Investigating the Determinants and Effects of Local Drought Awareness

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ABSTRACT

Literature in environmental public opinion has recently focused on the linkages between biophysical conditions and opinion formation. Where environmental issues and weather are more severe, individuals have been shown to have greater perception of environmental risk and greater support for environmental protection. Perceptions, however, do not always reflect actual weather, and perceptions may actually matter more when it comes to the formation of opinions. This paper explores this possibility in the context of drought, examining what variables determine individual awareness of drought and further exploring how drought awareness influences risk perception and policy preferences. Using data from two nationally representative probability-based panel surveys, as well as data from the U.S. Drought Monitor, the analysis indicates that while drought severity is the largest predictor of drought awareness, ideological and demographic variables also play a role. Importantly, drought awareness is actually a stronger predictor of concern for water shortages and support for water policy than drought severity, showing that understanding what determines drought awareness may be crucial for building policy support.

1. Introduction

Policies to solve environmental issues greatly depend on public support. The views, attitudes, beliefs, and values that citizens hold about issues, their public opinions, are important factors in the political and policy processes that identify problems and direct and limit public and private sector responses to those problems (Baumgartner and Jones 2015). Research in environmental public opinion has recently recognized that a major influence on support for environmental protection is experience of local weather conditions (Egan and Mullin 2012; Shao et al. 2014; Li et al. 2011). When individuals experience rising temperatures, increasing drought, and more natural disasters, they are more likely to recognize environmental issues and support policy to address them. This is not surprising since calls for political action often arise from those directly affected by problems. Still, not all individuals perceive local weather in the same way. While actual weather plays a role, other variables are also important in shaping the way individuals perceive the world around them (Goebbert et al. 2012; Spence et al. 2011; Li et al. 2011; Leiserowitz et al. 2012). Indeed, perception of local risk may actually play a larger role in individual policy support than objective risk (Zahran et al. 2006; Brody et al. 2007; Shao and Goidel 2016). For this reason, focusing on individual perceptions of weather may give insight into how citizen opinions about environmental issues are formed.

This is especially important in the case of drought, where increasing human demands on water and the growing specter of climate change make understanding public support for drought mitigation policy crucial. In this paper, we explore the determinants of individual awareness of drought as well as the effects of drought awareness on risk perception and policy preferences. We argue that drought awareness may actually be a more important variable in determining risk perceptions and policy preferences about water issues than actual drought severity. The occurrence of drought does not mean much if individuals are not aware of it. And indeed, at least in the survey utilized here, knowledge of local drought seems to be quite poor. While almost 95% of individuals surveyed for this study lived in areas that were identified by the U.S. Drought Monitor as being affected by some form of drought in the year prior to the

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survey, only about 30% of participants responded that a drought had occurred. Understanding why some individuals are aware of drought in their area and why others are unaware can provide insight into the way individuals form opinions related to environmental issues. Understanding what awareness means for risk perceptions and policy preferences can help us explore the relationship between the public and water policy development in the United States.

To explore these relationships, we use two nationally representative surveys of individuals on water issues to investigate what variables determine drought awareness and how drought awareness is related to individual risk perception and policy preferences about water issues. We draw from the literature on environmental public opinion in general to develop our models predicting awareness of drought. We argue that three different types of variables may play a role in whether individuals are aware of drought in their area. First, local drought conditions certainly play a significant role. People who experience more severe drought, longer lasting drought, or simply live in dryer areas may be more aware of drought than others. Second, predisposition variables may determine whether individuals are attentive to the environment and therefore more aware of drought when it occurs. Individuals who are more liberal may care more about the environment in general and therefore may be more likely to pay attention to drought in their area. Similarly, those with worldviews consistent with environmental concern may pay more attention to local weather problems. Religiosity has also been linked to environmental concern, although with some debate about the direction of the effect, so it may play a role as well. Those who consume more information about water in general may also be able to identify drought at higher rates. Finally, demographic variables have also been a consistent predictor of environmental opinions, and they are likely to affect individual awareness of drought as well.

We also investigate the relationship between drought awareness, risk perception, and policy preferences. Based on the literature stressing the importance of environmental perceptions relative to actual conditions, we argue that while the severity, duration, and timing of drought may have an effect on opinion about risk and policy, whether an individual is actually aware that a drought occurred in his or her area will be a strong predictor of both risk perceptions and policy preferences with respect to water scarcity issues. The awareness of drought, rather than objective measures of drought, will largely determine how concerned individuals are about water issues as well as their policy preferences about drought mitigation.

The balance of the paper proceeds as follows: In the next section, we evaluate the literature on the interaction between local environmental conditions, risk assessment, and policy preferences, with special attention to the distinction between objective environmental measures and individual perceptions. We then turn to a discussion of drought, the specific topic of analysis in the paper. We follow with a discussion of the data used in the analysis and lay out specific expectations for how individual awareness of drought is formed as well as discussing potential determinants of drought risk perception and policy preferences. We then present the results of the analysis and conclude with a discussion of the policy implications of the analyses.

2. Local environmental issues, risk assessment, and public opinion

A key component of understanding citizen opinion on environmental issues is the investigation of the factors that drive individual perceptions about environmental problems. The link between risk assessments, opinion, and policy preferences is a major interest in this analysis. Individual risk assessments are, we argue, a core component of citizen environmental opinions and a prime area of interest in sorting out the relationship between opinions and policy preferences (see, e.g., Mumpower et al. 2016; Kellstedt et al. 2008; Malka et al. 2009). A growing body of research in environmental public opinion looks at how local biophysical conditions influence opinion about environmental issues. Localized issue severity may influence risk evaluations and perspectives on different policies. A person who is exposed to an issue in his local environment may perceive the issue as more salient than someone who is not exposed to the issue. Across a number of different environmental policy areas, local issue severity has been shown to be a major factor in shaping public opinion about the environment.

Physical vulnerability to climate change has been linked to risk perception of climate change and policy support for climate change mitigation (Zahran et al. 2006; Brody et al. 2007). How far an individual is from the coast and the elevation above sea level have both been linked to increased concern about climate change (Brody et al. 2007). Additionally, local casualties from floods, hurricanes, and drought have been linked to support for increased climate mitigation policies (Zahran et al. 2006). Personal experience with flooding has also been linked to concern over the consequences of climate change (Spence et al. 2011). Rising temperature has been the most commonly used measure of local exposure to climate change, with a number of studies linking rising area temperatures and deviations from temperature norms to concern over climate change and desire for climate policy (Brooks et al. 2014; Egan and Mullin 2012; Goebbert et al. 2012; Joireman et al. 2010; Shao et al. 2014; Li et al. 2011; Zahran et al. 2006). Perhaps most relevant to this study, local drought conditions have been linked to individual concern over water supplies and support for government regulation of water resources (Bishop 2013). In general, there is a great deal of evidence that local environmental factors influence risk perception of environmental issues and desire for policy to mitigate those problems.

As a supplement to the literature on how local environmental conditions influence public opinion in general, several research teams (Spence et al. 2011; Li et al. 2011; Leiserowitz et al. 2012; Goebbert et al. 2012) have investigated how weather perceptions are formed. Building on previous literature that has found that perceived risk is often more important than actual risk when it comes to the formation of opinions on climate change (Zahran et al. 2006; Brody et al. 2007), these scholars argue that it is crucial to understand what contributes to individual perceptions of weather, rather than simply look at the direct effect of local weather on public opinion. Since these initial examinations of the important role of perceived risk on weather-related phenomena, other scholars have recently explored the importance of individual weather perceptions, rather than just the effect of actual local weather patterns, on risk perceptions and policy preferences (see, e.g., Shao and Goidel 2016; Lazrus 2016; Carlton et al. 2016; Howe and Leiserowitz 2013). In these studies, researchers found that while actual weather does matter to some extent (although this depends greatly on the type of weather investigated), political ideology, worldviews, and other attitudinal and demographic variables are also important factors in how individuals perceive weather-related problems in their area and the presence or absence of particular weather-related threats. While these studies have established the importance of perceptions of local weather conditions, they have not to this point investigated how these perceptions match actual weather conditions. We attempt to add to this growing literature by investigating individual awareness of drought by combining measures of individual perceptions with a metric of drought at the local level.

3. Defining and measuring drought

The empirical focus of this study, drought in the United States, is especially important when it comes evaluating the relationship between weather, weather awareness, and policy opinions. With shifting populations and climate change making access to water resources an issue of growing importance in the United States and abroad, understanding how the public is made aware of drought and how awareness influences concern for water resources and support for public policy is an important topic. As Van Loon et al. (2016) note, humans are not passive when it comes to drought. Calling for greater integration of the natural and social science research focused on drought, they argue that it will be human responses to water shortages that will ultimately determine the effects. Changing water policies and regulations will go a long way toward determining when drought occurs, how communities are equipped to combat it when it occurs, and how large of an impact it will have. Any meaningful policy for drought mitigation will require public support. Building drought resilience will not come exclusively from the natural sciences or engineering but will also come from understanding the social processes that determine the development of water policy (Medd and Chappells 2007). Indeed, a number of recent studies have attempted to understand how the experience of drought influences environmental evaluations in order to further explore the relationship between drought and policy (Carlton et al. 2016; Lazrus 2016; Bishop 2013).

Studying the question of the relationship between weather, awareness, and public risk assessments is important in the context of drought, but the subject area also brings challenges. While drought can generally be understood as "a condition relative to some long-term average condition of balance between rainfall and evapotranspiration in a particular area, a condition often perceived as 'normal'" (Wilhite and Glantz 1985, p. 111), there has been a great deal of debate over how to define and measure drought (Lloyd-Hughes 2014; Bachmair et al. 2016; Meadow Crimmins and Ferguson 2013). Drought definitions can generally be grouped into four types: meteorological drought, agricultural drought, hydrologic drought, and socioeconomic drought (Wilhite and Glantz 1985). Meteorological drought refers to drought as some level of dryness over some duration of time. This is usually in reference to a deficit in rainfall relative to some normal point. Agricultural drought refers to the effect of moisture shortages on agricultural production, taking into account how drought affects crops at different points in development. Hydrologic drought refers not to meteorological events alone but rather to how moisture shortages impact surface and subsurface hydrology. Finally, socioeconomic drought takes into account the effect of water shortages on human use. Given these different definitions of drought, it is very difficult to imagine a single universal metric of drought. In addition to the disciplinary issues in defining drought, definitions can be difficult due to great regional and ideological variation, especially because while all parts of the earth are affected by water shortages to some extent, the specific nature of the shortages will depend on regional context (Wilhite 1992). All of this means that consensus over a universal definition of drought is likely impossible (Lloyd-Hughes 2014). The lack of a single universal metric, however, does not mean it is not worth studying drought with the currently available measures. Indeed, that no universal measure exists or is likely to exist means identifying how the public perceives drought is especially important.

For the analysis here, we use the U.S. Drought Monitor (USDM) to identify drought [National Drought Mitigation Center (NDMC) et al. 2016]. The USDM has a number of properties that give it an advantage over other possible metrics of drought for this analysis (Svoboda et al. 2002; Heim 2002; Zargar et al. 2011). First, while a number of single indicator measures of drought exist, the USDM is a composite measure, meaning it does not use a single measure to indicate drought (Bachmair et al. 2016; Zargar et al. 2011; Heim 2002). Since there is little agreement on any single metric of drought, composite metrics like the USDM make use of multiple single indices to come up with combined measures that utilize information from multiple sources and perspectives. The USDM makes use of six key individual indices in developing the composite metric as well as a number of supplementary indices (Svoboda et al. 2002). The relationship between these indices and the ultimate designation of drought severity in the USDM is not fixed, however, but allows for flexibility over time, shifting with technological and scientific advancements (Svoboda et al. 2002).

Second, the USDM has an advantage over other composite indicators in that it also includes local knowledge in determining the level of drought (NDMC et al. 2016; Zargar et al. 2011; Svoboda et al. 2002). Since drought is a multifaceted phenomenon, even a composite index may not fully capture the local-level impacts. To verify that the composite measure is indicative of drought impacts, the USDM utilizes over 350 experts across the country that verify that the drought identifiers match with local conditions. In this way, the USDM is actually a qualitative measure that combines a number of quantitative indices with local-level expertise to determine drought severity at the local level (Svoboda et al. 2002; Zargar et al. 2011). The USDM attempts to blend the objective measures of weather with the subjectivity of local experts. This combination of qualitative expertise and quantitative indices allows for both precision and flexibility in the drought determinations. According to Heim (2002, p. 1162), this has the benefit of creating a drought metric that "is a consensus product reflecting the collective best judgement of many experts based on several indicators."

Finally, the USDM is useful for this analysis because one of its primary goals is to communicate information about drought conditions to local, state, and federal decision-makers (Svoboda et al. 2002). The monitor is not primarily meant for scientific use but rather for communication to stakeholders, governments, and citizens. Since it is meant to be a relatively generalizable and accessible measure of drought across the United States that is supported by major government agencies, including the National Oceanic and Atmospheric Administration and the Department of Agriculture, it provides an excellent measure for investigating individual drought awareness. Indeed, the USDM is growing in use and is commonly utilized in the media (Zargar et al. 2011). Although drought can be measured in many ways, understanding how citizens relate to a measure meant to be used in policy processes provides an interesting window into the relationship between citizens and science. The Drought Monitor's combination of quantitative and qualitative data as well as its purpose as a policy tool makes it a strong metric for the present study.

4. Data and models

The data used in this analysis relied on two national public opinion surveys of adults 18 years and older. Surveys were administered by GfK Custom Research, LLC. The research team in the Institute for Science Technology and Public Policy at Texas A&M University designed the instruments and used question batteries well tested for accuracy and completeness in both their own previous surveys and the published literature. The survey instruments were pretested by GfK Custom Research, LLC, for respondent understanding, accuracy, and precision. The first survey was in the field from 21 February to 12 March 2013 and resulted in 1616 completed surveys for a 56% completion rate. The second survey, which asked identical questions, was in the field from 2 April through 16 April 2013 and resulted in 1650 completed surveys for a 55.5% completion rate. The median survey completion time was about 28 min for each survey. The two samples were drawn from GfK's web-enabled KnowledgePanel, a probability-based panel designed to be representative of the U.S. population. A map showing the geographic distribution of the respondents can be seen in Fig. 1.

a. *Drought measures and awareness of drought*

The survey contained a question asking respondents, "When did you last experience a drought or water

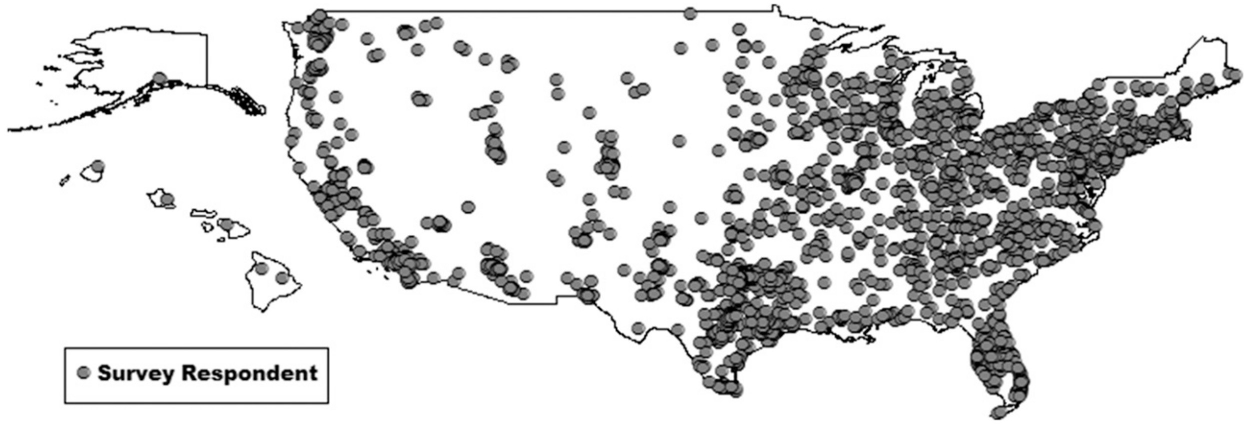

FIG. 1. Map of survey respondents.

shortage in your community?'' The respondents were given six possible answers: 1) never experienced a drought or water shortage, 2) within the past 12 months, 3) 1 to less than 2 years ago, 4) 2–5 years ago, 5) 6–9 years ago, and 6) 10 years or more ago. We were interested in whether respondents were able to identify whether they had a drought in their area in the past year, so we created a dichotomous measure of whether a respondent claimed to experience a drought in the past 12 months: 29% of respondents reported having a drought in their area in the past year, while 70% reported last having a drought in their area over a year ago or never.

To determine whether individuals were aware of drought in their area in the prior year, we used data from the USDM (NDMC et al. 2016; Svoboda et al. 2002). The database contains weekly categorical measures of drought for every county in the country. We matched the Drought Monitor data to each survey respondent by linking their zip codes to the nearest county. The Drought Monitor assigns five levels of severity. No rating suggests there are no issues with water in the county, D0 identifies an area as abnormally dry, D1 represents a moderate drought, D2 represents a severe drought, D3 represents an extreme drought, and D4 represents an exceptional drought. We developed a dichotomous measure of whether a respondent's county experienced at least a moderate drought in the previous year (D1 through D4). In contrast to the 29% of respondents that reported a drought in their community over the previous 12 months, we found that 93% of respondents were in an area that was identified by the USDM as having at least moderate drought at some point during that period.

Combining our measure of drought identification with the measure of USDM drought determinations, we created a dichotomous variable of whether individuals were aware of drought in their county. Of individuals whose county experienced moderate drought or worse, 31% correctly identified drought in their county. This dichotomous variable of drought awareness serves as a dependent variable in the first part of the analysis, which focuses on what factors determine a particular evaluation of drought conditions. The measure functions as the key-independent variable in the second part of the analysis, which focuses on how drought awareness informs risk perception and policy preferences. Descriptive statistics for this variable and all others used in the analysis can be seen in Table 1. Again, we expect that drought awareness will be a strong determinant of both risk perception and policy preferences about water issues. When individuals are aware of drought in their community, they will be more likely to perceive the risks of water shortages as high and will be more likely to want policy action to deal with those problems.

b. *Risk perception and policy preferences*

In the second part of the analysis, we seek to identify how drought awareness influences opinions, in this case looking at risk perception about water shortages and policy preferences about mitigation strategies. To measure risk perception about water quantity and drought, we created an index of risk perception. Respondents were asked a series of questions about the amount of water available in their community as well as the likelihood of a drought causing different types of disruptions in their region. We combined these questions into an index and standardized it for interpretation purposes. The standardized index ranges from −3.16 to 3.02, with negative values representing lower levels of risk perception and higher numbers representing higher risk perception. We also developed a standardized index measuring policy preferences. Respondents were

TABLE 1. Descriptive statistics.

	Mean	Std dev	Min	Max	Percentage
Continuous variables					
Risk perception index	0.03	1.00	−3.16	3.02	
Policy preference index	0.01	1.00	−5.11	2.98	
No. of weeks in drought	28.74	16.46	1	52	
Weeks since last drought	12.39	15.44	1	52	
Moisture index 2003–12	0.02	0.36	−0.94	0.82	
New ecological values	3.46	0.71	1	5	
Partisanship (Republican)	3.86	2.23	1	7	
Political ideology (Conservative)	4.30	1.56	1	7	
Religiosity	2.87	2.87	1	5	
Water information	4.09	2.10	1	10	
Age	50.21	16.86	18	93	
Household income	11.97	4.39	1	19	
Education	10.27	1.98	1	14	
Binary variables					
Correctly identify drought					30.98
D1: Moderate					23.28
D2: Severe					33.46
D3: Extreme					31.44
D4: Exceptional					11.82
Female					49.15
Black					8.74
Hispanic					14.48

asked a series of questions about support for policies that could be adopted in their city to mitigate long-term water issues as well as a series of questions about different policy options for managing water resources. Negative values represent lower levels of favorability toward policy to mitigate water shortages, while positive values represent higher levels of favorability. The index ranges from −5.16 to 2.94.

Both Cronbach's alpha and factor analysis can be used to quantitatively test the reliability of an index of items meant to represent an underlying concept. Cronbach's alpha is used to measure the internal consistency of an index and is meant to indicate to what extent the items in an index measure the same underlying construct (Bland and Altman 1997). Cronbach's alpha can range from 0 to 1, with higher values of alpha representing greater levels of internal consistency (Tavakol and Dennick 2011). Although there is no consensus for what level of Cronbach's alpha is necessary to validate an index, the general rule of thumb is that it should at least reach 0.7 (Tavakol and Dennick 2011). The risk perception index achieved a Cronbach's alpha of 0.87 and the policy preferences index achieved a Cronbach's alpha of 0.84, each well above the typical rule of thumb of 0.7.

Factor analysis also allows for the validation of indices. Factor analysis assumes that multiple variables are the result of underlying latent variables and estimates to what extent each of the observed variables can be explained by the underlying factors. Using eigenvalues, it is possible to identify the number of factors underlying the observed data. In the factor analysis of the risk perception variables, all of the individual items are loaded onto the first factor in the expected direction, and the first factor had an eigenvalue of 4.0 compared to a second factor with an eigenvalue of only 1.1, with the first factor explaining 83% of the variance. The strong loadings of the variables onto the first factor as well as the large drop in eigenvalue moving from the first to second factor provide strong support for a single index composed of the observed variables. Factor analysis also provided support for the validity of the policy preferences index, with all items loading onto the first factor in the expected direction and a large difference in eigenvalue between the first factor and the second.[1]

c. Independent variables

Consistent with our discussion above, in our analysis of the determinants of drought awareness, as well as our analysis determining risk perception and policy preferences, we include a number of variables that are common to the literature on environmental public opinion. We separate these variables into three separate

[1] Information on questions included in any indices used in the paper, as well as the results of the factor analysis, can be seen in the appendix.

TABLE 2. Independent variable measurement and expectations.

Survey question	Measurement	Expected effect on drought awareness	Expected effect on risk perception/policy preferences
Drought variables			
D2: Severe	Dummy variable of whether highest level of drought experienced by respondent was D2 or not.	+	+
D3: Extreme	Dummy variable of whether highest level of drought experienced by respondent was D3 or not.	+	+
D4: Exceptional	Dummy variable of whether highest level of drought experienced by respondent was D4 or not.	+	+
No. of weeks in drought	Count of the number of weeks a respondent experienced drought in the previous year.	+	+
Weeks since last drought	Count of the number of weeks since the respondent last experienced a drought.	−	−
Moisture index 2003–12	Continuous index bound between −1 and 1 represents balance between water demand and supply. Positive means greater supply. Negative greater demand.	+	+
Predisposition variables			
New ecological values	Continuous index of eight questions. Ranges from 1 to 5. Higher numbers mean higher belief in human–nature relationship.	+	+
Partisanship (Republican)	Seven-point scale from 1 = strong Democrat to 7 = strong Republican.	−	−
Political ideology (Conservative)	Seven-point scale from 1 = strongly liberal to 7 = strongly conservative.	−	−
Religiosity	Five-point scale of how often respondent attends religious services. Ranges from 1 = never to 5 = at least once a week.	+/−	+/−
Water information	Continuous index of how often respondents used any of eight resources for information. Ranges from 1 to 10. Higher numbers mean more information on water resources.	+	+
Demographic variables			
Female	Dummy variable of whether or not the respondent identified as female.	+	+
Black	Dummy variable of whether or not the respondent identified as black.	+	+
Hispanic	Dummy variable of whether or not the respondent identified as Hispanic.	+	+
Age	Age of respondent.	−	−
Household income	19-point scale of household income with options ranging between less than $5,000 to 175,000 or more.	+	+
Education	14-point scale of educational attainment ranging from no formal education to professional or doctorate degree.	+	+

categories: drought variables, predisposition variables, and demographic variables. Specific measurement and theoretical expectations for each independent variable can be seen in Table 2.

1) DROUGHT VARIABLES

First, we included a number of variables measuring the severity of the water issues experienced by respondents, with the expectation that higher levels of severity would lead to a greater ability to identify drought correctly. We included a series of dummy variables measuring the severity of the drought in each respondent's county by identifying the highest level of drought over the previous year. We included a dummy variable for each level of drought above D1, moderate drought, with a dummy variable for each category: D2, severe drought; D3, extreme drought; and D4, exceptional drought. D1 was left out as the comparison category. We also generated a count variable measuring the number of weeks in the past year a respondent's area had some form of drought. Finally, we created a variable measuring the number of weeks since a drought last occurred in a person's area. We expect that individuals who experience more extreme drought, more frequent drought, and more recent drought will be more likely to be aware of drought in their area and have higher risk perceptions and policy preferences.

We also included a measure of climatic moisture, developed by Willmott and Feddema (1992, 2015). We expect that individuals living in dryer areas will be more attentive toward water issues and therefore will be better at identifying drought in their area. We also expect they will have higher levels of risk perception and greater preferences for policies dealing with water issues. The Willmott and Feddema (1992) climatic moisture index integrates simple climatic measures like temperature, precipitation, and sunlight with the land's water retention capacity and potential evapotranspiration. In this way, it is a fuller measure of potential water availability than simple climatic measures. Another virtue of the measure is the mathematical nature of the index. It is a linear and symmetric index, bound between -1 and 1, with negative values representing areas in which the atmospheric demand is greater than the moisture supply and positive numbers representing areas in which the moisture supply is greater than the demand. By matching zip code centroid coordinates with the climate data, we included a measure of the average value of the moisture index from 2003 to 2012 for each respondent. We chose to include data from 2003 to 2012 in order to measure the general moisture levels of the area outside of the period meant to capture local drought.

2) Predisposition variables

The second set of variables we included is what we deem predisposition variables. These are variables that measure attitudes and behaviors that may be correlated with paying more or less attention to environmental issues.

First, values and worldviews have been found to have a major impact on public opinion about the environment (Slimak and Dietz 2006; Dake 1991; Leiserowitz 2006). Perhaps no measure of worldview has been found to have as large an impact on environmental public opinion as the new ecological paradigm (NEP), developed by Dunlap and Van Liere (1978) and revised since (Dunlap et al. 2000). Those who endorse NEP recognize biophysical constraints on human behavior and have a "primitive belief" in the balance of human–nature relationships, while those who do not continue to subscribe to the prevailing worldview of human development and dominance (Catton and Dunlap 1980; Dunlap et al. 2000).

The surveys utilized here included a series of eight questions that allows us to create an abbreviated NEP scale. The eight-item index yields a Cronbach's alpha of 0.85, and factor analysis further confirms the validity of the index, with only a single factor retained with an eigenvalue over 1. Our abbreviated index ranges from 1 to 5, with higher numbers representing greater ecological preferences. Although the full NEP scale contains 15 questions, Cordano et al. (2003) showed that abbreviated NEP scales can explain variance in environmental concern as well as the full NEP measures. To distinguish our measure from the full NEP scale, we refer to the index used here as new ecological values (NEV). We expect that individuals with higher levels of our NEV measure will be more aware of drought in their area. Additionally, we expect that higher levels of NEV will lead to greater risk perception of water issues as well as greater preference for policy on water issues.

Political partisanship and ideology have also been found to have a significant impact on opinion about environmental issues (Liu et al. 2014). We included measures of both political partisanship and political ideology. The partisanship measure asks for identification as Democrat or Republican, while the ideology measure captures self-identified liberal or conservative ideology. We expect that since Democrats and liberals tend to care more about the environment in general, they will be better able to identify drought in their area and have stronger risk perception and policy preferences.

Religiosity has been found to influence environmental beliefs as well, but the direction of the effect is not clear. Some have found that increasing religiosity increases environmental concern (Kanagy and Nelsen 1995), while others have found mixed evidence (Arbuckle and Konisky 2015). Regardless, it is clear that religion plays a role in the formation of environmental opinions, so we included a measure of religious service attendance as well.

Finally, we included a measure of water resources information. Respondents were asked how often they went to a series of sources for information on water resources, with 0 being never and 10 being very often. We created an index, ranging from 0 to 10, with a Cronbach's alpha of 0.85 and with only a single factor retained with an eigenvalue over 1. We expect that individuals who seek more information about water issues will be more aware of drought and have higher levels of risk perception and policy preferences.

3) Demographic variables

We also included a number of demographic variables in the analysis. The literature has long identified the "white male effect" in environmental public opinion, which suggests that white men are less likely than women and minorities to have concern for the environment (Kahan et al. 2007). For this reason, we included dichotomous variables indicating whether the respondent was female, black, or Hispanic. Age, income, and education have also been found to affect individual opinions of risk and policy, with younger, wealthier, and more educated individuals generally having higher levels of support for environmental policy (Van Liere and Dunlap 1980; Zahran et al. 2006), so we included measures for each.

d. *Models*

In our first analysis, our measure is a dichotomous variable of whether an individual was able to identify correctly that drought occurred in their area. Given this, a logistic regression is the appropriate modeling strategy. Our first model takes the following form:

$$C_i = \alpha_1 + \beta_1 W_i + \beta_2 P_i + \beta_3 D_i + \varepsilon_i,$$

where C represents the likelihood of correctly identifying drought (0 or 1) for respondent i, W represents actual weather characteristics, P represents predisposition variables, D is demographic variables, and α and ε are constant and error terms, respectively.

For our analysis of risk perception and policy preferences, our measures are standardized indices that do not vary greatly from a normal distribution, meaning ordinary least squares (OLS) regression is desirable. Tests for heteroscedasticity found evidence of heteroscedastic errors. The presence of heteroscedasticity means that the standard errors generated using OLS may be biased. To correct for this possibility, we calculate White–Huber robust standard errors and report them instead of conventional standard errors:

$$R_i = \alpha_1 + \beta_1 C_i + \beta_2 W_i + \beta_3 P_i + \beta_4 D_i + \varepsilon_i$$
$$F_i = \alpha_1 + \beta_1 C_i + \beta_2 W_i + \beta_3 P_i + \beta_4 D_i + \varepsilon_i,$$

where R represents the value of the risk index, and F represents policy preferences. All the other variables remain the same, with C now acting as an independent variable.

5. Results

a. *Drought awareness results*

Beginning with our model predicting a correct evaluation of drought, seen in Table 3, we find that local drought severity is by far the biggest predictor of whether an individual is aware of drought conditions in their area, while the findings for predispositions and demographics are mixed.

TABLE 3. Logit predicting correct evaluation of drought. Note that the standard errors are in parentheses. M.E. stands for the marginal effect of a one-unit increase in variable on the probability of correctly identifying drought.

Variable	Coefficient	*p* value	M.E.
Drought variables			
D2: Severe	0.66 (0.19)	0.00	+0.12
D3: Extreme	1.54 (0.20)	0.00	+0.27
D4: Exceptional	1.73 (0.23)	0.00	+0.31
No. of weeks in drought	0.01 (0.01)	0.03	+0.00
Weeks since last drought	−0.02 (0.01)	0.00	−0.00
Moisture index 2003–12	0.09 (0.20)	0.63	+0.02
Predisposition variables			
New ecological values	0.16 (0.07)	0.03	+0.03
Partisanship (Republican)	−0.01 (0.03)	0.68	−0.00
Political ideology (conservative)	0.04 (0.04)	0.31	+0.01
Religiosity	0.01 (0.03)	0.75	+0.00
Water information	0.06 (0.02)	0.02	+0.01
Demographic variables			
Female	−0.05 (0.10)	0.59	−0.01
Black	−0.91 (0.22)	0.00	−0.16
Hispanic	−0.23 (0.15)	0.13	−0.04
Age	0.00 (0.00)	0.09	+0.00
Household income	0.03 (0.01)	0.01	+0.01
Education	0.04 (0.03)	0.13	+0.01
Constant	−3.90 (0.52)	0.00	
N		2479	

It is difficult to evaluate the substantive effect of variables in a logit model from coefficients alone, so we use marginal effects to evaluate the substantive impact of our variables on individuals' drought awareness. As mentioned, drought severity is perhaps the largest single predictor of correctly identifying drought. Relative to individuals whose counties were subject to a moderate drought at some point in the previous year, individuals whose counties had severe drought were 12% more likely to be aware of drought in their area, those in counties that experienced extreme drought were 27% more likely, and those that experienced exceptional drought were 31% more likely. All of these relationships were statistically significant at conventional levels and were among the largest substantive effects found in the model.

Additionally, and as expected, we found that the number of weeks of drought in a respondent's county over the previous year had a positive relationship with individual drought awareness, while temporal proximity to drought also impacted drought awareness. Neither of these effects, however, had as large an impact on drought awareness as severity. A two standard deviation increase in the number of weeks in drought, equivalent to about 16.5 weeks, results in a 6% increase in the probability of drought awareness. A two standard deviation increase in the number of weeks since a survey respondent last experienced drought, equivalent to 15.5 weeks, results in a 12% increase in the probability of a respondent being aware of drought.

Surprisingly, the Willmott–Feddema measure of moisture was not found to have a significant effect on the probability of correctly identifying drought. After controlling for drought conditions in the previous year, individuals in historically dryer areas were not able to identify drought at higher levels than individuals in wetter areas.

Some of our predisposition variables were found to have an effect on drought awareness, while others were not found to be significant at all. The effect of new ecological values was positive and significant, although the size of the effect was modest. A two standard deviation increase in NEV results in a 4% increase in the probability of correctly identifying drought. Surprisingly, partisanship, political ideology, and religiosity were all found to have insignificant and substantively small effects on drought awareness. Finally, our index measuring the amount of water information consumed by individuals was found to have a modest impact on correctly identifying drought. A two standard deviation increase in the variable was found to lead to a 4% increase in the probability of an individual being aware of drought in his or her county.

The findings for our demographic variables were mixed and, in some cases, unexpected. Contrary to expectations, the effects of respondent identification as female or Hispanic were not significant. Additionally, black identification was significant but not in the expected direction. Black individuals were found to be aware of drought at far lower rates than white individuals, with the dummy variable for black decreasing the probability of drought awareness by 16%. Age had a positive effect on drought perception, and the effect was found to be significant at the 0.10 level, but the substantive size was very small. A two standard deviation increase in age only resulted in a 3% increase in the probability of drought awareness. Education was not found to have a statistically significant or substantively large effect, while income had a statistically significant and moderate sized effect on drought perception, with a two standard deviation increase resulting in a 5% increase in the probability of drought awareness.

b. *Risk perception results*

We now move to a discussion of how drought awareness influences risk perception and policy preferences. Again, we expected that awareness would have a major impact on risk perception and policy preferences and that identifying drought would potentially be more important than actual drought severity.

The first model in Table 4 shows the results of our OLS regression predicting risk perception. Since the indices are standardized, all coefficients can be interpreted as the standard deviation change in risk perception caused by a one-unit increase in the variable. The results show that awareness of drought in one's community significantly increases one's risk perception when it comes to water issues, while actual drought severity has a significant but smaller effect. An individual who was aware of drought in his or her area in the previous year is expected to have risk perception half a standard deviation higher than an individual who is unaware of drought, a substantively large effect that is among the largest in the model. Meanwhile, D3 (extreme drought) and D4 (exceptional drought) were found to be significant as well but with effect sizes significantly smaller than the measure of drought awareness. Additionally, neither drought frequency nor drought timing had a statistically significant or substantively large effect on the risk perception variable.

Interestingly, the Willmott–Feddema moisture index did have a strong and significant impact on risk perception. Although it was statistically unrelated to individual drought awareness, the level of the moisture index in an area between 2003 and 2012 did have a strong relationship with risk perception. Even after controlling for drought awareness and drought severity in the previous year, a one standard deviation increase in moisture leads to approximately a one-quarter standard deviation decrease in risk perception about water issues.

Predisposition variables also had an impact on risk perception. Our measure of NEV had a positive and statistically significant relationship with risk perception, with a two standard deviation increase in NEV resulting in over a half standard deviation increase in the risk perception index. We found that political ideology had a statistically significant relationship with risk perception, with conservatives surprisingly predicted to have higher levels, although the substantive size of the effect is modest. Partisanship was not found to significantly impact risk perceptions. Religiosity and information about water also had significant effects on risk perception, with a two standard deviation increase in religiosity and water information leading to 0.17 and 0.20 increases in risk perception, respectively.

We found that demographics had a limited impact on our risk perception index. None of the variables

TABLE 4. OLS regressions predicting risk perception and policy preferences. Note that robust standard errors are in parentheses.

Variable	Risk perception		Policy preferences	
	Coefficient	p value	Coefficient	p value
Drought variables				
Correctly identify drought	0.45 (0.04)	0.00	0.13 (0.04)	0.00
D2: Severe	0.03 (0.06)	0.72	0.04 (0.05)	0.48
D3: Extreme	0.11 (0.07)	0.09	0.10 (0.06)	0.10
D4: Exceptional	0.21 (0.08)	0.01	0.06 (0.08)	0.40
No. of weeks in drought	−0.00 (0.00)	0.99	0.00 (0.00)	0.13
Weeks since last drought	−0.00 (0.00)	0.47	0.00 (0.00)	0.05
Moisture index 2003–12	−0.69 (0.07)	0.00	−0.04 (0.07)	0.54
Predisposition variables				
New ecological values	0.40 (0.03)	0.00	0.70 (0.03)	0.00
Partisanship (Republican)	−0.01 (0.01)	0.34	−0.02 (0.01)	0.04
Political ideology (conservative)	0.05 (0.02)	0.00	−0.00 (0.02)	0.80
Religiosity	0.03 (0.01)	0.02	0.06 (0.01)	0.00
Water information	0.05 (0.01)	0.00	0.09 (0.01)	0.00
Demographic variables				
Female	0.10 (0.03)	0.00	−0.07 (0.03)	0.02
Black	−0.05 (0.07)	0.44	−0.08 (0.07)	0.29
Hispanic	0.00 (0.06)	0.98	−0.00 (0.05)	0.95
Age	0.00 (0.00)	0.00	0.00 (0.00)	0.00
Household income	−0.00 (0.00)	0.68	0.02 (0.00)	0.00
Education	−0.01 (0.01)	0.54	0.04 (0.01)	0.00
Constant	−2.15 (0.17)	0.00	−3.83 (0.19)	0.00
N	2479		2479	
R^2	0.27		0.37	

representing race, ethnicity, income, or education was found to have statistically significant relationships with risk perception, and the results for the gender and age, while statistically significant, were substantively small. Female respondents only had a risk perception index one-tenth of a standard deviation higher than men, and a two standard deviation increase in age resulted in a 0.12 increase in risk perception.

c. *Policy preferences results*

The results for policy preferences, also seen in Table 4, had some important differences. While individual awareness of drought had a positive and statistically significant effect on support for policies to mitigate drought and water shortages, the effect size was relatively small, with those aware of drought expected to have policy preferences 0.13 standard deviation above those who are unaware. Still, this positive and statistically significant effect is notable since none of the other weather variables had a large effect on policy preferences. Drought intensity, drought duration, and the level of the climactic moisture index had no significant effect on policy preferences. The time since drought actually had a positive and significant effect on policy preferences, but the effect size was very small, with a two standard deviation increase leading to a 0.09 increase in the policy preference index. While the finding was not as strong as in the model predicting risk perception, we found that awareness of local drought conditions has a positive effect on individual policy preferences for mitigating drought and water shortages.

Relative to the model predicting risk perception, the predisposition variables were much stronger in the policy preferences model. NEV, religiosity, and water information all had positive and significant relationships with policy preferences that were almost twice as large as the effects in the risk perception models. Additionally, partisanship had a significant, if small, effect on policy preferences. With respect to demographics, while black and Hispanic were not found to have statistically significant effects on policy preferences, age, income, and education all had positive and statistically significant relationships with policy preferences. Interestingly, the model showed that females actually had statistically lower levels of policy preferences, but the effect size was relatively small.

6. Conclusions

The results of both the analysis investigating the determinants of drought awareness and the analysis of the effects of drought awareness yielded some important findings. First, we found that by far the largest factor in

TABLE A1. Risk perception index.

Survey question	Sign	Item–test correlation
Please indicate whether you strongly disagree, disagree, neither disagree nor agree, agree, or agree strongly:		
There is enough water in my state to meet current needs.	−	0.54
There is enough water in my state to meet future needs.	−	0.59
How likely are the following drought impacts to occur in your region in the next 5 years (five-point Likert scale from very unlikely to very likely):		
Disruption of water supplies.	+	0.78
Increased food prices.	+	0.68
Increased water costs.	+	0.72
Loss of recreational activities.	+	0.75
Reduced water quality.	+	0.71
Increased fires.	+	0.74
Increased water user conflicts.	+	0.79
Chronbach's alpha		0.87

drought awareness is drought severity. It is those individuals in areas where drought is most severe that are best able to identify it. Additionally, frequency of drought and temporal proximity to drought also had statistically significant effects on drought awareness. While the short-term drought variables all had strong effects, long-term area moisture levels did not have a significant impact on individual awareness of drought. Although we expected individuals in areas with lower moisture levels to be more aware of drought due to long-term exposure to water issues, it appears that long-term water scarcity in an area does not improve short-term weather awareness. Some predispositions variables mattered for drought awareness, but the effects of the

TABLE A2. Policy preference index.

Survey question	Sign	Item–test correlation
Should government take action in dealing with water issues in your area? Please answer on a scale from 0 to 10 with 0 indicating no need for government to act and 10 indicating a strong role for government to act.	+	0.47
Increasing population means that cities will need more water for the long run (more than 10 years in the future). Listed below are several possible strategies that a city might consider to ensure adequate water supplies in the future. Please rate the strategies on a scale of 0 to 10 with 0 being not favored by you and 10 being highly favored by you.		
Permanently transferring water from farms to the city.	+	0.27
Building dams and reservoirs.	+	0.40
Constructing pipelines to bring water from other regions.	+	0.43
Reusing waste water on lawns and landscapes.	+	0.54
Requiring water conservation.	+	0.70
Limiting urban sprawl.	+	0.52
Increasing water rates.	+	0.39
A number of policy options have been proposed to manage water resources. Please indicate whether you strongly oppose, oppose, support, or strongly support each of the following options:		
Build infrastructure (dams, reservoirs, pipelines) to support water demands during a drought.	+	0.47
Conduct campaigns for voluntary water conservation.	+	0.60
Require mandatory water conservation.	+	0.62
Give tax incentives for the installation of water-saving equipment.	+	0.55
Develop a comprehensive national plan for allocating water across state borders.	+	0.55
Provide state tax cuts to companies that reduce their water use.	+	0.55
Prohibit government funding for developing in flood prone areas.	+	0.40
Require low water use landscaping.	+	0.61
Protect some water resources to preserve wildlife and fishery habitats.	+	0.59
Require that lawn watering use reclaimed/reused water instead of drinking water.	+	0.63
Chronbach's alpha		0.84

TABLE A3. New ecological value index.

Survey question	Sign	Item–test correlation
Please indicate whether you strongly disagree, disagree, neither disagree nor agree, agree, or agree strongly:		
We are approaching the limit of the number of people the earth can support.	+	0.72
When humans interfere with nature it often produces disastrous consequences.	+	0.73
Plants and animals have as much right as humans to exist.	+	0.77
The earth is like a spaceship with very limited room and resources.	+	0.78
The balance of nature is very delicate and easily upset.	+	0.59
If things continue on their present course, we will soon experience a major ecological catastrophe.	+	0.82
Today's policies must consider the needs of future generations.	+	0.59
Humans were meant to rule over the rest of nature.	−	0.48
Chronbach's alpha		0.85

individual variables were not especially large, with both NEV and water information affecting awareness. While we found age and income to have modest effects on drought awareness, race had by far the largest effect of any demographic variables. Contrary to our expectations, however, individuals who identified as black were much less likely to be aware of drought in their county. Exploring why race had such a significant impact on drought awareness could be an important avenue to explore in future research.

The second part of the analysis also yielded some important findings. As expected, we found that drought awareness was an extremely strong predictor of risk perceptions and also had an impact on policy preferences. Importantly, the effect of awareness was larger than any of the other drought variables included in the model. Awareness of drought appears much more important in determining concern and policy opinions than severity, temporal proximity, or drought duration. The difference between the models for risk perception and policy preferences provides crucial insights as well. While drought awareness was a greater predictor of both dependent variables than any of the other weather-related variables, the size of the effect varied greatly between the models. While individuals who were aware of drought were predicted to have almost a half standard deviation higher level of risk perception, awareness only led to a 0.13 standard deviation increase in policy preferences. Additionally, the predisposition and demographic variables mattered more for policy preferences than risk perception. This shows that while awareness of drought may increase concern for water issues, the role of awareness may be diminished compared to other variables when it comes to building actual support for drought mitigation policy.

Taken together, these results hold important implications for the environmental public opinion literature and for our understanding of drought in the United States. With respect to the literature on environmental public opinion, these results underscore the importance of studying perceptions of the environment in addition to objective measures of issue severity. That drought awareness mattered more than the actual drought measures for both risk perception and policy preferences provides yet another result showing the importance of examining perceptions of weather rather than

TABLE A4. Water information.

Survey question	Sign	Item–test correlation
Where do you get most of you information on water resources? Please indicate how often you use each of the following sources for information on water resources by using a 0 to 10 scale where 0 is never and 10 is very often:		
Newspapers	+	0.68
Television news	+	0.59
Internet	+	0.68
Radio	+	0.66
Scientific research reports	+	0.74
Government agencies	+	0.74
Nonprofit organizations	+	0.77
Environmental interest groups	+	0.77
Chronbach's alpha		0.85

TABLE B1. Risk perception factor analysis.

Survey question	Factor 1 loadings
Please indicate whether you strongly disagree, disagree, neither disagree nor agree, agree, or agree strongly:	
There is enough water in my state to meet current needs.	−0.47
There is enough water in my state to meet future needs.	−0.53
How likely are the following drought impacts to occur in your region in the next 5 years (five-point Likert scale from very unlikely to very likely):	
Disruption of water supplies.	0.76
Increased food prices.	0.65
Increased water costs.	0.69
Loss of recreational activities.	0.71
Reduced water quality.	0.67
Increased fires.	0.69
Increased water user conflicts.	0.77
Factor 1 eigenvalue	4.00

focusing exclusively on looking at actual occurrences of extreme weather. It is crucial to not simply examine what weather occurred in a specific geographic space but also to investigate how aware individuals are of the weather in their area and what determines that awareness. While we investigated the question in the context of drought, we feel as though there is room for further exploration in other contexts. Additionally, the unexpected results for some of the variables underscore the necessity for further theoretical development related to weather perceptions and awareness.

The results of this study also have important implications for our understanding of drought in the United States. The literature on drought has recognized that policy changes cannot come from science and engineering alone (Van Loon et al. 2016; Medd and

TABLE B2. Policy preference factor analysis.

Survey question	Factor 1 loadings
Should government take action in dealing with water issues in your area? Please answer on a scale from 0 to 10 with 0 indicating no need for government to act and 10 indicating a strong role for government to act.	0.40
Increasing population means that cities will need more water for the long run (more than 10 years in the future). Listed below are several possible strategies that a city might consider to ensure adequate water supplies in the future. Please rate the strategies on a scale of 0 to 10 with 0 being not favored by you and 10 being highly favored by you.	
Permanently transferring water from farms to the city.	0.13
Building dams and reservoirs.	0.27
Constructing pipelines to bring water from other regions.	0.30
Reusing waste water on lawns and landscapes.	0.52
Requiring water conservation.	0.71
Limiting urban sprawl.	0.49
Increasing water rates.	0.32
A number of policy options have been proposed to manage water resources.	
Please indicate whether you Strongly oppose, oppose, support, or strongly support each of the following options:	
Build infrastructure (dams, reservoirs, pipelines) to support water demands during a drought.	0.38
Conduct campaigns for voluntary water conservation.	0.58
Require mandatory water conservation.	0.62
Give tax incentives for the installation of water-saving equipment.	0.63
Develop a comprehensive national plan for allocating water across state borders.	0.49
Provide state tax cuts to companies that reduce their water use.	0.54
Prohibit government funding for developing in flood prone areas.	0.34
Require low water use landscaping.	0.63
Protect some water resources to preserve wildlife and fishery habitats.	0.60
Require that lawn watering use reclaimed/reused water instead of drinking water.	0.65
Factor 1 eigenvalue	4.54

TABLE B3. New ecological value factor analysis.

Survey question	Factor 1 loadings
Please indicate whether you strongly disagree, disagree, neither disagree nor agree, agree, or agree strongly:	
We are approaching the limit of the number of people the earth can support.	0.68
When humans interfere with nature it often produces disastrous consequences.	0.70
Plants and animals have as much right as humans to exist.	0.67
The earth is like a spaceship with very limited room and resources.	0.74
The balance of nature is very delicate and easily upset.	0.76
If things continue on their present course, we will soon experience a major ecological catastrophe.	0.81
Today's policies must consider the needs of future generations.	0.55
Humans were meant to rule over the rest of nature.	−0.33
Factor 1 eigenvalue	3.62

Chappells 2007). Policy changes to mitigate the negative effects of drought require understanding the human side of drought as well, which includes studying how individuals become aware of drought and how this awareness impacts their policy evaluations. The results of this study provide some preliminary insights into the dynamics that determine drought awareness, concern, and policy. While future work should consider expanding on this analysis in a number of ways, including a further exploration of geographic variability in drought understanding, these results are a crucial step in increasing our knowledge of drought awareness. Importantly, while drought awareness in this study is quite low in general, which suggests that significant attention needs to be given to communicating the existence of drought to the public, it is the case that increasing drought severity is by far the most important factor in determining awareness. This implies that once drought becomes severe enough, individuals begin to take notice. What is somewhat concerning from a policy perspective is the difference in results between the risk perception and policy preferences models. Drought awareness has a large effect on risk perception but a much smaller effect on policy preferences, while predispositions and demographics matter significantly more for policy preferences. Making individuals aware of drought may be enough to make them concerned about drought, but it may not be sufficient to drive desire for policy changes. Improved science communication to make individuals aware of drought when it occurs is an important step, but the results here show that a greater understanding of the drivers of support for policy beyond awareness is necessary as well.

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TABLE B4. Water information.

Survey question	Factor 1 loadings
Where do you get most of your information on water resources? Please indicate how often you use each of the following sources for information on water resources by using a 0 to 10 scale where 0 is never and 10 is very often:	
Newspapers	0.59
Television news	0.48
Internet	0.60
Radio	0.57
Scientific research reports	0.73
Government agencies	0.71
Nonprofit organizations	0.77
Environmental interest groups	0.77
Factor 1 eigenvalue	3.49

APPENDIX A

Indices Information

Tables A1–A4 include information on which questions were included in each of the four indices, with the sign and item–test correlation for each question.

APPENDIX B

Indices Factor Analysis

Factor analysis was used to further confirm the reliability of the four indices. The results can be seen in Tables B1–B4. Each factor analysis only retained one factor with an eigenvalue greater than 1.54, with the first factor retained in each case having eigenvalues of 3.49 or higher. All questions loaded in the expected direction.

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