should try to find ways to test how one's perceptions of various effective disaster visual frames further lead to different actual climate change behavioral intentions. In addition, future studies could build on Finding 2 to explore visual framing effects of diverse human roles in the disaster or social distance to the humans on public engagement with climate change.

Overall, our study is a first step toward a deeper understanding of the role of photographic frames of wildfire disasters in influencing climate change concern. The study shows the common visual framing practices such as catastrophic burning scenes, photographs of environmental impacts with smoky landscapes, and human and animal interest photographs appeal to different subgroups of people. It is expected that this study will encourage future research on the intersections between visual framing of natural disasters and the effect of disaster frames on climate change engagement. On the one hand, future research could continue to experimentally explore the uses and effects of various *combinations* of the different effective visual frames found in this study to communicate about the concern for climate change in a way that engages all types of people. On the other hand, future research should build on our findings to explore how people with different personal characteristics (i.e., environmentally-friendly values, altruism, numeracy, visual literacy, disaster experiences) might react to these three types of visual frames differently to take the audience segmentation into account while assessing the

effectiveness of various visual framing strategies, and this will further shed light on the nuanced impact that various disaster visual frames may have on the society's concern for climate change.

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Table 1 Wildfire image factor scores for climate change concern

Image ID	Image	Factor 1: Catastrophic Impacts: Extreme burning	Factor 2: Environmental Impacts: Panoramic view of smoky landscapes	Factor 3: Social Impacts: Individual human animal sufferings	Z score variance
1	Two firefighters near burning house	+ 2	0	+ 1	0.096
2	Lone burned tree on charred landscape	0	+ 3 **	– 1	1.041
3	'We shoot looters dead' sign	– 1	– 2	+ 1 **	0.266
4	**UC Davis Health doctors**	**– 3**	**– 4**	**– 3**	**0.012**
5	Tent full of food for victims	– 2	– 3	– 2	0.067
6	**3 men with hazard suits sifting through debris**	**+ 1**	**0**	**+ 1**	**0.023**
7	Cat with bandaged limbs	0	– 1	+ 3 **	0.639
8	**Search and rescue team meeting**	**– 3**	**– 3**	**– 3**	**0.009**
9	Cop cars with black smoke in background	0	+ 2 **	– 2	0.469
10	Hillside engulfed in fire	+ 4	+ 4	+ 1	0.281
11	Child standing in debris of burned house	+ 3 **	0	+ 1	0.245
12	**Tent city in front of Walmart**	**– 1**	**– 2**	**– 2**	**0.039**
13	Dog searching in burned vehicle	+ 1 *	0	0	0.07
14	Emotional couple in front of burned house	0	– 1	+ 3 **	0.344
15	Couple with coffee, wearing smoke masks	– 2	+ 1 **	0	0.529
16	Lady crying holding cat	– 2	– 3	0	0.519
17	Burned block of houses	+ 3	+ 2	+ 1	0.112
18	Single firefighter in front of burning structure	+ 3 **	+ 1	+ 2	0.173
19	Dinosaur wearing smoke mask	– 4	– 2	– 4	0.246
20	Volunteers making salads	– 3	– 4	– 3	0.156
21	Family displaced by the fire sleeping in car	– 2	– 2	+ 2 **	1.101
22	Before and after of skyline	– 4	+ 3	+ 2	1.697
23	Tree surrounded by fire	+ 2	+ 2	0	0.306
24	Before and after of dog	+ 2	– 1	+ 3	0.462
25	Horse shivering in backyard pool	+ 1	+ 1	+ 2 **	0.154
26	Inmate firefighters	– 1	– 2	+ 2 **	0.38

Table 1 (continued).

27	Group of volunteers holding boxes	– 3	– 3	– 1	0.286
28	"If you need anything just ask" sign	– 2	0	– 1	0.16
29	American flag amongst burned trees	0	– 1	– 3	0.323
30	Fallen tree on burned car	0	– 1	– 2	0.076
31	**Displaced victims getting distribution/donation**	**– 1**	**– 1**	**– 1**	**0.019**
32	Man carries water down burned and smoky street	0	+ 2 **	– 1	0.509
33	Football stadium surrounded by smoke	– 1	+ 3 **	– 2	1.049
34	Before and after of burned home	+ 2	0	+ 3	0.318
35	Firefighter feeding donkey in smoke	– 1	+ 1 *	– 1	0.084
36	House on fire	+ 3 **	+ 1	0	0.454
37	**Burned cars and bus**	**+ 1**	**+ 1**	**+ 1**	**0.021**
38	Aerial image of smoke/fire	+ 1	+ 4	+ 4	0.33
39	Students at school with smoky skies	0	0	– 4	0.725
40	**House with collapsing roof from fire**	**+ 1**	**+ 1**	**0**	**0.032**
41	Empty street burning with smoke	+ 1 *	– 1	0	0.168
42	Burning cars and home on fire	+ 4 **	+ 2	0	0.429
43	Timelapse of Camp Fire smoke	– 1	+ 3 **	– 1	0.482
44	Hospital workers evacuate patient in bed	+ 2	0	+ 4 **	0.416

Note: Factor scores range from – 4 (least concerning) to + 4 (most concerning) and are converted from z scores; ** Defining image at $p < .01$ level that evokes concern, and z-score for the image is higher than in all other factors; * Defining image at $p < .05$ level that evokes concern, and z-score for the image is higher than in all other factors. Bold descriptions refer to the consensus images that do not distinguish between any pairs of factors (non-sig. at $p > .05$ level).

Table 2 Factor Characteristics

	Factor 1: Catastrophic Impacts	Factor 2: Environmental Impacts	Factor 3: Social Impacts
No. of Defining Variables	17	11	6
Avg. Relative Coef.	0.8	0.8	0.8
Composite Reliability	0.986	0.978	0.96
S.E. of Factor Z-scores	0.118	0.148	0.2

Table 3 Correlations Between Factor Scores

	Factor 1: Catastrophic Impacts	Factor 2: Environmental Impacts	Factor 3: Social Impacts
Factor 1	1.0000		
Factor 2	0.5564	1.0000	
Factor 3	0.5253	0.3152	1.0000