Natural Variability or Climate Change?: Extreme Event Attribution, Public Perception, and the California Drought

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Abstract: Scientists can now connect extreme weather events with climate change using a methodology known as "extreme event attribution", or EEA. The idea of connecting climate change and extreme weather has long been heralded as a panacea for communications, connecting the dangers of climate change to real-world, on-the-ground events. However, event attribution remains a nascent science, and attribution studies of the same event can sometimes produce divergent answers due to precise methodology used, variables examined, and the timescale selected for the event. The 2011-2017 California drought was assessed by 11 EEA studies which came to varying conclusions on its connection to climate change. This article uses the case study of the drought and a multi-methods approach to examine perceptions of EEA among key stakeholders and citizens. Twenty-five key informant interviews were conducted with different stakeholders: scientists performing EEA research, journalists, local and state-level policymakers, and non-governmental organization representatives. In addition, two focus groups with 20 California citizens were convened: one with environmentalists and another with agriculturalists. While climate change was viewed by many as a mild contributing factor to the California drought, many stakeholders had not heard of EEA or doubted that scientists could conclusively link the drought to anthropogenic climate change; those that were familiar with EEA felt that the science was generally uncertain. In the focus groups, presentation of divergent EEA results led participants to revert to pre-existing ideas about the drought-climate connection, or to question whether science had sufficiently advanced to analyze the event properly. These results indicate that while EEA continues to provoke interest and research in the scientific community, it is not currently utilized by many stakeholders, and may entrench the public in pre-existing views.

Key words: extreme event attribution, climate change, perception, California drought, weather, climate communication

1. Introduction and Literature Review

For decades, when asked by members of the public whether a given drought, flood, or heat wave was the result of anthropogenic greenhouse gas emissions, climate scientists repeated the stock phrase "no individual weather event can be blamed on climate change" (Hassol, 2008; Hulme, 2014). But since the publication of an influential paper on extreme event attribution (EEA) in 2003, researchers have increasingly sought to link extreme weather events such as heat waves, droughts, floods, and hurricanes with climate change (Allen, 2003; Pidcock et al., 2019). At its most basic level, EEA involves comparing modeled climates with and without anthropogenic climate change, allowing researchers to assess whether a given event has become more or less likely, or more or less severe, due to greenhouse gas emissions and other forms of human activity (Jézéquel et al., 2018a).

Researchers have suggested that EEA could serve as a useful tool for assessing loss and damage caused by climate change, quantifying liability in court cases, or informing adaptation decisions (Allen et al., 2007; Stott and Walton, 2013; Thompson and Otto, 2015). So far, however, EEA's utility in these areas remains a matter of dispute. In terms of adaptation, some have argued that EEA privileges meteorological over societal risk factors (Hulme et al., 2011; Lusk, 2017), while studies have shown that stakeholders believe EEA might be useful for their work, but do not currently engage with its results (Stott and Walton, 2013; Schwab et al., 2017; Young et al., 2019). Meanwhile, issues of standing, justiciability, and the traceability of greenhouse gases to particular emitters have impeded climate change lawsuits in the United States and elsewhere (Brunnée et al., 2012; Lusk, 2017), and while there has been substantial debate about the applicability of EEA to loss and damage negotiations, there are few concrete movements in this area (James et al., 2014; Thompson and Otto, 2015; Lusk, 2017; Jézéquel et al., 2018b).

EEA has also been suggested as tool for communication, to increase public engagement and bring the problem of global climate change – typically seen as distant in both space and time – into more immediate human experience (Cullen, 2016; Haustein et al., 2016). Indeed, journalists have been early and frequent adopters of attribution science (Osaka et al., in submission), and in recent years media coverage of climate change with respect to extreme events has increased. Mainstream news outlets now frequently connect heat waves, extreme flooding, and droughts with anthropogenic climate change. Some researchers have even begun performing attribution studies in "near-real time", attempting to connect weather events with climate change while extreme events are still in the news cycle (Haustein et al., 2016; WWA, 2019).

But despite growing public interest and attention, few social scientists have examined how EEA results are perceived by citizens and stakeholders. This paper adopts a case-study approach to explore perceptions of EEA, examining the 2011-2017 California drought, which was subject to no fewer than 11 attribution studies and extensive media coverage. The goal of the paper is to understand how attribution science is perceived and understood by different social groups, and its potential and pitfalls for public communication.

1.1 Extreme weather and climate communication

There has been lengthy debate in the scholarly community about whether individuals can "experience" climate change on a first-hand basis (Akerlof et al., 2013). Some scholars have argued that global climate change is effectively invisible to laypeople, as climate change, by scientific definition, relies on statistical data compiled over long periods of time (Moser and Dilling, 2004; Weber and Stern, 2011). Ethnographic and survey results, however, have suggested that some members of the public believe that they have experienced climate change through seasonal changes, witnessing sea level rise, or living through extreme

weather events (Akerlof et al., 2013; Rudiak-Gould, 2013; Leiserowitz, 2019). A 2018 opinion poll found that 46% of Americans believe that they have "personally experienced" the effects of climate change, while 65% believe that climate change has affected some weather in the United States (Leiserowitz, 2019).

Research has previously shown that personal experience of climate change can increase concern, by making the issue more concrete and immediate (Spence et al., 2012; Jones et al., 2017). According to construal level theory, problems that are distant in both space and time are difficult for individuals to assess and respond to; therefore, when possible, issues should be made relevant to personal experience (Trope and Liberman, 2003; 2010). Some scholars have already detected links between local temperature changes and belief and concern in climate change (Li et al., 2011; Capstick and Pidgeon, 2014).

Meanwhile, as Demski et al. (2017, p. 150) argue, "One of the principle ways [climate change] is likely to be made concrete for ordinary people at a regional level is through extreme weather events." Extreme weather often provokes substantial media coverage both during and in the immediate aftermath of an event – particularly if it is a high-profile disaster that causes significant infrastructural or economic losses (Ungar, 1999). As a result, some have suggested that connecting climate change with the lived experience of extreme weather could increase engagement with climate change, heighten risk perceptions, and even encourage pro-environmental behaviors (Reser et al., 2014; Weber, 2016; Demski et al., 2017). For example, Demski et al. (2017) found that UK citizens who experienced flooding in the winter of 2013 and 2014 considered climate a more salient issue and even demonstrated increased support for climate mitigation. Research in Norway similarly found that having personal experience of damage due to flooding or landslides made residents more concerned about climate change. Others have demonstrated that perceived personal experience of climate change – including through extreme weather events – impacts belief in

the reality of climate change (Myers et al., 2013; Taylor et al., 2014). Some research, however, has shown that experience of extreme weather is also mediated by environmental values; extreme events are more likely to be perceived as climate change-related if the individual already has a pro-environmental worldview (Whitmarsh, 2008; Whitmarsh and Capstick, 2018).

So EEA could be a useful tool to link extreme weather with climate change in the public mind. But so far little research has examined how EEA is actually perceived by stakeholders and citizens. Focus groups with various stakeholders have indicated that there is substantial interest in EEA as a tool for communication, but questions remain about the uncertainties inherent in current attribution studies and how to communicate them effectively (Stott and Walton, 2013; Sippel et al., 2015; Osaka et al., in submission). There is some existing survey work on the role of EEA in influencing behavior, but this research primarily involves hypothetical attribution statements, rather than the results of actual EEA studies performed on a case-study event (cf. Halperin and Walton, 2017). There is, therefore, a paucity of research that has examined a specific EEA case and its lessons for public communication.

1.2 The 2011-2017 California drought

From December 2011 to March 2017, California experienced one of the worst droughts on state record (Boxall, 2017). The State Water Resources Control Board Chair, Felicia Marcus, called it "the most serious drought we've faced in modern times" (Williams and Dearen, 2014). Some scientists claimed the drought was the most severe that California had seen in over a millennium (Nagourney, 2015; Griffin and Anchukaitis, 2014). A ridge of high pressure in the Pacific Ocean directed precipitation away from the state for several years, and above-average temperatures exacerbated dry conditions. Although California was

officially in drought for a little over five years, the worst and most high-profile period began in early 2014, when Governor Jerry Brown instituted the state's first ever mandatory water restrictions and declared a "state of emergency", which lasted until late 2015 (Megerian et al., 2015). During these two years, the drought became a prominent regional, national, and even international news story; this correlated with high public attention to the drought issue and, ultimately, changes in water use (Milbrandt, 2017; Quesnel and Ajami, 2017). Quesnel and Ajami (2017) found that the abnormally high public awareness and widespread media coverage resulted in altered behavior and decreased water use in the San Francisco Bay Area during this period.

Meanwhile, the drought was accompanied by an unusually high number of EEA studies – 11 prominent studies were released just between 2014 and 2017, making the California drought one of the most-studied events in the history of EEA (see Table 1; Pidcock et al., 2019). (Most extreme weather events, including heat waves, floods, and hurricanes, are the subject of between one and three attribution studies, if any (Pidcock et al., 2019)). The *Bulletin of the American Meteorological Society (BAMS)* alone, which releases an annual special report on attribution science, published three such papers on the drought in 2014 (Funk et al., 2014; Swain et al., 2014; Wang and Schubert, 2014). A prominent report on the causes of the drought was also released by the National Oceanic and Atmospheric Administration (Seager et al., 2014), and other papers were published in *Journal of Climate*, *Geophysical Research Letters*, and elsewhere.

1 **Table 1. Prominent attribution studies of the 2011-2017 California drought.**

Author and year	Statement of results	Human influence
Aghakouchak et al. (2014)	"We argue that the global warming and the associated increase in extreme temperatures substantially increase the chance of concurrent droughts and heat waves."	Human influence found
Cheng et al. (2016)	"The results thus indicate that the net effect of climate change has made agricultural drought less likely and that the current severe impacts of drought on California's agriculture have not been substantially caused by long-term climate changes."	No human influence found
Diffenbaugh et al. (2015)	"We therefore conclude that anthropogenic warming is increasing the probability of co-occurring warm–dry conditions like those that have created the acute human and ecosystem impacts associated with the 'exceptional' 2012–2014 drought in California."	Human influence found
Funk et al. (2014)	"Long-term SST warming trends did not contribute substantially to the 2012/13 and 2013/14 California droughts."	No human influence found
Seager et al. (2014)*	"[A] long-term warming trend likely contributed to surface moisture deficits during the drought. As such, the precipitation deficit during the drought was dominated by natural variability, a conclusion framed by discussion of differences between observed and modeled tropical SST trends."	No human influence found
Seager et al. (2017)	"These results allow a tenuous case for human-driven climate change driving increased gradients and favoring the west coast ridge, but observational data are not sufficiently accurate to confirm or reject this case."	Uncertain
Shukla et al. (2015)	"Our results indicate that temperature played an important role in exacerbating the WY 2014 drought severity."	Human influence found
Swain et al. (2014)	"California's driest 12-month period on record occurred during 2013/14, and although global warming has very likely increased the probability of certain large-scale atmospheric conditions, implications for extremely low precipitation in California remain uncertain."	Uncertain
Wang and Schubert (2014)	"The 2013 SST anomalies produced a predilection for California drought, whereas the long-term warming trend appears to make no appreciable contribution because of the counteraction between its dynamical and	No human influence found

	thermodynamic effects."	
Wang et al. (2014)	"Therefore, there is a traceable anthropogenic warming footprint in the enormous intensity of the anomalous ridge during winter 2013–2014 and the associated drought."	Human influence found
Williams et al. (2015)	"Precipitation is the primary driver of drought variability but anthropogenic warming is estimated to have accounted for 8–27% of the observed drought anomaly in 2012–2014 and 5–18% in 2014."	Human influence found

*An update of this study was later published in *Journal of Climate* as Seager et al., 2015 (see References)

There was, however, no overall consensus on the influence of climate change on the intensity or likelihood of the California drought (Table 1). Some studies found that anthropogenic climate change had influenced the event in question (e.g., Aghakouchak et al., 2014; Wang et al., 2014; Diffenbaugh et al., 2015; Shukla et al., 2015; Williams et al., 2015), while others found that anthropogenic forcing had little or no effect on the drought conditions (Funk et al., 2014; Seager et al., 2014; Wang and Schubert, 2014; Cheng et al., 2016). Between 2014 and 2015, these divergent results were reported in the news media, which often utilized a narrative frame of uncertainty when covering EEA research (Osaka et al., in submission).

The California drought was thus a unique example of extreme event attribution, and one that warrants further study. Although some aspects of the drought case – for example, the prolonged nature of the event and the multiplicity of divergent EEA studies – render it an unusual instance of EEA, these factors also make it an important critical case study. In contrast to other, more easily attributable events such heat waves across mainland Europe, the California drought presented complexities for scientific analysis and public understanding. Analysis of this drought can bring the challenges and potential of EEA as a communication tool into clearer focus.

2. Methods

This study utilizes a mixed-method approach to investigate stakeholder and citizen perception of EEA on the California drought. It is guided by two interconnected research questions. First, how were EEA results interpreted by key stakeholders including scientists, journalists, citizens, and policymakers? And second, how did key stakeholders and citizens understand the role of climate change within the 2011-2017 California drought? The study concludes with an analysis of how the answers to these questions can inform climate change communication efforts.

2.1 Key stakeholder interviews

Twenty-five semi-structured interviews were conducted between September 2018 and March 2019 with stakeholders in key representative groups (Table 2). The primary groups were attribution scientists ($n = 9$), journalists who reported on the California drought ($n = 7$), and local and state-level policymakers ($n = 7$). These were supplemented by interviews with two environmental NGO representatives, who, owing to their institutionalization and routinization (Rootes, 2004; Tranter, 2010) could be expected to convey quite different perspectives to the 'grassroots' environmental activists included in the focus groups (see Section 2.2).

Table 2. Semi-structured interviews

Code	Occupation
Journalists	
J1	Staff writer for Southern California newspaper
J2	Staff writer for Northern California newspaper
J3	Former reporter for national newspaper
J4	Former reporter for national newspaper
J5	Staff writer for Northern California newspaper
J6	Staff writer for Northern California newspaper
J7	Staff writer for Northern California newspaper
Scientists	
S1	Associate professor at US university
S2	Professor at UK university

S3	Former chief scientist at climate change NGO
S4	Research professor at US university
S5	Professor at US university
S6	Former research scientist at national science laboratory
S7	Climate scientist at US university
S8	Associate research professor at US university
S9	Professor at US university
Policymakers	
P1	Water conservation supervisor at city water company
P2	Associate water resources specialist at regional water district
P3	Water resources manager at regional water agency
P4	Senior water resources specialist at regional water agency
P5	Assistant deputy director at state water bureau
P6	Climate and conservation manager at state water bureau
P7	Assistant officer – water supply division at regional water district
NGO representatives	
N1	Campaign organizer at environmental NGO
N2	Senior climate analyst at environmental NGO

Attribution scientists were either researchers who had authored or co-authored EEA studies on the California drought, or scientists prominent in the field of EEA. They were identified through a literature survey of California drought attribution studies and through the snowball sampling technique (Atkinson and Flint, 2004). Journalists who had covered the drought, and where applicable, its connection to climate change, were selected from major state (*San Francisco Chronicle*, *Los Angeles Times, Sacramento Bee*) and national newspapers (*New York Times*). Policymakers focusing on California's future water supply and/or climate change policy were selected at the local, regional, and state level to explicate potential scalar differences. Finally, NGO representatives were chosen either from existing contacts or by recommendation from other interviewees. All interviews underwent an abridged transcription by the first author and subsequent qualitative coding using established procedures for inductive, semantic and constructionist thematic analysis (Braun and Clarke, 2006). The abridged transcription merely cut out introductory questions that were designed to set interviewees at ease; the remainder of the interviews were transcribed verbatim.

Interviews lasted between 30 and 90 minutes, and were conducted at the office or workplace of the respondent when possible. Remote interviewees (mainly attribution scientists who were located across the United States) were interviewed via Skype. All interviewees were asked about:

1. What they perceived as the causes of the California drought, and whether anthropogenic climate change played a role in the drought's occurrence or severity;
2. Their familiarity with EEA, whether (and if so how), they had heard others (the public, co-workers, friends) connect the drought and climate change.

Each group was also asked a set of questions more specifically relevant to their line of work and profession. These questions are listed in Table 3.

Table 3. Key framing questions asked of semi-structured interview participants.

Universal questions	What do you think were the causes of the California drought? Do you believe climate change played a role in the drought?
	Are you familiar with extreme event attribution? If so, how?
	Have you heard others (the public, coworkers, friends) connect the drought and climate change?
For scientists	How can attribution science help stakeholders understand and respond to extreme weather events?
	Why did the attribution studies of the California drought come to different results?
	Who is the audience for EEA, besides other scientists?
	Is attribution science ready for communication to the public? Do you think laypeople understand attribution science?
	What is the role of a climate scientist in communicating the risks of extreme weather and climate change to a broader audience?
For journalists	(If applicable) what prompted you to start covering EEA?
	(If applicable) how did you represent the different EEA studies on the California drought?
	What are the challenges of communicating EEA to a public

	audience? Do you think laypeople/readers understand attribution science?
For policymakers	Can attribution science be useful in your line of work? Do you consider attribution science to be policy-relevant? (If applicable) what are your takeaways from the attribution studies on the California drought? Have they affected your actions or planning?
For NGO representatives	How do you try to work with journalists and the media to communicate climate change to a broader audience? Do you try to communicate connections between climate change and extreme weather, and if so, how? Is extreme event attribution relevant to communication efforts, or to other NGO projects?

2.2 Focus groups

Two focus groups of citizens were convened in Northern California in January 2019. Rather than selecting people with no known opinions or unprompted interests in the matter at hand, this study sought to broaden out what are considered to be legitimate constituencies of citizen deliberation by switching from ostensibly "unengaged" to already engaged citizens (Lezaun and Soneryd, 2007; Chilvers and Kearnes, 2016). We hoped to examine the extremes of possible citizen perspectives on climate change and extreme weather by soliciting responses from groups with relatively opposite worldviews and opinions on California's environmental issues. To this end, the study drew on participants from pre-existing groups already engaged in matters of water, environment, and climate, and occupying opposite ends of the political spectrum in California. We utilized these pre-existing groups to explore how people might discuss climate change and extreme weather "within the various and overlapping groupings within which they actually operate" (Kitzinger, 1994, p. 105). Although this meant that some of our participants knew one another, which could cause the

focus group to produce socially desirable answers, familiarity between participants also meant that they discussed the issue within a more "natural" grouping – i.e., with those whom they interact on a more regular basis (Kitzinger, 1994).

One group consisted of California agriculturalists who were members of the board of local farm bureau, a non-profit membership organization which provides legislative and regulatory support to farmers (n = 6). These participants were senior members of the farm bureau with decision-making authority and responsibility to other agriculturalists in the area. This group was supplemented by semi-structured interviews with other agriculturalists prominent in the Northern California region (n = 3). The second group was made up of members of two Bay Area environmental groups: a national environmentalist membership organization involved in environmental advocacy, volunteering, and campaigning; and a regional group focused on community science and environmental restoration (n = 11). As grassroots environmental groups tend to be more egalitarian in social structure, these participants were volunteer members, rather than officials, in the groups. Both focus groups were recruited with the assistance of organizational gatekeepers and each member was provided with an honorarium for their participation. The focus groups were around 75 minutes in length. Discussions were fully transcribed and then thematically analyzed in the same way as the key informant interviews described above.

The goal of the focus groups was first, to explore participants' pre-existing ideas of any connection between the California drought and climate change, and second, to introduce participants to media coverage of EEA and compare and contrast their responses. For the first 30 minutes, questions were deployed via a funnel technique (Krueger, 2000), with participants first asked about how the drought affected their personal lives and businesses, followed by increasingly specific questions about the role of climate change in the California drought. The second half of the group was devoted to media coverage. Three regional

newspaper articles were selected – one from the *Los Angeles Times*, and two from the *San Francisco Chronicle* – that covered the California drought's connection to climate change (Figure 1).[1] These articles covered three different scientific studies and reports with diverging perspectives: the *BAMS* report (2014), Seager et al. (2014), and Williams et al. (2015). One article reported that climate change had made the California drought worse, one that the drought was a result of "naturally changing ocean conditions", and one that scientists were still uncertain about any climate change and drought link (Figure 1; Alexander, 2014; Boxall, 2014; Fagan and Sernoffsky, 2015). These articles were shared one by one and discussed with participants.[2]

It is worth noting that the fieldwork for this study took place approximately one year after the official conclusion of the drought and a few years after its most intense period. This temporal distance between the event itself and the fieldwork could be seen as a limitation of this case study – much case study work seeks to explore events contemporaneously with their occurrence (Yin, 2003). However, in the case of the California drought the relative distance can also be seen as an asset. Interviews and focus groups showed that the drought was still fresh in the minds of the participants, and the time passed since the event allowed multiple EEA results to be viewed in a more holistic manner. Moreover, perceptions during the drought were likely more volatile and shifting, while this research attempted to account for more enduring perceptions of the role of climate change in the aftermath of the drought.

[1] Both newspapers are left-leaning (in keeping with the generally left-leaning state of California) and have significant climate change coverage.

[2] Participants in the agriculturalist group were presented with the articles in the order Alexander, Boxall, Fagan and Sernoffsky; participants in the environmentalist group were presented with articles in the order Fagan and Sernoffsky, Boxall, and Alexander. This order was chosen largely to increase the comfort of the participants with the material, particularly the agriculturalist group, which was known to be averse to the idea of anthropogenic climate change.

Figure 1. Article excerpts on EEA presented to focus group participants.

"Nature, Not Climate Change, Blamed for Drought"
Kurtis Alexander, *San Francisco Chronicle*

"California's historic drought is the result of naturally changing ocean conditions, according to a new federal report that dismisses man-made climate change as the root cause.

The study, released Monday by the National Oceanic and Atmospheric Administration, says sea surface temperatures in the tropical Pacific helped trigger a mass of high-pressure air along the West Coast — a wall that blocked storms from hitting California for three straight years.

Those ocean temperatures, which were initially cooler as a La Niña weather pattern emerged during the 2011-12 winter, were the result of natural variability, according to the report."

"**California drought and climate warming: studies find no clear link"**
Bettina Boxall, *Los Angeles Times*

Global warming contributed to extreme heat waves in many parts of the world last year, but cannot be definitively linked to the California drought, according to a report released Monday.

The third annual analysis of extreme weather events underscored the continuing difficulty of teasing out the influence of human-caused climate change on precipitation patterns. […]

Overall, the report editors concluded that the papers didn't demonstrate that global warming clearly influenced the drought, which is one of the worst in the state record.

"Study: Global warming has made California's drought worse"
Kevin Fagan and Evan Sernoffsky, *San Francisco Chronicle*

Human-caused global warming has made California's four-year drought worse and "substantially increased" the likelihood of extreme dry spells from now on, scientists concluded in one of the most detailed climate-change studies to date.

The bottom line of the report, published Thursday in the journal Geophysical Research Letters, is that the Earth being hotter than normal makes the soil and all that grows in it drier than normal — which then makes droughts worse than normal.

3. Findings

Table 4 shows several prominent themes that were identified across stakeholder interviews and in focus group discussions. These were "uncertainty", "utility", and "media representation". While all three themes came up in almost all groups, there were significant variations in how participants addressed the different themes. For example, participants

framed uncertainty through discussion of conflicting studies, complex model results, or doubt about the attribution process in general (Table 4). Many groups also addressed issues of utility – was EEA useful, and if so, for whom and for what purpose? Finally, many interviewees and participants brought up the role of the media in representing the drought and climate change; topics ranged from the portrayal of rural water users in the state to how EEA results were increasingly covered in newspapers.

Table 4. Primary themes appearing in interviews and focus groups.

Group	Uncertainty of EEA	Utility of EEA	Media representation of EEA
Scientists	due to variable selection and methods	useful for public awareness, adaptation planning, policymaking	increase in EEA coverage; portrayal of scientific disagreement
Journalists	due to conflicting studies from different scientists; due to variable selection and methods	public "asking the question" about a link between climate change and drought	emphasis on human interest stories during drought; increased confidence in invoking EEA during extreme events; portrayal of scientific disagreement
Policymakers	climate models for CA inherently uncertain; EEA potentially impossible	not useful for policymaking, adaptation planning; public "asking the question" about a link between climate change and drought	high volume of coverage on urban water rationing
NGO representatives	due to variable selection and methods	useful for public awareness and to motivate action	inadequate EEA coverage
Agriculturalists	due to conflicting studies, EEA potentially impossible	useful to understand perspective of the 'other side'; useful for media and scientists to attract funding or sell papers	rural water users unfairly blamed for drought; drought commonly connected with climate change
Environmentalists	due to conflicting studies, accurate attribution would take much longer	useful for public awareness	rural water users blamed for drought; media didn't connect drought and climate change

3.1 Interview Results

3.1.1. Attribution Scientists

In interviews, EEA researchers brought up the uncertainties and nuances inherent in attribution science and how those nuances were communicated to policymakers, media, and the broader public. Scientists argued that the consensus view was that the drought had been made worse by climate change (due to high temperatures), but that climate change had not necessarily increased the likelihood of the drought (i.e., the lack of precipitation). For example, one scientist noted:

> "If [we define the drought] as something that depends heavily on temperature, then there is most definitely an anthropogenic contribution going on there […] But if it's purely a precipitation event, I'd say the evidence hasn't unearthed much, or anything substantial so far" (Scientist 6 (S6)).

According to respondents, most of the confusion around this particular attribution could be explained by the difficulty of defining "drought" – whether the drought was meteorological, hydrological, or agricultural – and the selection of variables and approaches used by different researchers (see Table 1). Another scientist said:

> "It's a good example of where it's pretty easy to get confused, because depending on the variable you looked at you got a different answer. A lot of people didn't realize that drought means many things. There are formal definitions of drought, which don't necessarily coincide with the public perception of what it should be" (S2).

Many of the researchers emphasized that EEA results should therefore be interpreted in context, in tandem with findings from other researchers and with caveats. One scientist explained that he had received criticism for concluding that the drought had not been caused by a particular Pacific sea surface warming trend that was in turn linked to climate change. He clarified: "It needs to be appropriately scoped. I mean, we weren't claiming that climate change didn't produce *any* droughts in California" (S4).

Scientists noted that EEA was increasingly covered by the media, and that it was becoming normal to attribute weather events to climate change (S1, S2, S6, S8). One researcher argued that while in the past journalists were frustrated by the complexity of EEA

science, "now they kind of accept it, and recognize that this is just the way the information is" (S2). Most felt that their research had been accurately depicted by journalists, although some said that early reporting seemed to misrepresent the divergences between studies. For example:

> "I thought that the initial coverage was sometimes frustrating because there were opposing conclusions in some of these studies. They were pitted often as 'scientists are at each other's throats' […] which is not really an accurate presentation. [Researchers were] asking essentially different questions and coming to different answers just because they'd asked different questions" (S7).

Scientists also pointed out that while some attribution studies focused on whether the drought had become more *likely*, others examined whether it had become more *severe*, resulting in confusion among journalists and the public. One scientist noted: "[The public] will always get it mixed up. Did the probability double, or did the severity double? […] The media is always messing that stuff up too" (S8). A couple of researchers argued that the best way to communicate attribution was to leave out nuances like probability vs. severity, and focus on more basic statements (S1, S8). In the case of the drought, however, the difference between probability and severity was crucial in interpreting the various results (see Table 1).

Most scientists were optimistic about the audience for EEA research beyond the academic and scientific community. Many pointed to the importance of EEA for adaptation planning, to help decision-makers understand whether a given event might become more common in the future (S2, S4, S5, S6, S8). Almost all the respondents said that the public was also an intended audience for EEA, because EEA could help make climate change "tangible" (S6) and "create a mental model" (S3) for understanding the role of climate change in weather. However, scientists also emphasized that the primary audience for their research was other scientists – additional uses were seen as secondary to the primary goal of informing the academic community.

One scientist interviewed was active in meteorology but known to be critical of EEA. He argued that there was continued disagreement in the scientific community about whether EEA was a robust methodology, noting, "I think there's a lot of sloppiness to it […] you really need to look at trends and longer-term statistics to see whether global warming is causing the effect you're concerned about" (S9).

3.1.2. Journalists

All of the journalists interviewed said that they had noted a change in coverage of extreme weather events and climate change over the past decade. Four had reported directly on EEA studies in relation to the California drought, while the other three had reported more generally on climate change and the drought. Most noted that while in the past they had often written that "no particular weather event can be attributed to climate change," they now felt it was generally acceptable to extreme weather to climate change. Several recalled that during Hurricane Katrina in 2004 they were cautioned against linking it to global warming for fear of "scaremongering" (Journalist 3 (J3)); now, however, they increasingly associated heat waves, droughts, and even hurricanes with anthropogenic climate change (J3, J4, J5). One journalist noted: "The small clause 'X, Y, Z, is happening because of climate change' – I am much more likely to put that in now than I was, say, five years ago" (J3). Another commented, "When there's a heat wave [now] you can have a boilerplate statement that says 'These are all becoming more likely because of climate change'" (J4).

At the same time, journalists emphasized that when covering the drought, their role was to focus on the most salient stories for the public, which often incorporated a human interest angle. These included struggles over groundwater, loss of agricultural productivity, and more. Interviewees argued that they were responsible primarily to the public, and not a "mouthpiece" for scientists (J5). Research on EEA might be one part of their coverage area,

but not the primary part. Journalists also noted that the average reporter is inundated with scientific studies about climate change, and that they have to "pick and choose" which research is most important to cover (J2) – often by looking for novelty or unique perspectives (J1, J2, J5). A few respondents also said that in recent years they felt pressure to cover attribution science, either from green groups or from the general public "asking the question" about the connection between climate change and events like the drought (J4, J5, J6).

One strong theme among journalists was the role of scientific uncertainty in their coverage. Journalists generally felt that the public had difficulty understanding nuance, and that their role as writers was to simplify narratives as much as possible. One interviewee noted, mentioning the issue of California wildfires:

> "Communicating uncertainty is sort of antithetical to what we do. Because we try to make things simple and linear for people […] journalists are always quick to put out the disclaimer that we can't blame x, y, z, fire on climate change […] But it's a balancing act, because the more you cloud up a story with uncertainty, the more the readers' eyes glaze over." (J2).

Another said, "How do I simplify without falsifying? That is always the core issue" (J4).

At the same time, most of the journalists felt that the science around the attribution of the California drought had been particularly controversial (J4, J5, J7). Some identified a form of scientific consensus – that climate change had made the drought *worse*, but not necessarily *more likely* – but others were uncertain. J5 said:

> "You see studies offering different conclusions and obviously they're all prurient, but if they're saying different things they can't all be right. Even within the [attribution science] community there was disagreement."

In the face of this type of controversy, reporters emphasized that they were especially cautious about making strong statements connecting weather events and climate change.

Meanwhile, two journalists (J1, J2) reporting for regional papers expressed doubt about the legitimacy of EEA. J2 said:

> "Part of the problem is, you can never really point to specific events. The scientists always […] say – we can't say this fire happened because of climate change, or these hurricanes happened because of climate change. All we know is that climate is sort of brewing up a soup that makes all of this more likely to happen."

3.1.3. Policymakers

Local, regional, and state-level water policymakers agreed that climate change was likely to make California's droughts more severe in the future, and all said that they incorporated expectations of future climate change into their strategies and plans. But interviewees emphasized that, even though they were often questioned by constituents about the relationship between climate change and drought (Policymaker 1 (P1), P3, P4, P7), they did not publicly connect the 2011-2017 drought to climate change – beyond saying that it was emblematic of possible future climatic conditions. Several respondents at the local and regional level also said they believed attribution of a single event to climate change was impossible. One regional policymaker said, "Any good scientist will tell you that you can't really tell if [an event is] meteorological or climatological" (P4). A local policymaker was more direct, saying:

> "You do not take a single weather or climate event and say this is climate change, you cannot do that kind of attribution […] I tell everybody – no real climate scientist that I have ever heard of will do single event attribution to climate change" (P2).

Policymakers who already knew about EEA research (primarily at the state level), questioned its utility for decision-making. For example, one interviewee referenced a Williams et al. (2015) paper, which found that climate change had worsened the drought by between 8 and 23%:

> "Did that [paper] change anyone's opinion in the legislature? I doubt it. Did that change our approach to managing things? No. I'm not saying it's not a valuable contribution to the state of the science, I just don't know that it had either a political or a policy impact" (P6).

Most interviewees explained that during the drought they were focused on responding to urgent problems, and had to adopt a largely "reactionary" (P1) role focused on the day-to-day

issues of water shortages. They were similarly ambivalent about EEA's usefulness for adaption planning; several argued that knowing the impact of climate change on a particular event would have little impact on their ongoing decisions to improve diversity of water sources and push for urban conservation (P1, P2, P5, P6). Since they already expected droughts to become more likely and more severe in California's future, the role of climate change in a particular drought was thought by most to be immaterial.

3.1.4 NGO Representatives

NGO representatives were more optimistic about the role of EEA for policy and for public communication. Both interviewees (NGO representative 1 (N1), N2) argued that connecting extreme events and climate change would help to spur individual action and public interest. N2 said:

> "In terms of public perception and bringing climate change into the mainstream narrative – [EEA is] helpful for the piece that I do, which is getting people to take actions…"

One interviewee had worked with their NGO to shape media narratives around the drought, by encouraging activists and members of the public to write to newspapers and to encourage journalists to "connect the dots" on the drought and climate change (N2). Both interviewees expressed frustration with what they perceived as limited coverage of the drought in relation to climate change; in general, they argued that the media and the public should be more exposed to the relationship between ongoing and future dry conditions in the state and anthropogenic greenhouse gas emissions (N1, N2).

3.2. Focus Groups

In focus groups, the agriculturalists and environmentalists displayed very different sets of beliefs around anthropogenic climate change. Many participants in the agriculturalist group displayed skepticism about "human-caused" climate change, but said they believed the

climate was changing, due in part to their experiences as farmers (Agriculturalist 1 (A1), A2, A5). This was mirrored by the later interviews with agriculturalists (A7, A8). Participants in the environmentalist group, on the other hand, were confident that the climate was changing and was human-caused; many of them were openly supportive of Al Gore, Governor Jerry Brown, and other politicians they felt were attempting to push forward greener legislation (Environmentalist 6 (E6), E7, E11).

Both groups, however, said that they thought it possible that climate change, whatever its cause, may have played a role in the drought. In the environmentalist group, participants mentioned that the weather in California was becoming more and more variable. One participant said:

> "Areas that have been wet seem to be wetter, dry areas have been getting drier, warms getting hotter, colds getting colder, so I think that climate change is clearly impacting drought in both ways" (E4).

Another pointed out that the state's snowpack, historically a natural reservoir for water, was shrinking due to high temperatures (E5). In the agriculturalist group, some participants echoed concerns about extremes, temperatures, and snowpack – but caveated these concerns with a focus on adaptation. One farmer commented:

> "Did climate change, be it natural, be it man-made, play a role? I'm sure it did, because it's getting warmer here. We don't get the snowpack we used to here. But we've learned to adapt to it over the years" (A2).

Another said, "If [the climate's] gonna change we got to adapt to it […] no matter what's coming – no matter if the ice caps start melting, whatever" (A4).

Agriculturalists also used language of "natural cycles" and "normal cycles" to describe droughts in California, emphasizing that while climate change might impact the drought "a little bit" (A3), for the most part the drought was part of the expected pattern in the state. What made the 2011-2017 drought more severe, according to agriculturalists, was

less due to climate change and more due to increased population in the state, increased demands on water, and environmental regulations that made it more difficult for farmers to exercise their water rights (A1, A3, A4). Agriculturalists felt that the drought represented an opportunity for state lawmakers (often on the liberal side of the political spectrum) to impose further regulations on farmers, and joked that the state government "never let[s] a good crisis go to waste" (A3).

Interestingly, the agriculturalist group reported hearing many connections between the drought and climate change, while the environmentalist group was mixed. One farmer said, "It was the easiest [connection] to just make from the get-go. And once it's out there, it's really hard to take back, in terms of making that kind of profound a statement, of climate change causing the drought" (A5). Others in the agricultural group said that climate change was like a "silver bullet," an easy place to lay blame for the problems of the drought (A3). On the environmentalist side, however, about half of the participants said that they had heard friends, colleagues, or the media connect climate change with the drought. The others had not. One environmentalist said: "I think [the drought] was really well-covered, but I don't think the media at the time was making the connection. I think it was kind of up to the people" (E10).

When presented with media articles covering differing EEA studies (Figure 1), both groups seemed drawn to the articles and scientific studies that confirmed their existing views on the drought. The agriculturalist group focused most on the Alexander (2014) article, with the headline "Nature, not climate change, blamed for drought". The environmentalist group, meanwhile, focused on the Fagan and Sernoffsky (2015) piece which argued that the drought had been made worse by climate change. In both cases, participants discussed the types of evidence needed to show that climate change had influenced the drought and the nature of scientific evidence more generally.

In the agriculturalist group, participants focused on issues of interpretation and polarization in evidence. There was a sense in the discussion that most scientific studies and reports could be interpreted in a multiplicity of ways, and that perhaps there was no right answer. One farmer said:

> "Nowadays people are just finding the news that they believe in, because we go to certain resources. I try to balance myself out – a little bit of NPR, a little bit of Drudge Report, back and forth. But these studies – like, who are you gonna believe? There's a different study about everything. If you want a fact, a statistic, a study that proves your point – you'll find the information" (A4).

Another participant concurred, noting: "We could read the same articles and interpret different sets of facts out of them, or we could report a different story out of the same article" (A2). Group members emphasized that readers could simply pick whichever angle of the three articles they found most compelling, thus rendering this type of science "polarizing" (A6). One participant, reading the Alexander (2014) article that connected the drought to natural causes, was surprised that the report described had come from the National Oceanic and Atmospheric Administration (and thus, due to the year of its release, the Obama Administration). He felt that this study made him "question the whole balance and theory on [climate change] altogether" (A1).

Skepticism about the articles fed into a larger frustration for the agricultural group; many of them felt that the media had unfairly depicted farm water use during the drought. Many media sources reported that agriculture in California used 80% of delivered water in the state, which the group disagreed with – most farm communities argue that agriculture only uses 40% of the water in the state, since 50% of it is devoted to "environmental uses" (A6). In the words of A3: "There were a lot of numbers and statistics twisted around for whatever story or shock factor someone wanted to create." The sense in the group was that the public in California was susceptible to sensationalist headlines and linear narratives – narratives that either blamed farmers for the drought or anthropogenic climate change for the

drought. A few participants were concerned that, since all three of the article headlines mentioned "California drought" and "climate change," readers might assume that the articles were saying that climate change had caused the drought – even if the content of the piece was more nuanced.

In the environmentalist group, participants argued that it would take more time in order to prove adequately that climate change had influenced the drought – although many of them believed that eventually, sufficient evidence would come to light. One argued that, in the future, scientists would be able to "look back and say, yes, in this 50-100 year period, it was climate change" (E6). Another compared EEA to the legal sphere, commenting:

> "It's like the difference between a criminal case and a civil case. In a civil case you just need a preponderance of the evidence […] but in a criminal case you need beyond a reasonable doubt. And no, it's not beyond a reasonable doubt, and so people write articles like this" (E4).

Others argued that there was inadequate "statistical significance" in order to link the drought and climate change, but that this didn't necessarily mean that climate change *hadn't* influenced the drought – merely that it couldn't yet be proven (E1, E7).

At the same time, most of the participants in the environmentalist group said that it didn't matter much to them whether the drought was attributable to climate change or not. They brought up other evidence for anthropogenic climate change, such as glaciers melting and other impacts largely from climate change documentaries. E1 said, of the California drought: "Whether it's linked to [climate change] or it's not, the glaciers are still going to be melting." Others said that what mattered in the face of climate change was not the exact causation of various impacts, but whether there were solutions or actions that individuals could take in response. After reading an article which stated that climate change had not caused the drought, E7 said: "Even if this were true, it doesn't make any difference to me."

She said she would continue her water conservation strategies regardless. E3 also noted: "Science takes time. I would still rather do things to try to reverse climate change."

4. Discussion

Fifteen years since the first public-facing EEA study (Stott et al., 2004), this case study of the California drought provides an important starting point to understand how attribution science is perceived by stakeholder groups and citizens. We note two important takeaways: first, that different stakeholder groups and actors perceived EEA studies of the drought in different ways, and second, that many groups felt that the attribution of the California drought was plagued with uncertainty, thus reducing the perceived utility of EEA for communication or adaptation.

Some journalists, policymakers, and focus group members interviewed still believed that it was impossible to attribute any individual event to climate change. This aligns with existing stakeholder research on EEA (Parker et al., 2017; Young et al., 2019), and is likely due to the fact that EEA is still not widely known among a non-specialist audience, and runs contrary to longstanding received wisdom about the relationship between climate change and weather extremes (Hassol, 2008). Those who *had* heard of EEA, meanwhile, had varying perceptions of its accuracy and its ultimate utility. While scientists were optimistic about multiple uses for EEA (Table 4), policymakers were largely skeptical about any role that EEA could play in planning decisions, and journalists worried that the complexity of EEA made it difficult to convey useful information the public. These findings mirror those of, for example, Stott and Walton (2013), who found that representatives from the US/UK water sectors were uncertain of how they might leverage EEA for decision-making, while journalists and communicators reported difficulty explaining uncertainty within attribution science. In contrast, Sippel et al. (2015, p. 227) found that a mixed group of stakeholders

working in southeast Europe all believed that attribution was "potentially of high practical relevance to their work" (see also Young et al., 2019). More research will be needed to explore more carefully how stakeholders perceive EEA depending on their geography and particular needs.

Further, while the environmentalist group members were somewhat enthusiastic about the prospect of using EEA to raise public awareness, they seemed to connect more deeply with traditional climate change concerns: melting polar ice and other impacts far away in space and time. Thus it is not clear – at least from this study – that citizens were actively "asking the question" about the link between climate change and drought, although some local and regional policymakers did report that their constituents had asked about possible links (P1, P3, P4).

Interestingly, most participants in the study, especially in the focus groups, displayed a sense of reflexivity about the role of scientific modeling in determining and analyzing climate change impacts. Climate change was generally viewed as just one factor in a complex web of meteorological and sociopolitical conditions, which – depending on the participant's interests and perceptions – could be seen as more or less significant in influencing the drought. Other factors cited by participants included population growth, increased regulation, excessive urban (or rural) water use, inherent climatological variability, and more.

In the past, some scholars have worried that the emphasis on EEA might divert attention from vulnerability, thus prioritizing meteorological and climatological aspects of risk over sociopolitical ones (Hulme et al., 2011; Hulme, 2014; Grant et al., 2015). For example, Grant et al. (2015) argued that in Bangladesh some decision-makers blamed climate change for cyclones, in an effort to deflect attention from poor management practices. In the case of the California drought, however, most participants seemed to take a multidimensional

view on the extreme event, incorporating diverse factors such as regulation, population growth, and the geography of the state into their assessment of its causes. Participants emphasized that climate models were simply one way of understanding the drought; other forms of understanding might involve their own personal experience as residents or policymakers, the history of California and its relationship with extreme weather, or their professional knowledge. Many were adamant that while EEA could help inform their understanding of the drought, climate science and meteorology were not the only forms of knowledge appropriate for grasping its causes and ultimate impacts. Thus, while EEA is at some level transforming perceptions on the link between climate change and weather, it remains only one facet of how individuals perceive extreme weather events around them.

Another overarching finding was that many participants felt that the case of the California drought was plagued by uncertainty. Attribution scientists explained that the drought was an exemplar of how different variables, models, methods, and timescales can result in divergent EEA findings. For example, Williams et al. (2015) looked at the role of higher temperatures in exacerbating the drought, while Seager et al. (2014) examined the role of higher sea surface temperatures in creating a high pressure ridge that drove storms away from California (Table 1). The uncertainty between these two results was heightened in media coverage, which, although for the most part accurate to the scientific findings, framed the issue largely through a lens of disagreement (Osaka et al., in submission). In interviews, non-scientists rarely seemed to distinguish between the different variables studied by researchers, such as temperature or precipitation, and also did not focus on whether a given study was investigating the likelihood or the severity of the drought. Thus, crucial explanations for divergent EEA results went unnoticed by many actors.

In focus groups, participants faced with seemingly contrasting study results largely returned to their pre-existing beliefs about the link between climate change and drought.

Agriculturalists, who tended to believe the most important factors affecting the drought were regulation, water governance, and population growth, argued that the more "science-based" (A6) study was the Seager et al. (2014) study, which found that the drought was due to natural causes (reported in Alexander, 2014; Figure 1). Meanwhile environmentalists, who tended to connect the drought and other extreme events (such as wildfires) in California to climate change, were more credulous about the Williams et al. (2015) study (reported in Fagan and Sernoffsky, 2015).

This finding is in line with other research on the role of personal experience in climate change belief. For example, Myers et al. (2013, p. 345) argue that "Americans who are highly engaged in the issue (on both sides of the issue) are more likely to interpret their perceived personal experience in a manner that strengthens their pre-existing beliefs (that is, using motivated reasoning)." Those who believe strongly in climate change are more likely to interpret personal experiences of extreme events or other impacts as the result of climate change – while those who have ideologically opposite beliefs are more likely to view personal experience as proof that climate change is not occurring. For example, a study by Capstick and Pidgeon (2014) found that participants interpreted extreme cold weather in the UK either as evidence *for* climate change or as evidence *against* climate change, depending on their pre-existing levels of skepticism. Similarly, Corner et al. (2012) found that, when faced with conflicting news articles about climate change, individuals found articles which conformed with their existing point of view more reliable and trustworthy. This effect has been shown to be more common when individuals are faced with uncertain findings (Bastardi et al., 2011; Budescu et al., 2012). As Dieckmann et al. (2017, p. 472) argue, "users [of scientific information] may be motivated to discount (or underweight) information that is uncertain … to the extent that it supports their *a priori* goals or general point of view." Uncertainty, whether presented as divergent viewpoints or as a numerical scale or range of

risk, offers individuals more latitude to pick and choose perspectives that accord more closely with their worldviews.

Uncertainty in science is particularly difficult to communicate, as laypeople generally associate scientific knowledge with certainty and consistency (Corner et al., 2012). Many scientists worry that confessing uncertainty about *one* aspect of an issue such as climate change may lead to a public belief that scientists know nothing at all about the issue (Frewer et al., 2003; Pollack, 2005). According to a study by Corner and Hahn (2009), scientific statements including uncertainty are evaluated more stringently than non-scientific statements. Meanwhile, uncertainty in climate change science has been a particular challenge for communicators. The Intergovernmental Panel on Climate Change (IPCC) has struggled to convey its findings with respect to climate risks (Budescu et al., 2009), while some have suggested that uncertainty about some aspects of climate science (such as extreme event attribution) could spill over into uncertainty about anthropogenic climate change in general, a phenomenon known as "uncertainty transfer" (Spence et al., 2012).

The California drought case demonstrates how, even as some parts of climate change science are increasingly seen as certain and established, other aspects – including the effect that anthropogenic emissions have on extreme weather – remain contested in various scientific, stakeholder, and public spheres. The drought is thus a somewhat cautionary tale of the use of EEA for public communication. On the one hand, attribution of the California drought was substantively covered in the media and reached at least some stakeholders and policymakers. However, the EEA studies seemed to leave a message of uncertainty and ambiguity for many journalists, policymakers, and citizens. Such ambiguity is unlikely in the long run to help alter or form beliefs about climate change. Journalists in particular reported difficulty navigating the complex EEA studies with their differing variables, research questions, and methodologies. We also noted one potential case of "uncertainty transfer" in

our study – an agriculturalist who felt that the debate over EEA of the drought made him question the science of climate change in general (A1). But this was only one of our many participants, and more research would be needed to explore whether this phenomenon occurs in other contexts.

This drought was undoubtedly a special case, due to the high volume of attribution studies and their divergent approaches. It's worth noting that some types of events can be attributed more confidently to climate change than others; for example, there is more understanding on the role of climate change in extreme heat and cold events than there is for extreme rainfall, droughts, or tropical cyclones (National Academies of Sciences, Engineering, and Medicine, 2016). That said, certain issues in attribution – the distinction between likelihood and severity, as well as the diversity of variable selection for particular events – have occurred in other extreme events as well (see Otto et al., 2012), and will likely continue to be a sticking point for this methodology into the foreseeable future. Scientists in our interviews were direct about the difficulties of EEA and the fact that examining different variables led to different answers, but had few suggestions for how these issues could be ameliorated.

In the US in recent years, belief that climate change is harming individuals "right now" is on the rise – a trend that at least some have traced back to extreme event attribution and mounting extreme weather events (Leiserowitz, 2019; Schwartz, 2019). But the California drought case shows that more research and investigation will be needed into how EEA is perceived by stakeholders and citizens from various groups, and whether this new methodology is serving to shift perceptions or reinforce them.

5. Conclusion

Public communication has been one of several suggested uses for EEA since its development in the early 2000s. However, while a great deal of social science research has investigated the connection between climate change belief and experience of extreme weather events, few researchers have looked at the role of EEA in connecting extreme events directly to climate change (except Halperin and Walton, 2017), and to date no researchers have looked at a case study in which multiple attribution studies were released on the same event. This paper investigated how EEA results were perceived and utilized by scientists, journalists, stakeholders and citizens. We found that many stakeholders continue to be uncertain about the extent to which EEA can be practiced and its usefulness for policymaking. Meanwhile, results indicate that attribution largely reinforced existing views held by the two citizen groups, indicating motivated reasoning.

Ultimately, if EEA is to be used as a tool for public communication, further research is needed into its effects on the climate perceptions and beliefs of various segments of the public. For example, this study looked at two interested groups – environmentalists and agriculturalists – but future work could include a classical "unengaged" group without a strong stake in the drought, to see if they displayed similar forms of motivated reasoning. Meanwhile, other extreme events – such as heat waves or floods that have undergone only one or two attribution studies – would also benefit from similar analysis, to see how event type might influence perception.

EEA has also been cited as a useful tool for adaptation planning on the part of policymakers (Stott et al., 2015; Otto et al., 2015). This study, however, supports earlier research into policymaker utilization of EEA, which has shown that many decision-makers are ambivalent about the usefulness of EEA for their work (Young et al., 2019). All of the policymakers interviewed for this study were doubtful that EEA could be useful in adaptation

planning – most said that with or without EEA, they would make plans for future climate change (see also Lusk, 2017).

Finally, the slippage between EEA results – as scientists use different variables, timescales, and methodologies to assess the role of climate change – remains an issue in this emerging field. There are many reasons to continue researching EEA; it can add to scientific knowledge generally, and satisfy scientific curiosity about the physical processes that lead to extreme weather events (Hulme, 2014). However, as several scientists noted during study interviews, EEA results for certain types of events – among them droughts and hurricanes – remain highly susceptible to choice of method. If EEA is going to be communicated broadly to the media, researchers should think carefully about how the results are received by stakeholders and in the public sphere.

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