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Regional Extreme Weather Concern and its Relation to Support for Environmental
Action

A Thesis submitted in partial satisfaction of the
requirements for the degree Master of Arts
in Psychological and Brain Sciences

by

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ABSTRACT

Regional Extreme Weather Concern and its Relation to Support for Environmental Action

by

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[Using the framework of Construal Level Theory, we examine if concern about extreme weather—assessed at the aggregate level via Google search frequencies within the U.S.—in one’s geographic region is related to people feeling less distant from climate change and consequently engaging in more pro-environmental support. We assess a range of pro-environmental outcomes including beliefs about climate change, support for mitigation policies, and environmental behaviors. In Study 1 we externally validated Google search as a measure of weather concern, finding that in U.S. states where objective exposure to extreme weather was greater, search volumes for that respective weather type were greater. In Study 2 combining 4 national datasets ($n > 22,000$), we examined if extreme weather concern would predict regional levels of climate change beliefs and policy support. Controlling for search-based and demographic variables, extreme weather concern predicted beliefs but not policy support. In Study 3 ($N = 2538$), we examined if individuals who lived in states where there is greater extreme weather concern would feel less psychologically distant from climate change, and if this reduced distance would lead to greater pro-environmental support. Regional concern was found to predict individuals’ sustainability

behaviors but not their policy support or prioritization of climate change as a social issue. Lower psychological distance mediated the effect of regional weather concern on self-reported behaviors. This research advances two new methodological approaches to progress climate science: the use of Google search terms to operationalize extreme weather concern and a measure of psychological distance to climate disasters.]

Regional Extreme Weather Concern and its Relation to Support for Environmental Action

In growing numbers of communities, extreme weather caused by climate change is becoming a part of daily life. From deadly heatwaves in Paris and London (Stott et al., 2004) to poor harvests in South Africa (Herring et al., 2018), scientists have been able to identify the human fingerprint on extreme weather events all over the globe since the early 2000s (Pidcock et al., 2020). Extreme weather is felt within the United States as well although the specific disasters vary regionally: Californians fight fires, New Jersey shore residents barricade their homes from coastal storm surges, Floridians prepare for tropical cyclones every summer, and Texans endure extreme heat waves and severe summer drought (Environment America, 2020).

While climate change is a problem that is international in scope (Eom et al., 2016), the present report focuses attention on the United States. The U.S. has acted uniquely in the case of climate change, being the only nation to withdraw from the Paris Climate Agreement (Hersher, 2019) and one of the only countries that is politically divided on the causes and solutions to climate change (McRight & Dunlap, 2011; Dunlap et al., 2016). What is more, the U.S. was ranked as the second-highest global contributor to CO₂ emissions in 2017, according to the most recently available data (Union of Concerned Scientists, 2020). All of these realities—and the great regional differences in climate support that exist throughout the nation—likely reflect the ambivalence of Americans about the climate change issue.

Although a rising majority of Americans think that global warming is happening and express worry and concern (Gustafson et al., 2019), great regional variation exists surrounding climate change beliefs, risk perceptions, and policy support, according to estimates gathered by the Yale Program on Climate Change Communication (YPCCC)

(Marlon et al., 2019). Striking variation exists at the county level, for example, as counties just a few miles apart can differ as greatly as 30 percentage points in the extent to which their inhabitants believe in global warming (Howe et al., 2015). While this variation in climate opinion is typically attributed to demographic variables such as political party affiliation by scholars and the press (e.g., Hamilton et al., 2015; Dunlap et al., 2016; Mastroianni, 2015), we suggest that the local weather may be an important driving factor as well: people who live in areas where extreme weather has not hit to the same extent may fail to see the impact of climate change on their personal lives, and therefore feel less compelled to act. Yet, environmental action from *all* Americans is urgently required, as projections from the UN Intergovernmental Panel on Climate Change (2018) alert that “unprecedented change is needed” within the next ten years in order to prevent the earth from warming 1.5°C above preindustrial levels, beyond which droughts, floods, extreme heat, and poverty for hundreds of millions of people would become the norm. In three studies, we investigate the potentially motivating impact of extreme weather experiences (i.e., concrete experiences with disasters caused by climate change) on two important outcomes—Americans’ climate change *beliefs* and *actions*—both at the aggregate and individual levels.

Researchers have posited that the abstract, distant nature of climate change is a main psychological barrier to environmental action. People have a bias towards addressing their immediate problems, making it difficult to focus on climate change, which is perceived as slow, distant, and separate from one’s direct experience (e.g., Wang et al., 2019; Duan et al., 2019). Yet, recent reviews raise the question about whether immediacy is in fact a central factor in driving individuals’ climate action. As the climate continues to change, individuals are increasingly having personal and tangible experiences with extreme weather (Bouwer, 2019). With six out of the top ten most destructive California wildfires occurring in the past

three years, Californians have recognized the dismal new reality that each fire season will surpass the last, setting records for magnitude, destruction, and loss of life (CAL FIRE, 2019; Cart & Lin, 2019). A statewide report projects that the average burn area in California should increase 77 percent by the end of the century should fossil fuels not be regulated (State of California, 2019). Further, projections based on hurricane tracking data warn that the risk of tropical storm surge is expected to rise by 25 to 57% in the coming years for coastal populations in Florida and the U.S. Gulf of Mexico, and that hurricanes approaching the U.S. East Coast will become even more rapid and intense (Balaguru et al., 2016; Ting et al., 2019). As these findings illustrate, Americans range in their experiences with extreme weather, both in type and severity. The present work takes a novel regional approach towards studying how weather concerns shape people's level of environmental support. It is important to understand the role of these regional concerns in the widespread American divide on climate change issues. With this knowledge, public leaders can tailor their climate science communication strategies to audiences living in different geographic regions to better resonate with people who hold a diversity of weather concerns (Sherman et al., in press).

Through the framework of Construal Level Theory (CLT; Trope & Liberman, 2010), the present research seeks to understand the ways in which the prevalence of extreme weather positions climate change as an immediate threat, and the motivating impact that perception has on different forms on pro-environmental support. In so doing, this research advances two new methodological approaches to advance climate science: the use of Google search terms to operationalize extreme weather concern (Study 1, 2, 3), and a measure of psychological distance to climate disasters (Study 3). In Study 1, we seek to validate Google search frequencies for extreme weather topics as a measure of a region's level of concern

about extreme weather. In Study 2, we utilize Google search frequencies to examine if U.S. regional differences in extreme weather concern explain the widespread variation in climate change beliefs and policy support among American communities. In a survey of individuals (Study 3), we introduce a measure of psychological distance to climate change and examine it as a potential mechanism through which concern about local weather may translate to pro-environmental support.

Psychological Distance of Climate Change

In what he refers to as “the dragons of inaction,” environmental psychologist Robert Gifford (2011) argues that people engage in judgmental discounting of environmental problems: they expect conditions to be worse *elsewhere* and *later*. This spatial and temporal discounting is what contributes to a lack of motivation to act on climate change locally and in the present.

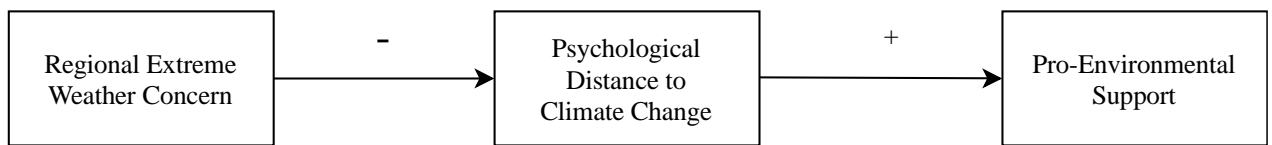
Construal Level Theory posits that individuals are only capable of experiencing the here and now (the proximal) and have to imagine or mentally construct everything in the past or future (the distant). Hence, people construe the same object or event differently depending on whether it occurs in the present moment or is distant in time and space, is happening to strangers, or is uncertain to happen. One’s psychological distance to an object determines whether it is mentally represented at a high- or low-level construal. People tend to think about distant entities at a high-level construal, perceiving them as abstract and de-contextualized, while thinking about proximal entities at a low-level construal, perceiving them as concrete, detailed, tangible, or vivid. In the case of varying temporal distance, when imagining the concept of climate change one hundred years from now, for example, one might form an abstract mental image involving rising sea levels, disappearing coral reefs, and melting glaciers; when thinking about climate change tomorrow, one might think about

the unusually hot or cold temperature outside, active weather alerts on their phone, stocking up on groceries for the upcoming storm, or other low-level, tangible details (Liberman & Trope, 1998).

Thus, the distant nature of climate change and its consequences may contribute to people thinking about it in an abstract way. In the present work on climate change and psychological distance, we propose the following theoretical model:

Figure 1

Proposed Model



Concern for climate change-related extreme weather in one’s geographic region reduces one’s psychological distance to climate change. In other words, this model hypothesizes that living in regions that are more impacted by extreme weather increases the personal relevance of climate change: people begin to visualize its negative impacts more vividly, seeing how the abstract concept of “climate change” affects their own lives. This reduced psychological distance is theorized to lead to greater *pro-environmental support*, a construct inclusive of environmental beliefs, policy support, and personal sustainability behaviors. It is important to acknowledge that there are many other factors besides regional extreme weather concern that lead to pro-environmental support: thus, this model also accounts for regional and individual variation in political party affiliation and socioeconomic status (demographic predictors of pro-environmental support identified in prior research; Lee et al., 2015) before examining the relationships proposed above. In three studies, we investigate this model at the collective level using publicly available population

datasets and at the intrapersonal level through a survey of an American sample chosen to be representative of major demographic groups in the U.S.

Proximity Increases Affect-Related Judgments

Prior research on affect and risk communication has examined why proximity to climate change related disasters should motivate environmental action. Extreme weather events increase the immediacy of the climate change threat, and threats that are immediate and vivid tend to arouse more negative emotion than threats that are distant and abstract (Damasio, 1994). It is these negative emotions of fear and anxiety that should, in turn, lead to behavioral change (Weber, 2006). To illustrate, when humanitarian crises arouse more immediate emotion, people donate more to address the crises (Huber et al., 2011). People also donate more of their extra credit points towards environmental causes if the negative consequences of climate change have been framed as immediate and certain (vs. distant and uncertain) (Kortenkamp & Moore, 2006). In more applied work, New Zealanders from a nationally representative sample were more likely to believe in climate change and support governmental regulation of carbon dioxide emissions the closer they lived to the shoreline (Milfont et al., 2014). Taken together, these findings indicate how thinking concretely about and being more proximal to climate change may elicit the emotional response needed to motivate environmental action.

However, the literature is somewhat mixed: focusing on proximal impacts does not always motivate people to respond (Brügger et al., 2016). In a study examining the influence of proximal versus distant risk perceptions on pro-environmental support, researchers found that it was individuals' *distant* risk perceptions of climate change that better predicted their willingness to support mitigation and adaptation policies; only with personal adaptation intentions were proximal risk perceptions a larger predictor (Brügger et al., 2015). In

another study that manipulated perceived spatial distance to a climate-affected location (the Maldives), reduced psychological distance did not translate into increased policy support (Schuldt et al., 2018).

Methodologically, this prior work has either surveyed respondents in affected areas or experimentally manipulated a sense of proximity among individuals and examined their consequent beliefs and actions. As noted, the results have been generally mixed (see Brügger et al., 2016 for review). Approaching the question of psychological proximity to climate change and environmental action from a new angle, the present work investigates the relationship between regional extreme weather concern and pro-environmental support by measuring perceived closeness to climate disasters via the aggregate data approach (e.g., Ettredge et al., 2005; Jun et al., 2018).

Aggregate Data Approach

We utilize a novel aggregate-level psychological variable of proximity to climate disaster: Google search data for extreme weather topics, collected through the Google Trends service (<http://trends.google.com>). Google Trends is a relatively recently developed tool for measuring regional concerns and has been used to study topics ranging from Ebola concerns and political preferences (Campante et al., 2020) to fragile masculinity and votes for Donald Trump (DiMuccio & Knowles, 2020). We adopted the Google search term approach for several reasons. First, as people tend to feel anonymous when typing questions into a search engine, search data can be more informative about people's level of concern over sensitive topics than responses from self-report questionnaires (Stephens-Davidowitz & Pabon, 2017). For gauging concern about climate disaster, currently a politicized issue (Unsworth & Fielding, 2014), using Google is advantageous because while people may be

likely to respond in line with their politics on self-report surveys as a form of socially desirable responding (Paulhus, 1984), anonymous search behavior attenuates this bias.

Further, Google's data is based on millions of searches and consists of a score for every U.S. region representing search activity for any given topic. This ability to inspect regional differences with Google Trends directly services our research question, which studies the role of *region-specific* weather concerns in contributing to the widespread variation that exists in American environmental support. As prior work investigating the effect of personal climate change experience on beliefs has consisted of studies examining the relationship between a singular geographic proxy of climate change immediacy (typically coastline erosion) and varying environmental outcomes (Zahran et al., 2006; Milfont et al., 2014), we cannot expect the findings of these papers, taken individually, to generalize to people who are concerned about other types of weather events. The present research addresses this gap by combining Google search data for four different extreme weather categories into a single variable representing extreme weather concern, allowing us to capture the apprehensions of people throughout the United States who experience different forms of extreme weather.

To examine the outcome of pro-environmental support, we utilize a second aggregate-level dataset: map estimates of Americans' climate change beliefs and policy support at the state and county levels gathered by the Yale Program on Climate Change Communication (YPCCC) (Marlon et al., 2018). Since 2017, the YPCCC has been one of the pre-eminent programs on climate change communication, launching training programs that help television weather presenters and reporters discuss climate change and offering tips on their website for activists and everyday people to use. Their interactive partisan climate opinion maps of the United States have played a key role in advancing climate science

communication, gaining recognition in outlets such as the *New York Times* for their clear portrayal of regional differences in attitudes towards global warming and support for policies (Popovich et al., 2017). And while the Yale Climate Opinion Maps contain many variables of interest to psychologists, they have still not been explored for the purpose of understanding of the psychological drivers of pro-environmental support. By using U.S. population search activity data from Google to predict U.S. population climate opinion estimates from Yale, the present work advances the study of environmental psychology by examining commonly researched behavioral and attitudinal variables through a novel aggregate data approach.

Differentiating Among Environmental Outcomes

Across three studies, we examine several different outcomes of pro-environmental support—beliefs, policy support, and personal behaviors. Previous findings (e.g., Reczek et al., 2018) suggest that these outcomes may be activated by different motivational mechanisms and should be theoretically differentiated when researching how psychological distance affects environmental action (see also: Brügger et al., 2015; Brügger et al., 2016).

Particularly, *Construal Level Theory* suggests that the abstraction of the environmental outcome being motivated should match the individual's construal mindset: when people perceive climate change to be a distant entity (i.e., possessing a more abstract mindset), they would be more likely to engage in abstract forms of environmental action (e.g., policy support); when people perceive climate change to be a proximal entity (i.e., possessing a more concrete mindset), they would be more likely to engage in concrete forms of action (e.g., sustainability behaviors). For different environmental actions, CLT implies that policy support is more abstract than individual behavior because its implementation and consequences are more distant on the different dimensions of psychological distance (e.g.,

temporal, social, spatial, hypothetical). For example, policies require support from many people before becoming enacted, their consequences are widespread, and they take time to unfold, whereas behavior change typically requires just oneself, has clear-cut steps, and has visible and immediate consequences (Demski et al., 2017; Ziegler & Tunney, 2012). As Brügger et al.'s (2016) review suggests, “proximizing” may not increase environmental support indiscriminately: it may only be effective for actions that seem specific and easy to implement individually, but not for actions whose visible benefits to the environment seem distant and abstract.

The Present Research

The present work makes several contributions to the literature on climate change proximity and pro-environmental support, and the emerging methodological literature on the use of freely available data to represent psychological constructs and behavioral trends.

First, Study 1 seeks to validate Google search frequencies for extreme weather topics as a measure of concerns about extreme weather at the regional level. To date, concern about extreme weather has only been studied at the individual level through surveys or lab experiments. The present work advances this enquiry at the collective level through a novel operationalization of extreme weather concern.

Second, Study 2 seeks to advance the understanding of factors that contribute to regional variation in pro-environmental support by integrating large datasets from two sources: Google Trends and Yale Climate Opinion Maps. It is important to study what contributes to regional divides in climate policy throughout the United States. American environmental policy is highly decentralized, and research has shown that this has a potential detrimental effect on national emissions. Projections suggest that if all the subnational initiatives were realized, this could help to stabilize U.S. emissions (Lutsey &

Sperling, 2008). Besides policy, it is also important to understand what contributes to regional divides in eco-friendly behaviors, such as waste management activities (Wolske et al., 2019). Both external variables, such as norms and convenience, and internal variables, such as perceived behavioral control and concerns for the future, have been shown to contribute to variation in individual pro-environmental behavior (Li et al., 2019). Further identifying these contextual and psychological predictors and how they interact can aid in developing effective strategies for climate science communication and policy making.

Another contribution of the present work is that we examine a wide variety of pro-environmental outcomes. We focus on beliefs and policy support in Study 2 and measure a range of pro-environmental behaviors in Study 3 to understand how regional weather concerns differentially motivate these different forms of action.

Finally, prior research has theorized that psychological distance may be a mechanism responsible for extreme weather experience leading to action but has not directly tested it. In Study 3, we include a measure of construal to capture people's subjective experiences of distance to climate change and test the full theoretical model, examining whether a reduced sense of psychological distance may help to explain the effect of extreme weather concern on pro-environmental support.

Study 1: Validating Google Search Frequencies as a Measure of Regional Concern

The major contribution of Study 1 is to externally validate regional Google search volumes for extreme weather topics as a measure of concern about extreme weather in one's local area. We hypothesized that regions that are more affected by extreme weather objectively would contain higher search volumes for extreme weather topics. The Google searches ostensibly represent people searching for information about what is occurring in their local area in order to stay safe and informed.

We present the following study that tested the hypothesis that extreme weather Google searches represent concern for extreme weather events occurring in one's local area. To do this, we conducted a study of archival data sources (National Hurricane Center, National Drought Mitigation Center, Federal Emergency Management Agency (FEMA), and Insurance Information Institute (III)) containing state-level information on the measurable impacts of tropical cyclones, droughts, floods, or wildfires (the chosen search topics, described below). Examining one weather category at a time, we predicted that in states where measurable impacts from these weather events were greater, Google search volumes for the corresponding topic would also be greater.

Method

Procedure

Study 1 examined the relationship between objective negative impacts from extreme weather and Google search scores for the corresponding weather term by U.S. state within a specified time frame. First, we located archival data sources of objective negative impacts from four extreme weather events of interest (e.g., wildfire, drought, tropical cyclone, and flooding). "Objective negative impacts" were defined as quantifiable measures of harm (e.g., number of acres burned, number of incidents) incurred by these events. As no single data source existed for all four weather types, data from four separate yet equivalent sources (three government databases, one U.S. industry association) were used that together summarize number of events, cost of damages, acres burned, or percentage of people currently affected by wildfires, tropical cyclones, droughts, or flooding.

While data at the same unit of analysis for each of these sources (state-level) were obtained, the four data sources described different time periods. Thus, we compared Google search data for each weather topic to each weather type's corresponding objective harm data

for the same or comparable time period (i.e. regional Google search data for the topic “Wildfire” in 2019 was compared to the number of wildfires and acres burned by state in 2019). Keeping time period of the objective harm data and Google search data consistent enabled an examination of whether people were searching for information about current events.

Predictor Variable: Regional Extreme Weather Exposure

Wildfire Exposure. Wildfire exposure was assessed with data on number of wildfires that occurred in each U.S. state in 2019 ($M = 1007.60$ wildfires, $SD = 1567.71$) and number of acres burned by state in 2019 ($M = 93229.20$ acres, $SD = 356706.39$). This data was acquired from the Insurance Information Institute (III), a trusted industry source of insurance data and information for the media and consumers since 1960. This source contained data for all 50 U.S. states.

Tropical Cyclone Exposure. Hurricane exposure was assessed with data on U.S. mainland hurricane strikes by state from 1851 – 2004 ($M = 22.11$ hurricane strikes, $SD = 27.39$) acquired from the National Hurricane Center (nhc.noaa.gov). This source contained data for 19 U.S. states (31 were missing, as hurricanes do not occur in inland states).

Drought Exposure. Drought exposure was assessed with data on average percent area in U.S. drought monitor categories by state in 2019 ($M = 19.08$ percent, $SD = 16.01$) from the National Drought Mitigation Center (droughtmonitor.unl.edu). This source provided weekly data on percent area in each drought monitor category from D0 (least severe) to D4 (most severe). For each state, percent area in each of the four drought monitor categories were summed to obtain total percent area in any drought monitor category D0 to D4. These scores were then averaged across 52 weeks to calculate a yearly average percent

area in U.S. drought monitor categories by state for 2019. This source contained data for all 50 states.

Flooding Exposure. Flooding exposure was assessed with data on number of flood events by U.S. state in 2016 ($M = 100.60$ flood events, $SD = 101.93$) from the Federal Emergency Management Agency (FEMA.gov). This source contained data for all 50 states.

Outcome Variable: Regional Extreme Weather Concern

Aggregate-level extreme weather concern was operationalized using Google searches for *wildfire*, *drought*, *tropical cyclone*, and *flood*. We chose these four searches because these are extreme weather events whose increasing frequency and intensity can be attributed to anthropogenic global warming (Trenberth, 2012; Stott et al., 2004; Rahmstorf & Coumou, 2011; Marjanac et al., 2017), rather than weather events whose association to human activity and climate change is ambiguous or nonexistent (e.g., earthquakes) (e.g., Boykoff & Boykoff, 2007).

Rather than download data by exact term, each query's data was downloaded based on Google Trends "topics." Topics represent groups of related searches that the Google algorithm regards as approximate synonyms (e.g., the topic "Wildfire" includes searches for "Australian wildfires" and "Alaska wildfires 2019.") Collecting data on these searches by topic rather than by query or term verbatim is advantageous because it captures the range of phrases that people can use to search for the same information and extends the number of geographic regions for which Google Trends provides data.

Acquisition of Google Trends Data

Search volumes for each of the four extreme weather search topics were downloaded from Google Trends. For each extreme weather type, data was acquired for the time frame corresponding to the time frame of the objective harm data and at the level of U.S. state.

Search data for all four extreme weather topics was available for all 50 U.S. states and Washington, D.C. ($N = 51$). Search volumes are scaled by Google Trends relative to 100, with 100 representing the state with the highest search volume for that term, and lower numbers representing a proportion of that highest volume. Importantly, search volumes are determined relative to total Google searches in a region, thereby not being affected by regional population or internet usage rates.

Control Variables

Google Searches. In order to rule out the alternative that the objective weather exposure data for each weather type would predict search behavior for *any weather topic* (not just the corresponding weather type), in each analysis the three remaining Google search topics were treated as control variables. For example, when examining whether acres burned by wildfire in 2019 would predict Google search frequencies for *wildfire* in 2019, we conducted additional regressions with *tropical cyclone*, *drought*, and *flood* search volumes as the outcome variables to verify that these would not also be predicted by number of acres burned by wildfire¹. As expected, bivariate correlations between extreme weather Google searches ranged from $r = -.19$ to $r = .37^2$, as there is a range of regional overlap in the prevalence of these extreme weather events.

Demographic Covariates. Factors such as population density have been shown to exacerbate extreme weather's effects on a region (Molarius et al., 2014). Further, great regional differences in political ideology, income, and education exist, and these demographics may bias the extent to which people in different regions search for information on the internet about extreme weather events. For example, research has shown that individuals' political ideology dominates their climate change views, and their climate

¹ See Supplemental Online Materials for results of these regressions.

change views are largely intertwined with the extent to which they perceive extreme weather events as harmful (Zanocco et al., 2019). Regarding the general tendency to search for information on the internet, medical studies have shown that people with higher income and education levels tend to be more likely than those with lower income and education to search for health-related information on the internet before going to a clinic (AlGhamdi & Moussa, 2012). Thus, we controlled for the percentage of Republican voters by state in 2016 using Gallup data, and population density, median income, and median education levels by state using ACS five-year estimates. Controlling for proportion of Republican voters is a common method of controlling for regional political ideology consistent with previous social-psychological research (e.g., Mildemberger et al., 2017).

Analytic Plan

Multiple regressions are reported below for each weather type (e.g., wildfire, tropical cyclone, drought, and flooding), with proxies of objective extreme weather harm (e.g., acres burned) as the predictor variable and regional Google search volumes for that weather type as the outcome variable. Regional population density, political ideology, median income, and median education levels are included as demographic controls in these regression models, and all analyses are conducted at the level of U.S. state. See supplemental online materials for bivariate correlations between key variables and multiple regressions with the three remaining Google search topics as the control outcomes.

Results

Wildfire

Two multiple regression analyses were conducted to examine the effect of wildfire exposure on *wildfire* searches after controlling for regional population density, percentage of

² See Table X in Supplemental Online Materials for bivariate correlations.

Republican voters, median income, and median education levels. First, number of acres burned by wildfire by state in 2019 significantly predicted *wildfire* searches by state for the year of 2019 (January 1, 2019 to December 31, 2019), unstandardized B = 3.283E-5, SE = .000, 95% confidence interval (CI) = [.000, .000], $t(44) = 9.617$, $p < .001$. U.S. states that suffered a greater negative impact from wildfires contained higher Google search volumes for the topic *wildfire*. However, *number* of wildfires by state in 2019 did not predict Google search volumes for *wildfire*, $p = .83^3$, controlling for demographic covariates.

Tropical Cyclone

Next, a multiple regression analysis was conducted to examine the effect of hurricane exposure on *tropical cyclone* searches after controlling for demographic covariates. As predicted, number of hurricane strikes by state from 1854 to 2004 significantly predicted *tropical cyclone* searches by state from 2004 to present⁴, unstandardized B = .497, SE = .102, 95% CI = [.277, .717], $t(13) = 4.882$, $p < .001$. U.S. states that suffered a greater negative impact from hurricanes contained higher Google search volumes for the topic *tropical cyclone*.

Drought

Third, a multiple regression analysis was conducted to examine the effect of drought exposure on *drought* searches after controlling for demographic covariates. Average percent area in U.S. drought monitor categories by state in 2019 was found to significantly predict *drought* searches by state in 2019, unstandardized B = .254, SE = .097, 95% CI = [.058, .450], $t(44) = 2.606$, $p = .012$. U.S. states that suffered a greater negative impact from droughts contained higher Google search volumes for the topic *drought*.

³ There was no correlation between number of wildfires and number of acres burned by state, $p = .450$.

Flooding

Finally, a multiple regression analysis was conducted to examine the effect of flooding exposure on *flood* searches after controlling for demographic covariates. Contrary to what was predicted, number of flood events by state in 2016 were not significantly related to *flood* searches by state for the year of 2016, unstandardized $B = .029$, $SE = .018$, 95% CI = $[-.008, .066]$, $t(44) = 1.593$, $p = .118$. U.S. states that suffered a greater negative impact from flooding in terms of number of flood events did not contain higher Google search volumes for the topic *flood*.

Discussion

In Study 1, Google searches for extreme weather topics occurred more frequently in U.S. states that are more objectively harmed by extreme weather. These results present initial evidence that externally validates extreme weather Google search activity as a measure of concern about local weather. Proceeding to Studies 2 and 3, these findings enable us to rule out the possibility that searches merely reflect a regional *interest* in extreme weather while still being spatially distant (i.e., due to media coverage) rather than a sense of feeling personally affected, apprehensive, and vulnerable because the weather is encroaching upon one's neighborhood and endangering oneself and loved ones.

Establishing that Google search data represents a sense of concern about local events was a necessary precursor to Study 2, where we examine if region-specific concern about extreme weather plays a role in widespread variability in beliefs about climate change and policy support in the United States. We integrate Google Trends search data and Yale Climate Opinion Maps estimates to test the hypothesis that U.S. regions where people feel

⁴ This time frame was chosen because Google Trends was first introduced on May 11, 2006 and releases insights as far back as 2004.

more concerned about extreme weather will have a greater proportion of people who exhibit greater pro-environmental beliefs and support for climate change mitigation policies.

Study 2: Regional Extreme Weather Concern and its Relation to Regional Climate Change Beliefs and Pro-Environmental Policy Support

As extreme weather events negatively affect certain parts of the country more than others, Study 2 examines the role that region-specific extreme weather concern plays in explaining the widespread regional divides surrounding Americans' climate change beliefs and support for policies. Study 2 combines four large, publicly available datasets—Google Trends, Yale Climate Opinion Maps, Gallup polling data from 2016, and American Community Survey five-year estimates—to examine if people's concerns about extreme weather (i.e., concrete manifestations of climate change) predict global warming beliefs and support for environmental policy at the collective level, separate from the prevailing political ideology of the area. We predicted that in U.S. metro areas where Google search queries for extreme weather topics are more popular, a greater proportion of people would believe that climate change is happening and that scientific consensus on it exists, and would be more likely to support various pro-environmental policies.

Method

Predictor Variable: Regional Extreme Weather Concern

Aggregate-level extreme weather concern was operationalized using the Google search topics validated in Study 1: *wildfire*, *drought*, *tropical cyclone*, and *flood*. Search popularity for these four topics were averaged into a composite variable (Extreme Weather Index) because these weather events impact different parts of the country and averaging

ensured that each region's concern for extreme weather was represented through this score⁵. Scores on this index ranged from 0 to 100, with higher scores denoting that extreme weather searches were more popular in a region. Search volumes for *global warming* and *climate change* were downloaded for exploratory purposes, to examine if averaged extreme weather searches would predict an interest in the topics of global warming and climate change⁶.

Acquisition of Google Trends Data

Google Trends data was acquired at the level of Designated Market Area (DMA)⁷ from January 1, 2008 to December 31, 2018, the same time frame that Yale Climate Opinion Maps used as a basis for their climate change public opinion estimates (Marlon et al., 2018). Data was available for at least 3 extreme weather terms for all DMAs except for Tucson, Arizona; the mean number of extreme weather terms with search data was 3.98 ($SD = 1.00$). As explained earlier, extreme weather searches were averaged into a composite variable to represent concern for *region-specific* weather. Figure 2 depicts search volumes for DMAs across the U.S.

Outcome Variable: Regional U.S. Climate Change Beliefs and Policy Support

For the outcomes of climate change beliefs and policy support, we examined public opinion estimates compiled by the YPCCC. These estimates are based off of national survey

⁵ Even though averaging the four searches introduces measurement error because each region's score contains noise from searches of the other weather events that do not typically occur there (e.g., a California region's score is the mean of *wildfire*, *flood*, *drought*, and *tropical cyclone* search volumes), the composite should only reflect concern for *local* weather because search volumes for the nonrelevant terms would be low or close to zero (i.e., people would search less for remote weather events, consistent with theory and Study 1 results).

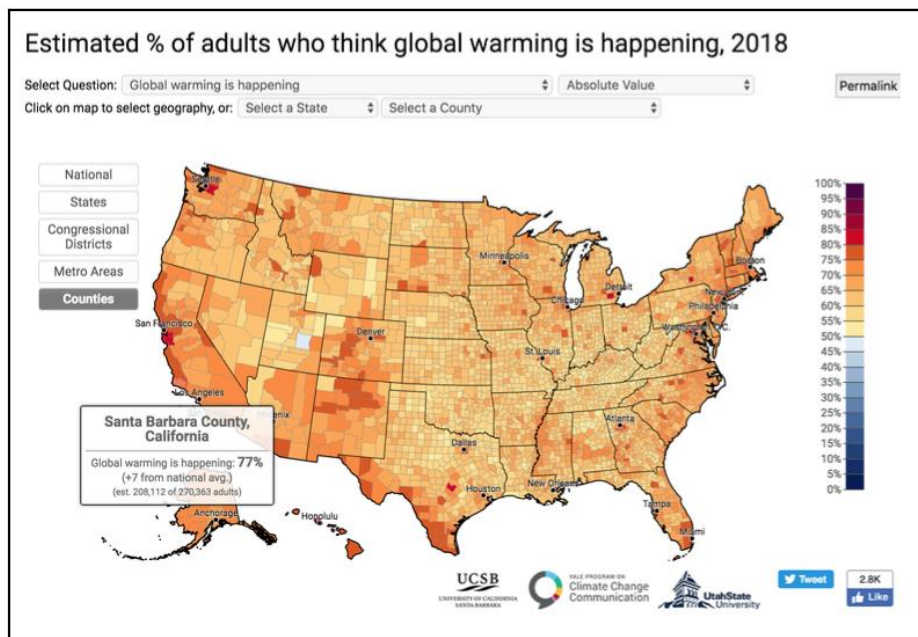
⁶ See Supplemental Online Materials for these results.

⁷ Created by Nielsen Media Research, DMAs are geographic partitions comprised of one or more counties where the population receives the same television, radio, and broadcast channels. With the exception of parts of Alaska, the 210 Nielsen DMAs fully cover the United States. DMA is the smallest geographic unit for which Google Trends makes search volumes publicly available.

data ($n > 22,000$) gathered between 2008 and 2018, and comprise interactive maps illustrating how Americans' climate change beliefs, risk perceptions, policy support, and behaviors vary at the state, congressional district, metro area, and county levels (see Figure 3).

Figure 3

Yale Climate Opinion Maps 2018



Climate Change Beliefs. Climate change beliefs were assessed with the following two questions: “Do you think that global warming is happening?” and “Most scientists think global warming is happening. Which comes closest to your own view?” The data for each of these variables is presented as a percentage from 0 to 100, indicating the percentage of people in each region that selected “yes” to thinking that global warming is happening and that they believe “most scientists think global warming is happening.”

Policy Support. Policy support was assessed with the following six pro-environmental policies: “Fund research into renewable energy sources,” “Regulate CO₂ as a pollutant,” “Set strict CO₂ limits on existing coal-fired power plants,” “Require fossil fuel

companies to pay a carbon tax,” “Require utilities to produce 20% electricity from renewable sources,” and “Provide tax rebates for people who purchase energy-efficient vehicles or solar panels.” Scores on these variables represent the percentage of people in each region that either “strongly” or “somewhat support” each policy.

Control Variables

Regional Negativity Control. In order to exclude two alternative explanations—1) that *greater search behavior* for any term on Google would predict climate change beliefs and policy support and 2) that regional concern for *catastrophes* (not just climate disasters) drives climate change beliefs and policy support—four non-weather-related disaster searches were averaged into a control index. These search topics were *aviation accident and incident, virus, drug overdose, and shooting*. These topics were selected to form a comparison group because they are semantically different from extreme weather yet comparable in impact and emotional devastation, having a quality of “rupture” which involves a sudden transition from a dormant state to a crisis (Sornette, 2002). As these negative events are not region-specific, the control index exhibited less variability across U.S. DMAs than the extreme weather index (variances = 17.34, 53.38, *SDs* = 4.16, 7.31, respectively). As expected, there was no relationship between regional extreme weather search volumes and control search volumes, $p = .41$.

Demographic Covariates. As in Study 1, regional differences in political ideology, income, and education level were controlled for, as prior research has shown that party identity as well as income and education levels can greatly influence one’s attitudes towards climate change and environmental policy (Lee et al., 2015). Estimates of percentage of Republican voters by DMA in 2016 were obtained through Gallup data, and income and

education levels by DMA were obtained through American Community Survey (ACS) five-year estimates (United States Census Bureau, 2019).

Analytic Plan

Data from Yale Climate Opinion Maps, Gallup, and ACS five-year estimates were collected at the county level, while Google Trends was collected at the DMA level. Counties are perfectly nested within DMA, with anywhere from 1-20 counties in a DMA. To make the four datasets compatible, the data was standardized by DMA and DMA was used as our unit of analysis ($N = 205^8$). As part of this process, we created a weighting variable signifying the proportion of the DMA that each county constitutes and multiplied the county-level data by this variable to assign more weight to climate opinion and demographic estimates in large counties than in small counties.

When analyzing regional variables, it is best practice to control for demographics such as income, education, and politics. Multiple regressions of the four-predictor models are reported below. See supplemental online materials for results of the bivariate correlations.

Results

Climate Change Beliefs

Two multiple regression analyses were conducted to examine the effect of regional extreme weather concern on regional climate change beliefs after controlling for percentage of GOP voters, median income, and median education level by region. As hypothesized, regional extreme weather concern significantly predicted regional beliefs that global warming is happening, unstandardized $B = .096$, $SE = .014$, 95% $CI = [.068, .124]$, $t(200) = 6.745$, $p < .001$, and that scientists agree that global warming is happening, unstandardized B

= .112, $SE = .022$, 95% CI = [.069, .155], $t(200) = 5.146$, $p < .001$. Regional negativity searches did not predict either of these beliefs, p 's $> .162$, or change the above findings when added as a fourth covariate to the models, dismissing the alternatives that negativity and search behavior were driving these effects. In summary, in metro areas where Google search activity for extreme weather topics is greater, a greater percentage of the United States population believes in climate change and scientific consensus.

Policy Support

Next, six multiple regression analyses were conducted to examine the effect of regional extreme weather concern on support for pro-environmental policies. Counter to our prediction, we did not find a positive relationship between extreme weather Google searches and policy support: instead, range of results was found such that regional extreme weather concern was unrelated to four out of the six environmental policies (e.g., “Fund research into renewable energy sources”) but was negatively related to the two others (e.g. “Regulate CO₂ as a pollutant”). Control index search volumes were not significantly related to any measures of pro-environmental policy support besides “Provide tax rebates to people who produce energy-efficient vehicles or solar panels,” unstandardized B = .039, $SE = .017$, 95% CI = [.006, .073], $t(203) = 2.329$, $p = .021$, but this result was likely spurious. Taken together, these findings suggest that a region’s Google search activity for extreme weather does not predict how supportive people in that region would be of implementing climate change related policies. Results of the multiple regression analyses are summarized in Table 1.

⁸ Number of DMAs containing data for all eight extreme weather and control searches.

Table 1

Relation between Regional Extreme Weather Google Search Volumes and Regional Policy Support

Climate Change Policy	Estimate	SE	95% CI	t (200)	p
Fund research into renewable energy sources	-.014	.012	[-.038, .011]	-1.105	.271
Regulate CO ₂ as a pollutant	-.063	.014	[-.090, -.036]	-4.531	< .001
Set strict CO ₂ limits on existing coal-fired power plants	.025	.021	[-.017, .066]	1.178	.240
Require fossil fuel companies to pay a carbon tax	-.024	.018	[-.059, .011]	-1.354	.177
Require utilities to produce 20% electricity from renewable sources	.032	.011	[.011, .032]	3.039	.003
Provide tax rebates for people who purchase energy-efficient vehicles or solar panels	-.030	.008	[-.047, -.014]	-3.654	< .001

Note. Unit of Analysis: Designated Market Area ($N = 205$). Regressions controlling for percentage of Republican voters by region, income, and education. CI = confidence interval.

Discussion

In Study 2 we identified, using two datasets of the United States population, that regional variation in concern about extreme weather predicts regional variation in climate change beliefs—specifically, belief that global warming is happening and belief that scientists agree that global warming is happening. A region’s level of concern about extreme weather, however, *did not* predict how supportive its populace would be of implementing various pro-environmental policies, even after controlling for the political views of the area. As prior work has shown that proximity to climate disaster motivates various forms of action, including policy support (e.g., Milfont et al., 2014; Scannell & Gifford, 2013), this was an unexpected finding. In Study 3, we include different climate change policy measures

Five DMAs had missing searches.

as well as additional outcomes of pro-environmental support to more closely examine the impact that extreme weather concern has over each of them.

In Study 2, we inferred *regional* extreme weather concern from Google search activity, but we did not actually measure the psychological experiences of the *individuals* living within those regions. While our archival study demonstrated that regions with greater extreme weather exposure exhibit greater search volumes for those weather terms, it is possible for people to search for information with Google about a topic without feeling personally at risk. Moreover, Study 2 was conducted entirely at the aggregate level so we cannot draw conclusions about the individual experience.

Study 3 tests a mediational model examining whether Google searches for extreme weather at the collective level predict individuals' psychological experience of climate change, particularly how close or distant they feel from it. We further investigate the extent to which this reduced psychological distance predicts individuals' environmental action, including their everyday sustainability behaviors and policy support. Participants responded to a series of questions asking them how close in time, space, interpersonally, and uncertainty-wise they perceive climate change to be, and to subsequently complete measures assessing the frequency of their environmental behaviors and their level of policy support. To assess collective extreme weather concern, we merged existing state-level Google search data into the dataset of participant responses from an online survey of Americans.

Study 3: Regional Extreme Weather Concern and its Relation to Individual Psychological Distance and Environmental Action

Study 3 addresses three questions. First, the present study examines whether a regional sense of concern about the local climate captured through an aggregate variable is sufficiently strong to influence *individuals within those regions'* perceptions of distance to

climate change and their resultant environmental behaviors. To do this, we recruited a large online sample of Americans selected to match national demographic characteristics to participate in a survey and examined their responses in tandem with the Google search score of the state they resided in. To clarify, the individuals who took our survey were *not* the same people who searched for the terms on Google; we intended for the Google scores to serve as an index of concern *for the entire region where participants reside*.

Second, a primary purpose of Study 3 was to assess pro-environmental support in terms of different dependent variables and to examine whether extreme weather concern would differentially impact them. Thus, we included measures of climate change belief, policy support, issue prioritization of climate change for the 2020 election, and everyday environmental behaviors in the survey as proxies of pro-environmental support. Third, Study 3 aimed to understand the mechanism through which extreme weather concern leads to environmental action. While we found support for part of our theoretical model in Study 2, we tested the full mediational model in Study 3.

First, we predicted that survey respondents who lived in states where there is a greater collective sense of weather concern would both report lower psychological distance to climate change and greater pro-environmental support: living in an area which suffers greater impacts from climate change should make it seem like a more immediate threat and lead to action. Next, we predicted that respondents who report lower psychological distance to climate change would report greater pro-environmental support, as seeing climate change's effects concretely should activate the emotional response which precedes action (Damasio, 1993; Weber, 2006). Finally, we predicted that a reduced sense of psychological distance to climate change would mediate the effect of regional extreme weather concern on individuals' environmental support, including their pro-environmental beliefs, everyday

environmental behaviors, policy support, and issue prioritization of climate change for the 2020 presidential election.

Psychological Distance Measure

Study 3 theoretically extends upon previous work by assessing individuals' subjective perceptions of psychological distance to climate change on a novel Likert-style index. Based in CLT, individuals report their perceptions of temporal, spatial, interpersonal, and hypothetical distance to climate change. As CLT posits that people feel similarly proximal or distant of each of the four different dimensions of psychological distance, we combined the items on this index to form a composite variable, with higher scores indicating greater psychological distance from climate change.

Method

Participants and Design

The present work is a correlational study examining relationships among six key variables, as part of a larger study examining sociocultural moderators of pro-environmental support (Sherman et al., in preparation). Participants were recruited online through a professional survey firm, TurkPrime (currently renamed to CloudResearch). The investigators of the larger study set a quota of 2,000 individuals in order to obtain a dataset large enough to test their proposed model and the study was conducted from May 1 through May 10, 2019. Participants were compensated for the amount that they agreed to depending on the platform through which they entered the survey (\$2.00 - \$3.00). 3,185 individuals completed the study, and 645 individuals were excluded for unsatisfactory responses based on TurkPrime data control criteria (i.e., suspicious IP addresses). All analyses were run on

the remaining 2,540 participants. Participant demographics and sampling target proportions based on U.S. demographics are presented in Table 4⁹.

Table 4

Participant Demographics

		Target Quota (%)	Target N	Number of Participants Collected	% Of Total
Gender	Male	49%	986	1152	45%
	Female	51%	1014	1388	55%
Ethnicity	Non-Hispanic	84%	1677	2183	86%
	Hispanic	16%	323	348	14%
Race	White	79%	1572	1911	76%
	Black	13%	261	318	13%
	American Indian or Alaska Native	1%	24	57	2%
	Asian	5%	98	96	4%
	Other	2%	45	140	6%
Region	Northeast	17%	344	426	17%
	Midwest	21%	418	471	19%
	West	24%	476	618	24%
	South	38%	762	1025	40%

⁹ Sherman et al. (in prep.) pre-registered the exclusion rule of omitting participants who completed the survey in less than 3 minutes; this resulted in two participants being excluded from the primary analyses, leaving a final sample of 2538.

Education	Less than High School	11%	216	326	13%
	High School Graduate	29%	578	754	30%
	Some College	18%	362	429	17%
	Associate’s Degree	10%	198	240	10%
	Bachelor’s Degree	21%	410	453	18%
	Master’s	9%	176	186	7%
	Doctorate	1%	34	51	2%
	Other post-high school vocational training	1%	26	51	2%

Note. N = 2540, and sampling target proportions based on U.S. national demographics.

Procedure

Participants were invited to complete a study about “Public Perception of Current Issues” investigating how Americans view social issues and engage in social behaviors. After consenting to the study requirements, they completed the Qualtrics survey (see OSF for survey instrument). This study was approved by the Institutional Review Board at UC Santa Barbara.

Key Measures

Predictor: Regional Extreme Weather Concern. Aggregate-level extreme weather concern was operationalized the same way as in Study 2, using Google searches for the topics of *wildfire*, *drought*, *tropical cyclone*, and *flood* averaged into an extreme weather index ranging from 0 (region with lowest extreme weather concern) to 100 (region with highest extreme weather concern). Since participants reported information about their state of residence on the Qualtrics survey, we downloaded state-level searches to make the Google Trends and TurkPrime datasets compatible. Each state contained data on all four extreme weather topics. As the online study was conducted in May 2019, we downloaded

extreme weather searches for the ten years preceding (May 2, 2009 to May 2, 2019)¹⁰.

Mediator: Psychological Distance. Participants' perceived distance to the threat of climate change was assessed via the following four items corresponding to each of the dimensions of psychological distance¹¹: "Climate change is more likely to cause harm to others than to me personally." (1 = *Strongly Disagree* to 7 = *Strongly Agree*; $M = 3.57$, $SD = 1.67$); "When do you think climate change will start to harm people in the United States?" (**R**) (1 = *Never* to 6 = *They are being harmed right now*; $M = 2.53$, $SD = 1.78$); "How much do you think climate change will harm the area in which you live?" (**R**) (1 = *Not at all* to 5 = *A great deal*; $M = 2.89$, $SD = 1.18$); and "How likely do you think it is that you will directly experience a major climate-related problem in the next year?" (**R**) (1 = *Extremely Unlikely* to 5 = *Extremely Likely*; $M = 3.92$, $SD = 1.88$). These four items were standardized and averaged into a composite variable of general psychological distance, with higher scores indicating greater perceived distance of climate change ($M = 0$, $SD = 1$, $\alpha = .70$).

Outcome: Pro-Environmental Support.

Environmental Behavior (Combined Measure). A combined continuous and binary measure of environmental behavior was calculated by standardizing and then averaging the two scales described below. Analyses were conducted both on the combined and the continuous measures of self-reported environmental behavior.

Environmental Behavior (Continuous). Participants' re-occurring environmental behavior was assessed on the six-item Recurring Environmental Behavior Scale (derived

¹⁰ We downloaded searches for a time period of ten years to capture the general trend of concern for weather patterns in a region, our construct of interest, and to prevent the occasional seasonal outlier from biasing results. Search volumes over ten years should more accurately capture regional concern for extreme weather than search volumes over one year, as these may be uncharacteristically high or low if the region happened to experience an atypical weather season that year.

¹¹ Items are presented in the order: social, temporal, spatial, and hypothetical distance.

from the 21-item REBS; Brick et al., 2017). This scale asks participants about their frequency of performing the following six everyday sustainability behaviors: “When you visit the grocery store, how often do you use reusable bags?”; “How often do you turn off your personal electronics off or in low-power mode when not in use?”; “How often do you act to conserve water when showering (by turning off water while soaping)?”; “How often do you sort your trash into the recycling?”; “How often do you carry a reusable water bottle?”; and “How often do you wait until you have a full load before running laundry?” on a scale from 1 = *Never* to 5 = *Always*. Scores on these items were averaged into a composite, with higher values indicating greater re-occurring pro-environmental behavior ($M = 3.25$, $SD = .84$, $\alpha = .58$)¹².

Environmental Behavior (Dichotomous). Environmental behavior in the last week was measured through six items asking participants to indicate on a binary scale (1 = *No*, 2 = *Yes*) whether or not they engaged in the following activism or discussion-based environmental behaviors that week: “I had discussions in favor of pro-environmental action in person.”; “I posted pro-environmental messages or articles online (Facebook, Twitter, etc.).”; “I engaged in political action or activism related to protecting the environment.”; “I educated myself about the environment (e.g., reading newspaper articles or online information).”; “I walked, bicycled, carpooled, or took public transportation instead of driving a vehicle by myself.”; and “I had at least one day of meatless eating (i.e., no chicken or beef).” Scores were averaged to create a composite, with higher scores indicating more pro-environmental behavior in the last week ($M = 1.32$, $SD = 0.25$, $\alpha = .61$).

Climate Change Belief. Participants’ climate change belief was assessed using the

¹² With the REBS, a low Cronbach’s alpha is expected because these behaviors are diverse and people may not behave similarly on all of them (e.g., being a frequent recycler

eleven-item Belief in Global Climate Change scale (Heath & Gifford, 2006) adapted by Eom et al. (2018). Participants were asked six questions about their belief in climate change (e.g., “I am quite sure that global warming is occurring now.”) and five filler questions (e.g., “The American public education system is in crisis.”) on a scale from 1 = *Strongly Disagree* to 7 = *Strongly Agree*. The six belief in climate change items were averaged into a composite variable, with higher scores indicating greater belief ($M = 5.07$, $SD = 1.39$, $\alpha = .94$).

Policy Support. Support for pro-environmental policy was assessed through three items adapted from the American National Election Survey (ANES) (2016) (e.g., “Do you think the federal government should be doing more about rising temperatures, should be doing less, or is it currently doing the right amount?”) and two items from the World Values Survey (WVS) (2014) (e.g., “I would give a part of my income if I were certain that the money would be used to prevent environmental pollution.”). Scores on these five items were averaged to create a composite ($M = 4.52$, $SD = 1.37$, $\alpha = .84$). These five items have been used in prior research on predictors of support for pro-environmental action (Eom et al., 2018 for ANES; Eom et al., 2016 for WVS). See OSF for full scale text.

Issue Priority for 2020 Election. Participants’ issue priority for the 2020 election was measured by asking individuals to rank nine issues in order of personal importance in their 2020 presidential election decisions from 1 = *Most Important* to 9 = *Least Important*. The nine issues are: (1) Campaign Finance, (2) Civil Rights, (3) Climate Change, (4) Economy, (5) Gun Control, (6) Healthcare, (7) Immigration, (8) Income Inequality, and (9) National Security. Higher ranking of climate change as an issue of personal importance reflects greater pro-environmental support, $M = 4.95$, $SD = 2.51$.

does not guarantee that someone also bikes to work); what is important is that participants

Control Variables

We included three covariates at both the state and individual levels: income, education, and politics. Data on median income and education level by state were obtained through X, and percentage of Republican voters was used as a proxy for state-level political ideology. At the individual level, political ideology was assessed using a 7-point scale item ranging from 1 = *very liberal* to 7 = *very conservative* ($M = 3.99$, $SD = 1.75$). Education was measured via six education levels attained: 1 = *Less than high school graduate*, 2 = *High school graduate*, 3 = *Some College*, 4 = *Associate's Degree*, 5 = *Bachelor's Degree*, 6 = *Master's Degree or higher* (Median = *Some College*). For income, participants chose between one of eight income categories from “Under \$15,000” to “Over \$150,000” (Median = \$35,001-\$50,000).

Additional Variables

The survey contained additional scales not used in the present analyses. These included the Individualism-Collectivism Scale (adapted from Oyserman et al., 2002), three questions on perceived descriptive norms about pro-environmental behavior (Eom et al., 2016), the twelve-item personal control scale (Lachman & Weaver, 1998), the harmony control scale (Morling & Fiske, 1999; Morling & Evered, 2006), a word search game (Boggle) as a volunteering behavioral measure, and more extensive demographic questions. All study materials and zero-order correlations of the key measures are available at OSF.

Analytic Plan

To determine whether a cluster analysis was necessary to investigate our research questions (as the present data exists at both the state- and individual-levels), we computed the intra-class correlation (ICC) using the `lme` () function of the “nlme” R package

engage in these behaviors more frequently overall (Lange & Dewitt, 2019).

(Pinheiro et al., 2020) for each of the five outcome variables as a preliminary analysis. The ICC's ranged from .002-.092 (*Policy Support*: ICC = .002, *Issue Prioritization*: ICC = .0085, *Environmental Behavior*: ICC = .014, *Climate Change Belief*: ICC = .014, *Psychological Distance*: ICC = .092), suggesting there is very little dependency of the outcome variables within a state. These ICC's did not exceed the .10 cutoff point determined by Markov chain simulations to require the use of multi-level modeling (Kianoush & Masoomehni, 2015), and four out of five outcome variables did not exceed Muthén's 5% rule of thumb (1991, 1994). Thus, it can be assumed that there are independent observations and that the data is not clustering by state. The analyses reported below were all exploratory and were conducted through multiple linear regression where we included state-level predictors and individual-level predictors. As in Study 2, we controlled for demographic covariates of climate change outcomes: income, education, and political ideology.

However, several analyses (Musca et al., 2011; Cheung & Lucas, 2016) suggest that even with lower ICC, multi-leveling modeling should still be used to analyze data bearing a hierarchical structure to reduce the potential for Type I error. Thus, we also tested our hypotheses using clustered regressions in Stata, which adjusted for nesting by state. We did not expect the results of these models to differ from, but rather to provide converging evidence for, the simple linear regressions since the low ICCs suggested that within each state, individuals were equally varied on their responses to the five outcomes. Indeed, almost identical results were found with and without clustering. See online supplemental materials for results of the cluster analyses.

Results

Psychological Distance

A multiple regression analysis was conducted to examine the effect of regional extreme weather concern on individual psychological distance to climate change after controlling for state and individual level income, politics, and education. As theorized, individuals who resided in U.S. states where Google search interest for extreme weather topics was greater reported feeling less distant from climate change, unstandardized $B = -.005$, $SE = .002$, 95% $CI = [-.008, -.001]$, $t(2530) = -2.387$, $p = .017$. In other words, Google search scores, indexing an entire region's level of concern, were predictive of how close or distant any single individual living within that region felt from climate change.

Pro-Environmental Support

Next, five multiple regression analyses were conducted to examine the effect of regional extreme weather concern on individuals' self-reported environmental behavior, belief in climate change, pro-environmental policy support, and issue prioritization of climate change, controlling for demographic confounds.

Environmental Behavior. Two multiple regression analyses were conducted to examine the relationship between regional concern about extreme weather and individuals' self-reported activism/discussion-based and personal/habitual environmental behaviors on the combined and continuous self-report measures, respectively. First, there was no significant relationship between Google searches for extreme weather topics and individuals' self-reported environmental behavior on the combined (binary-continuous) measure, unstandardized $B = .003$, $SE = .002$, 95% $CI = [-.002, .007]$, $t(2530) = 1.168$, $p = .243$. Living in a state where Google searches for extreme weather were more popular did not predict individuals' engagement in a combination of activism/discussion-based and personal/habitual environmental behaviors.

Next, we examined the relationship between Google searches for extreme weather topics and self-reported environmental behaviors on the continuous REBS. Regional Google search volumes were found to significantly predict self-reported environmental behaviors on the continuous measure, unstandardized $B = .007$, $SE = .002$, 95% $CI = [.003, .012]$, $t(2530) = 3.087$, $p = .002$. Individuals who lived in states where there is greater extreme weather search interest reported engaging in habitual environmental behaviors on a more frequent basis.

Climate Change Belief. Next, we tested whether statewide Google searches for extreme weather topics would predict individuals' belief in global warming. Contrary to hypotheses, there was no significant relationship between Google search volumes for extreme weather topics by state and the level of climate change belief of individuals residing in those states, $p = .486$. This finding failed to replicate the finding of Study 2, where U.S. regional extreme weather concern significantly predicted U.S. regional beliefs that global warming is happening and that scientific consensus on global warming exists.

Policy Support. Third, we examined whether statewide Google searches for extreme weather topics would predict individuals' climate policy support. Consistent with Study 2, the findings revealed that there was no significant relationship between the two, $p = .61$. Residing in a state where the public is generally more concerned about the weather does not appear to predict one's support for policies designed to mitigate climate change. To explore the possibility that regional extreme weather concern would affect individuals' support for *specific* policies, we regressed each of the five policy items from the composite variable onto state level extreme weather search interest. Again, the findings revealed no significant relationships, even after controlling for regional politics and self-reported political orientation, p 's = .110 - .839.

Issue Prioritization of Climate Change. Finally, we examined the association between regional extreme weather concern and individuals' ranking of climate change as an important issue for the 2020 election, relative to other issues. Results of the multiple regression revealed that there is no significant relationship between the two, $p = .41$. Individuals who lived in states where there was a greater collective sense of concern about the weather did not rate climate change as a higher-priority issue for the upcoming presidential election.

As suspected, investigating four different variables of pro-environmental support exposed that not all forms of support are similarly motivated: even after controlling for politics and other confounds, regional experiences with extreme weather may drive individuals to change their everyday behaviors but not to engage in more civic forms of pro-environmental action.

Mediational Model

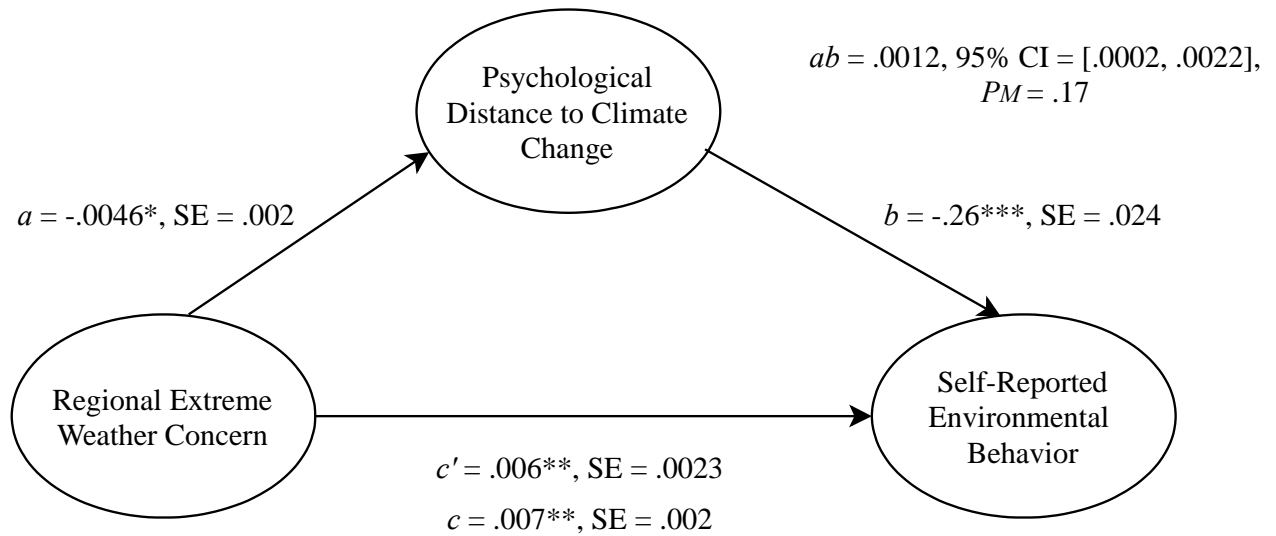
Finally, we tested the theoretical model (Figure 1). We hypothesized that, relative to individuals who do not live in areas where the public is generally concerned about extreme weather, individuals who reside in U.S. states where there is a greater sense of weather concern would be more likely to report engaging in re-occurring environmental behaviors. Furthermore, we predicted that this effect would be mediated by psychological distance to climate change. Specifically, we reasoned that individuals who reside in states where there is greater extreme weather concern would report engaging in habitual environmental behaviors on a more frequent basis because they tend to feel less distant and removed from the threat of climate change. To test these hypotheses, we conducted a mediational analysis using the PROCESS procedure for SPSS (Model 4) (Hayes, 2013). The results of these analyses are summarized in Figure 4.

First, the direct effect of regional extreme weather concern on psychological distance was statistically significant, unstandardized $B = -.0046$, $SE = .0019$, 95% $CI = [-.0084, -.0008]$, $t(2424) = -2.387$, $p = .017$. The individuals who resided in states where there was a greater sense of concern about extreme weather were the individuals who reported that they felt less distant from climate change. Next, the indirect effect of regional extreme weather concern on pro-environmental behavior (continuous REBS measure) through the variable of psychological distance was statistically significant, unstandardized $B = .0012$, $SE = .0005$, $p = .02$. Individuals who lived in states where there is greater concern about extreme weather reported feeling less distant from climate change, which in turn, predicted their self-reported environmental behaviors. We confirmed these results using nonparametric bootstrapping (Preacher & Hayes, 2004, 2008). In this analysis, mediation is significant if the 95% bias corrected and accelerated confidence interval for the standardized indirect effect (IE) does not include zero. Results based on 1000 bootstrapped samples confirmed that the indirect effect (the mediated effect) was statistically significant (IE = .0012, $SE = .0005$, 95% $CI = [.0002, .0022]$). The proposed mediator of psychological distance accounted for roughly 17% of the total effect, $P_M = .17$.

These findings support the hypothesis that regional extreme weather concern is associated with pro-environmental behavior at least in part because the individuals who reside in states where there is greater weather concern are less psychologically distant from climate change. Results of the mediational analysis are presented in Figure 4.

Figure 4

Unstandardized Regression Coefficients for Relationship between Regional Extreme Weather Concern and Pro-Environmental Behavior, as Mediated by Psychological Distance



Note. $N = 2432$; 106 cases were deleted due to missing data. Analysis controlling for state- and individual-level income, education, and political ideology. $*p < .05$ $**p < .01$ $***p < .001$.

Discussion

In Study 3, we examined the process that may be responsible for the effects of extreme weather immediacy on pro-environmental support. Results from exploratory analyses revealed that survey respondents who lived in U.S. states where Google search volumes for extreme weather topics were greater felt closer to climate change: they reported that it was geographically closer, would happen sooner, was more likely to affect someone like them, and was more certain to happen. These exploratory results provide initial evidence in support of our proposed theoretical model: that living in an area where people are generally more concerned about extreme weather predicts that one will feel less distant from climate change, and that this reduced distance, in turn, predicts pro-environmental behavior.

Examining associations between regional extreme weather concern and each of the four types of pro-environmental support revealed interesting relationships. Particularly,

regional extreme weather concern was found to predict habitual sustainability behaviors but not activism or discussion-based behaviors, policy support, or issue prioritization of climate change, and these results were found after controlling for covariates. As in Study 2, it appears that extreme weather experiences are not equally motivating for all types of action: consistently, weather concern does not seem to have any effect on people's support for governmental policies designed to combat climate change or their engagement in social or political activism. Of note, the positive relationship observed in Study 2 between regional extreme weather concern and regional climate change beliefs did not replicate in Study 3: survey respondents who lived in U.S. states where there is greater weather concern did not report greater belief in global climate change.

General Discussion

As climate change continues on its course, people living in communities all over the world become personally affected by it through experiences with extreme weather. In the United States, weather disasters ranging from record heat to large snowstorms kill or injure hundreds of people and cause billions of dollars in damage each year (Environment America, 2020). While environmental scientists such as Leah Stokes (2018) have posited that these personal experiences may finally provide people with the motivation to change their behaviors and “become the policy champions we sorely need,” psychologists have found mixed support for this idea. The present research tested the hypothesis that concern about local weather will lead to pro-environmental support, including climate change beliefs, policy support, and self-reported environmental behavior. We also examined whether these differences in the degree to which people feel concerned about the weather in their local area could help to explain vast regional differences in American public opinion about climate change.

In Study 1, we sought to externally validate Google search behavior as a measure of local weather concern. We found that in U.S. states where objective harm from extreme weather was greater, Google search volumes for that respective weather term were also greater. In Study 2 we found that in U.S. regions where there is a greater sense of concern about extreme weather, a greater proportion of people are likely to believe that climate change is happening and that scientific consensus on it exists. However, we did not replicate this finding that regional weather concern predicts belief in climate change in Study 3. In Study 3, we found that people who reside in states where the population is more concerned about extreme weather report engaging in routine environmental behaviors more frequently, in part because they feel less distant from the threat of climate change. In both Studies 2 and 3, we found no relationship between a region's level of concern about extreme weather and people's support for pro-environmental political policies.

Methodological Limitations

Using Google search volumes to operationalize concern about extreme weather in one's local area was predicated on finding the evidence that internet searches for extreme weather topics occur more frequently in areas that are actually being impacted by extreme weather. This Study 1 was conducted, albeit with several limitations. First, accounting for unidimensional proxies of damage (e.g., number of incidents, acres burned) is oversimplified when trying to establish a region's overall level of negative exposure to extreme weather. More realistically, there are numerous factors which together contribute to the total amount of harm incurred by a certain disaster type on a region, but Study 1 did not account for that additive contribution. Further, as we were unable to locate one single data source summarizing damages from all four extreme weather categories, we examined four separate sources corresponding to each weather type; yet, this inconsistency may have

introduced measurement error to the findings through random variation due to source type. Finally, it was not always possible to find Google search volumes for the time frame which corresponded to the objective harm data exactly (e.g., hurricane exposure was assessed with data on U.S. mainland hurricane strikes by state from 1851 – 2004 while Google searches for *tropical cyclone* were only available starting 2004), making it difficult to conclude that regional searches for that event (e.g., *tropical cyclone*) signaled concern about current weather. While these limitations existed, we decided to invest our time into developing the theoretical model and understanding the relationships between its constructs rather than into continuing to pursue data sources on regional extreme weather exposure.

Further, these correlational studies employing the use of aggregate-level data have inherent strengths and weaknesses. While we introduced an accessible way of measuring people's growing climate concerns around the country, it is not possible to infer causality from these findings because a potential third variable may be responsible for the relationships observed between regional extreme weather concern, environmental beliefs, and pro-environmental support. This concern was mitigated by controlling for potential confounding variables of these relationships, including political ideology, education level, and household income. Observing mostly consistent relationships across two multi-methodological studies further corroborates our findings. However, it is still possible that a third variable caused the results we reported, and we recommend caution before interpreting causality from these findings.

Another limitation that stems from the use of aggregate-level data is not being able to distinguish among individual respondents and having to rely on several assumptions. In Study 2 mapping regional Google searches for extreme weather onto regional estimates of environmental beliefs, one cannot be sure that the population who searched for terms on

Google was the same population who responded to the questions on the Yale Climate Opinion survey: it is assumed that these two datasets represent the same population, but it is also possible that they were constituted by two entirely different pools of people. In Study 3 we encountered the same issue, as, while we recruited a sample of individuals that was chosen to match the U.S. population on key demographics, we cannot confirm that our sample represented the population of Americans *who tend to search for extreme weather terms on Google*. Compared to a laboratory study where a sense of regional extreme weather concern is experimentally manipulated on a small sample, our studies have greater ecological validity when aiming to understand how extreme weather affects Americans' climate change beliefs and behaviors, at the expense of reduced internal validity because of the potential for a third variable to be responsible for these findings. Nevertheless, we argue that the major strengths of this research lie in its direct generalizability to the American population as well as in the novelty of our methods.

Inconsistent Findings and Future Directions

In Study 2, while we found that regional extreme weather search volumes predicted environmental beliefs, they were not associated with support for various pro-environmental policies. At the aggregate level, our results echo previous social-psychological findings: we are observing a disconnect between beliefs about the environment and support for environmental policy (e.g., Eom et al., 2016; Eom et al., 2018). While people may believe that the climate is changing, their support for pro-environmental policy may be determined by other factors, such as the social norms for political participation in their local area (Doherty & Webler, 2016; Eom et al., 2018), their general views on government involvement (i.e., supporting a free-market ideology; Campbell & Kay, 2014; Heath & Gifford, 2006), and their perception that enacting policies will actually result in a positive

change (i.e., efficacy beliefs; Hart & Feldman, 2016). Another potential explanation for these findings may be that the local estimates in the Yale model rely heavily on partial pooling (e.g., the beliefs of a rural individual in Nebraska are being estimated through a composite process that draws from other people like them across the country) (Howe et al., 2015). For this reason, it is difficult to interpret the signature of localized spatial events in the data, as it is likely that the individuals engaging in the Google searches are not the same exact individuals who are responding to the questions on the Yale Climate Opinion survey.

Next, while Study 2 found that regional extreme weather concern predicted regional beliefs in climate change, Study 3 did not replicate this result. Therefore, the finding that regional extreme weather concern predicts belief in climate change should be interpreted with caution. One possible explanation for this inconsistency may be due in part to the differential construction of Study 2 and Study 3's datasets. Because of how the Yale Climate Opinion dataset was constructed, climate change beliefs and policy support were examined at the same level, as outcome variables under the classification of "pro-environmental support." Yet, it is important to recognize that beliefs are also one of the main *predictors* of pro-environmental action, and people's concern about the weather and their beliefs about climate change may influence pro-environmental action concurrently through different psychological pathways (Zanocco et al., 2019). Future research should examine how beliefs predict environmental action as a function of different levels of proximity to climate disaster. Ongoing research pursuing this question demonstrates that initially skeptical individuals who experienced debris flows in Montecito, CA and received an intervention connecting the event to climate change were more likely to increase in their pro-environmental behaviors, policy support, and support for climate change education than

Montecito residents who were already high in their climate change beliefs and received the same intervention (Anderson et al., in prep.).

In Study 3, we also found that regional extreme weather concern did not predict climate policy support, both when we examined the construct as a scale composite and when we looked at the relationships between extreme weather search and each policy item separately. However, we did find that regional extreme weather concern predicted self-reported pro-environmental behaviors (on the continuous measure). As prior correlational work has found that experiencing the negative impacts of climate change (i.e., living by the coastline, experiencing flooding) does predict climate policy support (e.g., Milfont et al., 2014; Demski et al., 2017), the literature is conflicted about the nature of this relationship. As Demski et al.'s (2017) findings—that negative affect mediated the relationship between flooding experience and personal action intentions but not policy support—suggest, perhaps there are secondary qualities about extreme weather other than a sense of risk, or unidentified third variables, which motivated policy support in the aforementioned studies. Examining our own model through a different perspective, recent research suggests that perceived personal harm (a construct similar to psychological distance) may be a key *moderator* of extreme weather's influence on policy support. In a study by Zanocco and colleagues (2019), researchers interviewed people in 10 communities that experienced extreme weather events, finding that self-reported personal harm moderated the relationship between political ideology and climate policy support. Particularly, conservatives expressing higher levels of personal harm from extreme weather events were more likely to support climate policy than conservatives who reported lower levels of personal harm, suggesting that extreme weather exposure may only motivate policy support to the extent that people

perceive it as personally harmful. Future work is needed to understand when, and for whom, extreme weather exposure motivates climate policy support.

In Study 3, extreme weather Google searches were found to predict pro-environmental behavior on the continuous Recurring Environmental Behavior Scale but not on the combined (binary-continuous) measure. A possible explanation for this inconsistent finding with environmental behavior is that the combined measure assessed people's frequency of engaging in activism/discussion-based pro-environmental behaviors in addition to their frequency of engaging in personal/habitual environmental behaviors. Thus, the results of Study 3 may be signaling that disaster concern is motivating towards maintaining personal sustainability habits but not towards involvement in political or social activism of any kind. Nevertheless, the evidence presented here that regional extreme weather concern motivates pro-environmental behavior is inconclusive, and future research should re-investigate the nature of this relationship.

Lastly, in Study 3 we found support for our proposed theoretical model: regional extreme weather concern predicted lower psychological distance among individuals, which in turn, predicted greater habitual pro-environmental behaviors. However, with a correlational design, it is not possible to determine if it was weather concern that led to feeling less distant from climate change, or that those who felt less distant from climate change would feel more concerned about the weather. To verify the direction of this relationship, future work should experimentally manipulate regional extreme weather concern using validated methods (i.e., having people read about negative climate change impacts to their local area or showing them vivid images of climate impacts to their local area) (Scannell & Gifford, 2013; Duan et al., 2017) and then measure self-reported

psychological distance and pro-environmental behavior at two subsequent time points before re-testing the full psychological model.

A greater understanding of the internal processes underlying extreme weather experiences could inform communication strategies targeting varying forms of support. For example, climate activists, expert panels, and citizen climate lobbyists increasingly rely on the strategy of emphasizing extreme weather's impacts to local communities in order to convince legislators to adopt more pro-environmental policies, as well as citizens to go out and vote for them (Stokes, 2018; Sherman et al., *in press*). However, we did not find clear evidence to suggest that extreme weather concern drives climate policy support in the same way that it drives environmental behaviors. A study by Demski and colleagues (2017) provides insight: while the researchers found that flooding experiences increased both personal behavioral intentions to act on climate change and support for climate-related policies, they found that negative affect mediated the relationship between extreme weather experience and behavioral intentions but *not policy support*. This suggests that support for climate policies may be less affect-driven than intentions to take personal action, given that supporting a political policy represents a more abstract decision made about wider society (Ziegler & Tunney, 2012). Therefore, appeals framed to emphasize the urgency of extreme weather may be better suited towards motivating people to change their personal behaviors, such as switching from disposable to reusable containers or opting to bike instead of driving, than towards motivating them to advocate for policies that affect the broader society.

Methodological Contributions

The present work makes four major contributions to the literature on climate change proximity and pro-environmental action. First, Study 1 establishes Google search frequencies for extreme weather topics as a validated measure of concern about weather

occurring in one's local area. Second, Study 2 furthers our current understanding of which variables predict regional variation in environmental support. While demographic predictors of regional climate opinion variation have already been identified (e.g., Hamilton & Keim, 2009), psychological predictors have yet to be examined at the aggregate level. Third, unlike previous studies which treated environmental outcomes as interchangeable, Study 3 measures and theoretically differentiates among four diverse outcomes of pro-environmental support. Lastly, while prior work has inferred that extreme weather experience reduces the abstractness of climate change, this has not actually been examined through empirical research. Study 3 directly tests, using a novel index of psychological distance, whether the people who live in states that are more affected by extreme weather feel less removed from the issue of climate change.

Measuring human behavior has long been a time-consuming, expensive process. By integrating search volumes from Google Trends and Yale Climate Opinion Maps estimates, Study 2 generates insights about environmental action in a way that is faster and cheaper than traditional methods, within a context that directly generalizes to the American public. Both Google Trends and Yale Climate Opinion Maps (assembled by the YPCCC) have garnered interest from researchers and the popular press in recent years. While containing many variables of interest to environmental psychologists, the Yale Maps were extolled for their communication purposes but not for understanding the psychological drivers of pro-environmental support. Using this dataset for a novel purpose, Study 2 examined estimates from Yale Climate Opinion Maps as outcome variables to understand not only where in the U.S. climate opinion differs, but why that difference occurs.

Similar to Yale Climate Opinion Maps, Google Trends has received attention from the media as a useful tool for capturing an entire region's level of interest or concern about a

topic. Promoting its usage in his book, *Everybody Lies: Big Data, New Data, and What the Internet Can Tell Us About Who We Really Are*, author and Harvard economist Seth Stephens-Davidowitz (2017) argues that using big data holds several advantages over more traditional methods because it informs us of people's true thought patterns and behaviors, unaltered by response bias. Indeed, Knowles and DiMuccio showcased big data's ability to shed light on sensitive topics in their work on regional levels of fragile masculinity and voting patterns for Donald Trump throughout the U.S., covered in the Washington Post (2018), and more recently, researchers have tracked Google search patterns to assess the impact of coronavirus lockdown on unhappiness, loneliness, and boredom (Brodeur et al., 2020).

While Google Trends has been used to track collective thought patterns and behavior, one thing that has not yet been examined, that the results of the present studies show, is the extent to which regional search volumes may inform us about the psychology of any single individual living in those regions. In our work, the Google searches represent collective concern about environmental disasters, but in Study 3, we observe that Google search scores are reflected in the individuals within those regions' feelings of distance from these disasters. This finding advances the understanding of Google Trends because it suggests that, while we do not know what each person's Google search history is, the search pattern for the region in which they reside does seem to correlate onto the individual's psychological reality. In this way, Google Trends are an invaluable tool not only for tracking American concerns but also global concerns about extreme weather, as searches are informative about the psychological state of people living in different regions. Future research should examine, in conjunction with other large freely available datasets (e.g., The World Bank Group's on CO₂ emissions (metric tons per capita), 2020), how extreme

weather concerns predict global differences in quantifiable pro-environmental outcomes such as CO₂ emissions or conservation behaviors. Continuing to examine the relationships between extreme weather concern and support for various pro-environmental outcomes around the globe will further the understanding of when and for whom extreme weather experiences motivate pro-environmental support.

Conclusion

The goal of this paper is to understand psychological proximity to extreme weather and its implication for American regional differences in pro-environmental support. Prior findings surrounding the effects of extreme weather experience on environmental action have only been conducted at the individual level and are greatly inconsistent. Moreover, while large freely available datasets of Americans' climate change attitudes exist, researchers have not examined the extent to which psychological—not just demographic—factors contribute to widespread variability in those estimates. We aimed to fill these gaps in knowledge both by investigating regional extreme weather concern's role in regional variability of climate change beliefs and policy support, and by investigating the psychological mechanism underlying the effect of extreme weather concern on environmental action.

We conducted two studies investigating how collective concern impacts pro-environmental support. Across these two studies, we found tentative evidence that a collective sense of concern, captured by an entire region's internet search activity for extreme weather, is related to individuals' psychological experience of climate disaster and their personal environmental behaviors. We also found that policy support does not seem to be related to people's concern about extreme weather. Even though we controlled for politics in both studies, it may be that displaying support for climate change mitigation

policies is so entangled with partisan identity that even when people are very worried about extreme weather, they are motivated to change their personal behaviors but not act towards policy.

The biggest weakness of this research are the inconsistencies in the findings. In Study 2, regional extreme weather concern predicted climate change beliefs, but this finding did not replicate in Study 3. In Study 3, regional extreme weather concern predicted pro-environmental behavior on the continuous but not on the combined self-report measure. We have attempted to address this by explaining how the differential construction of the datasets used in each study may have contributed to these results. We also posit that the inconsistent finding in Study 2 with the two pro-environmental behavioral measures may reflect the general pattern observed in this work as well as in prior research that experiencing extreme weather motivates people to change their personal actions but not to get involved in environmental activism of any type.

As extreme weather encroaches on communities throughout the United States, will people feel psychologically closer to climate change and will this motivate pro-environmental support? This is the question that is motivating ongoing and future work.

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