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The effects of extreme drought on climate change beliefs, risk perceptions, and adaptation attitudes

J. Stuart Carlton[1,2] · **Amber S. Mase**[3] · **Cody L. Knutson**[4] · **Maria Carmen Lemos**[5] · **Tonya Haigh**[6] · **Dennis P. Todey**[7] · **Linda S. Prokopy**[1]

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Abstract The role of extreme weather events in shaping people's climate change beliefs and adaptation attitudes has been extensively studied and discussed in academic literature, the popular press, and policy circles. In this manuscript, we contribute to the debate by using data from pre- and post-extreme event surveys to examine the effects of the 2012 Midwestern US drought on agricultural advisors' climate change beliefs, adaptation attitudes, and risk perceptions. We found that neither climate change beliefs nor attitudes toward adaptation changed significantly as a result of the drought. Risk perceptions did change, however, with advisors becoming more concerned about risks from drought and pests and less concerned about risks related to flooding and ponding. Though increased risk perceptions were significantly

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✉ J. Stuart Carlton
stuartcarlton@tamu.edu

[1] Department of Forestry & Natural Resources, Purdue University, 195 Marsteller St., West Lafayette, IN 47906, USA

[2] Present address: Texas Sea Grant College Program, Texas A&M University, PO Box 1675, Galveston, TX 77553, USA

[3] Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706, USA

[4] National Drought Mitigation Center, School of Natural Resources, University of Nebraska-Lincoln, 821 Hardin Hall, Lincoln, NE 6858-0988, USA

[5] School of Natural Resources & Environment, University of Michigan, 440 Church St., Ann Arbor, MI 48109, USA

[6] National Drought Mitigation Center, School of Natural Resources, University of Nebraska-Lincoln, 810 Hardin Hall, Lincoln, NE 68583-0988, USA

[7] Department of Agricultural & Biosystems Engineering, South Dakota State University, Box 2120, Brookings, SD 57007, USA

associated with more favorable adaptation attitudes, the effects were not large enough to cause an overall shift to more favorable attitudes toward adaptation. The results suggest that extreme climate events might not cause significant shifts in climate beliefs, at least not immediately. Additionally, the results caution that policy designs that rely on increasing risk perceptions to motivate action on climate change may be overestimating the effects of extreme events on feeling at risk, at least in the context of buffered systems such as large commercial agriculture in the US.

1 Introduction

Whether or not firsthand experience with extreme events shapes people's perceptions of climate change and galvanizes them to take action has been the focus of growing attention in the risk management literature and in policy circles. There are several reasons for this important debate. First, the complex problem of climate change has rallied considerable intellectual and financial effort to understand the drivers of action or inaction in mitigating and adapting to potential climate impacts. Second, the perception that extreme events will be increasingly frequent and severe has sparked urgency in understanding what it will take to mobilize people and resources to prevent and/or adapt to such events. In this study, we use a natural experiment to investigate the effects of the severe 2012 Midwestern US drought on climate change beliefs and adaptation attitudes among agricultural advisors, a group with both a significant stake in agricultural production and an influential role in farmers' decision making (Prokopy et al. 2015).

In addition to the strong influence of political ideologies, cultural values, and demographics on climate change beliefs (e.g., Kahan et al. 2011; McCright and Dunlap 2011; Myers et al. 2013), a significant body of research has shown that there is a positive association between experience with extreme weather events and concern about climate change (Diggs 1991; Brody et al. 2008; Spence et al. 2011). The assumption in these studies is that experience with extreme weather helps climate change feel more real, immediate, and local, which in turn reduces some of the cognitive barriers to climate change action (Gifford 2011) and increases the likelihood of people being concerned about climate change (Weber 2006). However, other research has failed to demonstrate this relationship (e.g., Whitmarsh 2008), and there is evidence that people's climate change beliefs influence their interpretation of extreme events rather than the other way around (Goebbert et al. 2012; Myers et al. 2013).

While the relationship between extreme events, climate change beliefs, and risk perceptions may be unresolved in the literature, understanding this relationship has important practical implications for climate change communication. Studies generally have found that higher perceived risk from climate change is associated with greater willingness to adapt to climate change (O'Connor et al. 1999, 2005; Syal et al. 2011; Weber and Stern 2011). Additionally, the reasoned action model of behavior (Fishbein and Ajzen 2010) suggests that people are likely to adapt to climate change if they have more favorable attitudes toward adaptation. Following Kingdon's (1984) three streams model of policy action, if extreme events (i.e., the crisis stream) can be shown to markedly increase climate change beliefs and risk perceptions, then they might act as a critical trigger for climate related policy and action.

Testing this relationship is a challenge, in part because the unpredictability of natural disasters often imposes significant limitations on data collection and research design, especially in the case of longitudinal research. Hence, previous attempts to explore the causal relationship between extreme events, risk perception, and adaptation have measured personal experience with climate change absent a focusing extreme event (Myers et al. 2013), measured the effects of a series of events over time (Spence et al. 2011), or used data that measured experience with extreme events after-the-fact (Whitmarsh 2008).

In this study, we used an opportunistic natural experiment based on data collected shortly before (February 2012) and 1 year after (February 2013) the 2012 extreme Midwest US drought to determine whether the drought changed climate change beliefs, risk perceptions, or adaptation attitudes. The nature of droughts makes them particularly apt for studying the effects of extreme events on climate change beliefs: the public appears to perceive droughts more accurately than they do temperature changes, perceptions of which have been influenced by the public climate change debate (Goebbert et al. 2012).

The 2012 drought was the most severe in at least 25 years, with the highest summer precipitation deficits in recorded history and corn yields that were more than 25 % lower than expected values (Hoerling et al. 2013). Though the National Oceanic and Atmospheric Administration (NOAA) determined (after this study was completed) that the drought was caused mostly by natural climatic variability, the extent to which climate change may have increased the severity or likelihood of the drought is uncertain. In any event, the drought was a highly salient climatic event in the agricultural sector that received extensive media coverage throughout the Midwest and the broader US. The severe nature of the drought, combined with a coincidental prior study of climate change beliefs and attitudes in the area (Prokopy et al. 2013) gave us a unique opportunity to advance knowledge in this area.

1.1 Agriculture and climate change

Our study population is agricultural advisors across four Corn-Belt states (Indiana, Iowa, Michigan, and Nebraska), a rarely examined population that is critical to a vital sector of the US economy (Prokopy et al. 2013). Agriculture contributes approximately 1 % of the US economy by GDP value added (U.S. Bureau of Economic Analysis 2013) and 8 % of national carbon dioxide emissions (EPA 2013). Agriculture has caused massive changes in land use: croplands and pasture now compose ~40 % of the Earth's land surface (Foley et al. 2005). Anticipated climate change impacts on this sector include increasing temperatures, changes in timing and amount of precipitation and pest/disease patterns, and increasing occurrence of extreme weather (Hatfield et al. 2014; Rosenzweig et al. 2001; Malcolm et al. 2012). The US agricultural system already passively adapts to climatic variability by altering planting dates, hybrid selection, and irrigation decisions (Easterling 1996). However, proactive agricultural adaptation is a complex enterprise that (a) is influenced by climatic, socioeconomic, and agronomic factors; (b) takes place at scales from local to global; (c) covers both short- and long-term adjustments; and (d) is geographically and sectorally context-dependent (Chiotti and Johnston 1995; Olesen and Bindi 2002; Smit and Skinner 2002; Arbuckle et al. 2013b).

Agricultural advisors are a critical part of the agricultural sector. Modern agriculture is intensive and complex, requiring multiple concurrent decisions about crop and seed selection, nutrient application, insurance, marketing, and other issues often several months in advance in addition to in-season tactical decisions about planting timing, fertilizer and pesticide decisions, and harvesting. Because of the complexity and variety of information and skills involved in decision making, farmers often rely on significant input from agricultural advisors. In the US, these advisors range from University Extension agents to employees of government agencies (such as state Departments of Agriculture, the Natural Resources Conservation Service, and soil and water conservation districts) to for-profit consultants (such as seed and fertilizer dealers, Certified Crop Advisors, bankers, and lawyers), and insurance salespeople. Although agricultural advisors are not the sole source of climate information for farmers, advisors could potentially broker and customize climate information to aid in decision making. Though agricultural advisors typically are not climate change experts, they might play a significant role in long-term planning to respond to climate change (Prokopy et al. 2013; Lemos et al. 2014; Haigh et al. 2015).

1.2 Hypotheses

We investigated whether the drought caused a significant change in respondents' climate change beliefs, risk perceptions, and attitudes toward adaptation among agricultural advisors. Specifically, we tested the following three hypotheses:

H1. Belief in climate change would increase after the 2012 drought.
H2. Climate-related risk perceptions would increase after the 2012 drought.
H3. Attitudes toward climate adaptation would become more favorable after the 2012 drought.

2 Methods

We conducted an online survey of 7836 agricultural advisors in Indiana, Iowa, Michigan, and Nebraska in 2012 and 5478 advisors in the same states for the 2013 follow-up. These states were selected to capture the diversity of corn cropping systems in the region (Prokopy et al. 2013). Most advisor email addresses were obtained from their organization or agency websites. In a few instances, organizations distributed the survey to their membership to protect confidentiality. By the nature of harvesting email addresses from websites, our survey distribution list included recipients who do not advise corn producers. A screening question was used to eliminate such respondents. In all, 864 advisors responded to both surveys.

The survey was developed by a team of social scientists and state climatologists and was administered over the Internet using Qualtrics (Iowa in 2013 and Indiana, Michigan, and Nebraska in both years) and SPSS Dimensions (Iowa in 2012), allowing for personalized email greetings to most recipients. Up to two reminders were sent to nonrespondents. Both the 2012 and 2013 surveys were administered in February and March, prior to the corn-growing season.

Table 1 shows the specific wording of the survey questions. The climate change belief question, first used in the Iowa Farm Poll (Arbuckle et al. 2013a), was also used to calculate a binary measure of belief in climate change. Respondents who chose any of the options that indicated a belief that climate change was occurring were counted as believing in climate change and respondents who chose either of the two options that indicated a belief that climate change was not occurring were counted as not believing in climate change. This same variable was also used to calculate a scale of belief in anthropogenic climate change. Adapting from Mase et al. (2015), a score of 1 was assigned to those who believed climate change was "caused mostly by natural changes in the environment", a score of 2 was assigned to those who said climate change "is caused equally by natural changes in the environment and human

Table 1 Survey questions. Year-by-year averages can be found in the supplemental materials

Construct	Question	Internal consistency/ Factor loading	Analyzed individually or as a scale?	Use in risk perceptions models
Climate change beliefs	*Please select the statement that best reflects your views about climate change*: Climate change is occurring, and it is caused mostly by natural changes in the environment. Climate change is occurring, and it is caused mostly by human activities. Climate change is occurring, and it is caused equally by natural changes in the environment and human activities. Climate change is not occurring. There is not sufficient evidence to know with certainty whether climate change is occurring or not.	NA	NA	Independent variable
Risk perceptions	*How concerned are you about the following potential problems for corn production in your area*? (4-point scale from "Not Concerned" to "Very Concerned")		Factor analyzed, factors retained as a scale	Dependent variable
	Wet risks	$\alpha = 0.82$		
	Increases in saturated soils and ponded water	0.863		
	More frequent extreme rains	0.856		
	Increased flooding	0.802		
	Increased loss of nutrients into waterways	0.718		
	Dry risks	$\alpha = 0.80$		
	Longer dry periods and drought	0.913		
	Increased heat stress on crops	0.913		
	Nuisance risks	$\alpha = 0.87$		
	Increased insect pressure	0.932		
	Increased weed pressure	0.875		
	Higher incidence of crop disease	0.872		
Drought severity	Drought severity index (see text for calculations)	NA	Individual item	Independent variable

Table 1 (continued)

Construct	Question	Internal consistency/ Factor loading	Analyzed individually or as a scale?	Use in risk perceptions models
Drought beliefs	*The drought that began in the summer of 2012 affected many farmers inside the Corn Belt. Based on your experience with the drought, please provide your opinions on the following statements.* (5-point scale from “Strongly Disagree” to “Strongly Agree”)	NA	Individual items	Independent variables
	The farmers I work with were negatively affected by the drought			
	I expect events like the summer 2012 drought to increase in frequency in upcoming years			
	Belief that severe droughts are a natural part of the climate			
	Belief that severe droughts are a natural part of the climate			
Adaptation attitudes	*Given what you believe to be true about the potential impacts of climate change on agriculture in the Corn Belt, please provide your opinions on the following statements*: (5-point scale from “Strongly Disagree” to “Strongly Agree”)	$\alpha = 0.83$	Individually and averaged as a scale	NA
	I would like to provide advice based on climate forecasts			
	Farmers should take additional steps to protect farmland from increased weather variability			
	In my role as an advisor, I should help farmers prepare for increased weather variability			
	Changing practices to cope with increasing climate variability is important for the long-term success of the farmers I advise			
	It is important for farmers to adapt to climate change to ensure the long-term success of US agriculture			

activities", and a score of 3 was assigned to those who said climate change "is caused mostly by human activities". Those who did not believe in climate change were given a score of 0 on this scale.

McNemar's Chi-Square was used to analyze sample-wide differences pre- and post-drought; logistic regression was used to analyze which factors contributed to changes in beliefs.

The risk perception questions measured concern about potential problems for corn production (Table 1). Principal components factor analysis with varimax rotation was performed to categorize the risk perceptions, with three factors being retained based on factor scores (>1) and examination of a scree plot: "wet risks", or risks from too much water (flooding, extreme rains, field ponding, and nutrient loss); "dry risks", or risks from too little water (drought and heat); and "nuisance risks", or risks from nuisances (pests, weeds, and disease). The three factors explained 71.7 % of the variance and all factor loadings were greater than 0.40. Factor scores were retained for analysis (Stevens 2012).

Within-subject changes in adaptation attitudes and risk perceptions were tested with paired t tests and Wilcoxon sign-rank tests (a nonparametric alternative to the paired t test; Hollander et al. 2013). For the relationship between adaptation attitudes and risk perceptions, a regression line was fit to scatterplots comparing average adaptation attitudes to the risk perception factors.

Multiple linear regressions with robust standard errors were used to analyze changes in risk perceptions pre- and post-drought. Predictor variables included two proxy controls: a measure of drought severity (described below) and respondents' assessment of how negatively affected their clients were by the drought. Other predictors included the drought beliefs described in Table 1 and age and gender as demographic controls. Logistic regression was used to compare those who switched to believing in climate change after the drought to those who continued to disbelieve climate change after the drought. The same drought beliefs and demographic controls were used as predictors.

Drought severity was measured using US Drought Monitor data (http://droughtmonitor.unl.edu). The Drought Monitor lists the percent of each county in drought condition each week. Drought categories, which are subjectively determined based on key indicators and local reports, range from D1 (moderate drought) to D4 (exceptional drought). To measure drought severity, we summed the following: (1 * % of county in D1) + (2 * % of county in D2) + (3 * % of county in D3) + (4 * % of county in D4) for each respondent's home county weekly from April 3–September 25, 2012, approximately the corn-growing season.

3 Results

3.1 Response rate and demographics

In total, 864 advisors responded to both the 2012 and 2013 surveys. The response rate in 2013 was 29.4 % compared to approximately 27 % in 2012 (Prokopy et al. 2013). Those who indicated that they do not advise corn producers were not included in the response rate calculation. The average age of respondents was 48.7 years and about 75 % of respondents were male. The demographic characteristics of those who took the survey in both 2012 and 2013 were similar to those who only took the survey in 2012, so no weighting or post-hoc adjustments were made.

3.2 Drought beliefs

On average, respondents slightly agreed (average 3.85/5) with the statement that "the farmers I work with were negatively impacted by the summer 2012 drought." Respondents were uncertain (3.04/5) about the statement that "I expect events like the summer 2012 drought to increase in frequency in the coming years". Generally, respondents thought the drought was a natural occurrence: they slightly agreed (3.72/5) that "events like the 2012 drought are a natural part of the Corn Belt Climate", though those who did not believe in climate change prior to the drought agreed more strongly with this statement (mean 4.04/5 compared to 3.63, $p < 0.001$). Respondents were less certain that "climate change makes events like the 2012 drought more likely to occur" (3.24/5) and slightly disagreed (2.74/5) that "climate change made the 2012 drought worse."

3.3 Change in climate change beliefs

Overall, agricultural advisors' climate change beliefs did not significantly change after the 2012 drought: 72.8 % believed in climate change in 2012 vs. 73.6 % in 2013 ($p = 0.59$; Supplemental Figure 1). This result generally held true regardless of the severity of drought experienced by respondents (Supplemental Figure 2). However, 17 % of respondents reported changing their beliefs about climate change: 8.1 % switched from believing in climate change to not believing in climate change and 8.9 % switched from not believing in climate change to believing in climate change.

Differences among respondents who switched from not believing in climate change to believing in climate change and vice versa are presented in Table 2. Contrary to expectations, those who switched away from believing in climate change suffered more severe drought than those who switched to believing in climate change ($p = 0.01$).

In the logistic regression models (Supplemental Figure 3; Supplemental Table 1), the only significant ($p < .05$) predictors of switching to believing in climate change were the expectation that droughts would increase in coming years (odds ratio = 2.19, $p = 0.004$) and the drought severity index, with increasing levels of drought *decreasing* the likelihood of switching to believing in climate change (odds ratio = 0.99, $p = 0.005$).

Table 2 Differences among those who switched to believing in climate change and switched from believing in climate change after the 2012 drought

Measure	Mean, switched to believing in climate change (n = 64)	Mean, switched from believing in climate change (n = 58)	p-value
Drought severity index	2631.70	3305.20	0.012
The farmers I work with were negatively affected by the drought (5-pt scale)	3.80	3.83	0.880
I expect events like the summer 2012 drought to increase in frequency in upcoming years (5-point scale)	3.02	2.63	0.004
Concern about drought in 2012 (4-pt scale)	2.81	2.86	0.640
Belief that severe droughts are a natural part of the climate (5-pt scale)	4.08	3.62	0.003

The only significant predictor of switching from believing in climate change to not believing in climate change was the expectation that droughts would increase in coming years, with increases in that expectation being associated with a decrease in likelihood of switching away from believing in climate change (odds ratio = 0.27; $p < 0.001$). The drought severity index was on the border of significance ($p = 0.05$), with worse drought severity increasing the odds of switching to not believing in climate change.

3.4 Risk perceptions

Wilcoxon signed-rank tests revealed no significant change in average risk perception after the drought (mean concern 2.57/4 pre-drought and 2.58/4 post-drought; $z = -1.09$, $p = 0.277$)). There was a slight *decrease* in wet risk perceptions ($z = -6.25$, $p < 0.001$) compared to slight *increases* in dry risks ($z = 4.03$; $p < 0.001$) and nuisance risks ($z = 3.02$, $p = 0.03$; Fig. 1). This relationship generally held true across levels of drought severity (Supplemental Figure 4) and there were no significant correlations between drought severity index and change in risk perceptions (Supplemental Figure 5). Together, these results offer **mixed support for H2** that risk perceptions would increase.

Results of multiple regressions predicting the change in risk perceptions between 2012 and 2013 are presented in Fig. 2 (unstandardized coefficients) and Supplemental Table 2 (standardized coefficients).[1] The explanatory power of the models was low ($R^2 = 0.02$, 0.05, and 0.02 for change in wet risk, dry risk, and nuisance risk perceptions) and only the model for the change in dry risk perceptions was significant. Belief in climate change prior to the drought was a significant positive predictor of change in dry risk perceptions.

3.5 Adaptation attitudes

Overall, attitudes toward climate adaptation did not change. Of the five adaptation attitudes we measured, only one ("Farmers should take additional steps to protect farmland from increased weather variability") significantly increased after the drought (Fig. 3). These results generally held true regardless of the severity of drought experienced by respondents (Supplemental Figure 6) and there were no significant associations between drought severity index and change in adaptation attitudes (Supplemental Figure 7). There were weak-but-significant positive correlations between changes in risk perceptions and changes in adaptation attitudes (Supplemental Figure 8). In light of these results, **H3** (attitudes towards adaptation would become more favorable after the drought) **is rejected**.

4 Discussion

This study used a natural experiment to investigate the effects of an extreme climate event on agricultural advisors' climate change beliefs, risk perceptions, and climate adaptation attitudes. The results show that there was no significant shifts in climate change beliefs or adaptation attitudes though there was a change in some, but not all, climate-related risk perceptions. These results add empirical weight to the idea that the relationship between extreme events and

[1] Note that the concern about drought variable was omitted from the dry risk perceptions model because that variable was a component of the dry risk dependent variable.

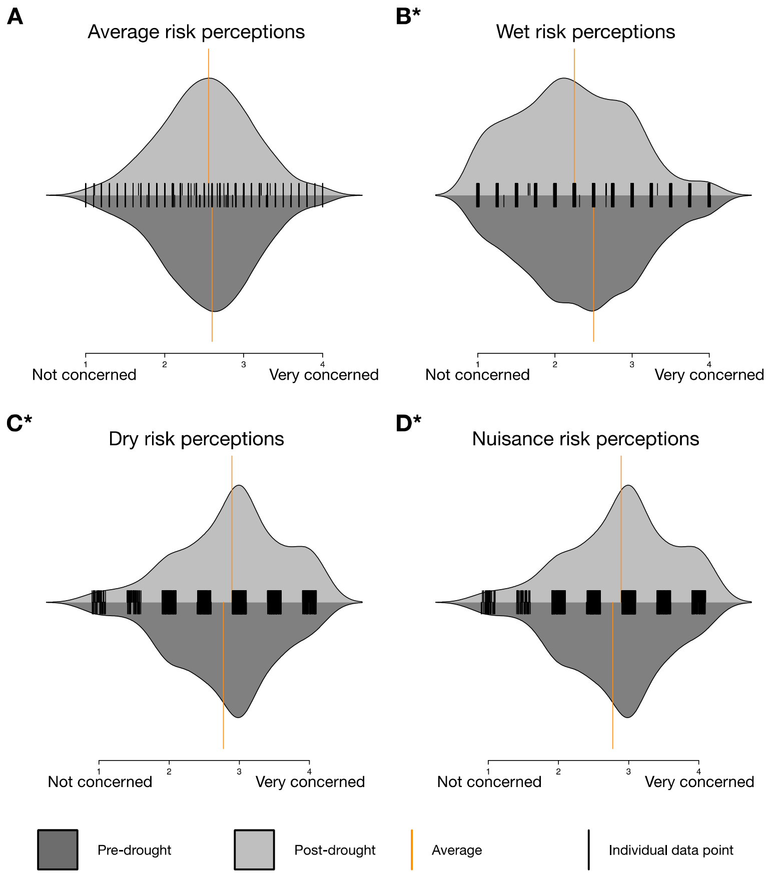

Fig. 1 Beanplots comparing risk perceptions pre- and post-drought. The *shape of the beanplots* represents a kernel density estimate for the distribution of responses. The *vertical black lines* represent individual responses, which were jittered to improve clarity. Statistically significant differences are indicated by **a** * and include plots **b** ($p < 0.001$), **c** ($p < 0.001$), and **d** ($p = 0.003$)

changing beliefs and attitudes is not straightforward and that experiencing a single event, even a severe one, might not be enough to change climate change beliefs and attitudes.

Though the widespread nature of the drought and the opportunistic nature of the pre- post-design precluded us from having a control group, we would expect a "dosage effect" if the drought had influenced beliefs. That is, there should have been larger changes occurring at higher levels of drought exposure and smaller changes occurring at lower levels of drought exposure. The absence of dosage effect strongly suggests that the drought did not impact climate change beliefs among those who did not believe in climate pre-drought. Recent work has described various influences on climate change beliefs, including cultural values (e.g., Kahan et al. 2011; Carlton et al. 2015), environmental attitudes, and political beliefs (McCright and Dunlap 2011). Other studies (Goebbert et al. 2012; Myers et al. 2013) have shown that people exhibit subconscious motivated reasoning about environmental changes: that is, their beliefs about climate change influence how they interpret observed environmental changes. Climate change believers and nonbelievers significantly disagreed over whether droughts like

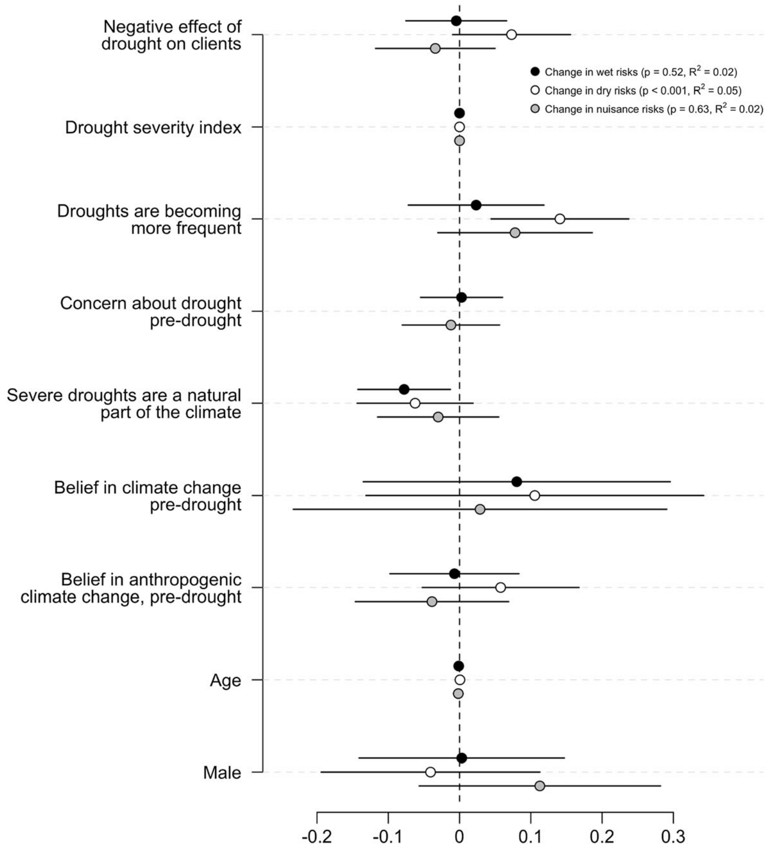

Fig. 2 Multiple regression models predicting change in risk perceptions after the drought. *Dots* represent unstandardized point estimates and *horizontal lines* represent 95 % confidence intervals. Confidence intervals that contain 0 are statistically insignificant

the 2012 drought were part of the natural climate. Perhaps motivated reasoning caused respondents to interpret whether the drought was "natural" in the context of their climate change beliefs.

If respondents did not identify the drought as an effect of climate change, then the drought cannot be expected to cause the "visceral reactions" (Weber 2006) that might lead to a change in climate change beliefs. Weber and Stern (2011:324) speculated that experiences with an extreme event would only change public opinion "if it is vivid and catastrophic, if it strikes in the United States and gets intense media coverage, and if it fits a widely held mental model of climate change". Our results do not contradict this idea: the drought apparently did not fit the mental model of climate change among those who did not believe in climate change (as evidenced by the neutral response to whether climate change makes severe droughts more likely). Our results also leave open the question of media coverage of the drought's relationship to climate change.

Risk perceptions changed after the drought. The direction of the shift (increased concern about risks from nuisances and too little water and decreased concern about risks from too much water) indicates that the changes in risk perception may have resulted from specific

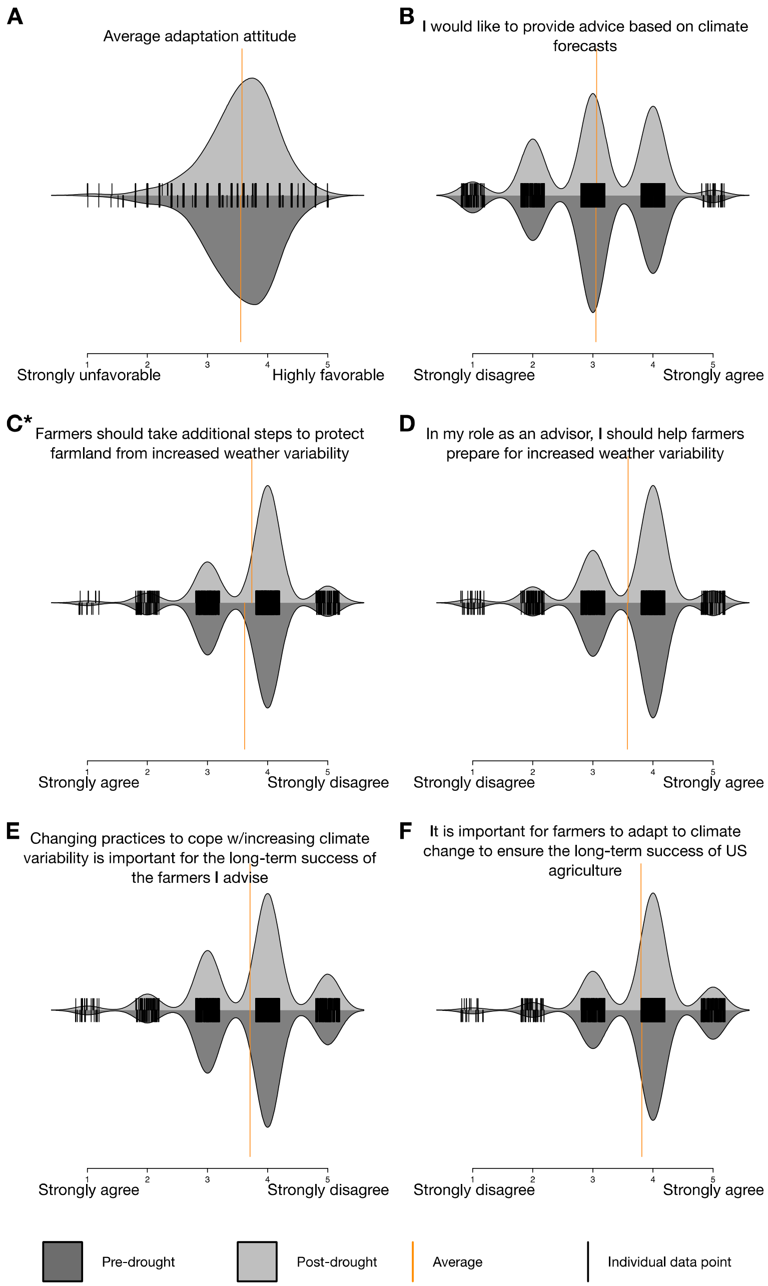

Fig. 3 Beanplots comparing adaptation attitudes pre- and post-drought. Plot **c** is a statistically significant difference ($p < 0.05$)

hazards being made more or less salient by the drought. In other words, people were more worried about drought-related hazards (and less worried about hazards related to too much water) after the drought.

If people have finite pools of worry (Weber 2006), that is, a limit to the number of things about which people can worry at one time, the increase in concern about immediate, drought-related risks and away from more distant-seeming, less salient risks like floods is not surprising. Finite pools of worry might also explain why some people shifted from believing in climate change to not believing in climate change after the drought: increases in other risk perceptions left little room to worry about climate change. This hypothesis could be explored in future research.

Respondents did not appear to connect the climate-related risks we measured to climate change adaptation. If they had, we presumably would have found changes in adaptation attitudes similar to the shifts in risk perceptions. We did not find such changes. Since attitudes toward climate adaptation did not become more favorable after the drought, the reasoned action model (Fishbein and Ajzen 2010) predicts that advisors surveyed are not more likely post-drought to work to adapt to climate change adaptation, though they may be more likely adapt to the specific risks that they now perceive as more salient or relevant. This finding is consistent with prior research showing that people may be concerned about salient, climate-related hazards even if they are not concerned about climate change specifically (Carlton and Jacobson 2013).

Feeling at risk from climate change may lead to an increased intention to perform adaptive behaviors (O'Connor et al. 1999, 2005; Syal et al. 2011; Weber and Stern 2011). However, empirical evidence of this direct effect is mixed. In the US Southwest, farmers may be less willing to make adaptive decisions as their farms are buffered from impact of climate-related events because of access to irrigation and little institutional incentive to change (Eakin et al. 2014). Conversely, a study of Australian farmers found that climate change belief was associated with certain adaptive behaviors, such as changing irrigation strategies (Wheeler et al. 2013). Our results found that, though overall adaptation attitudes did not change, there was a significant association between increases in risk perceptions and increasingly favorable adaptation attitudes (Supplemental Figure 8). However, the effect of risk perceptions was not large enough to cause an overall change in adaptation attitudes. Adaptation attitudes are multifaceted and might not change solely from increased risk perceptions from extreme events. Policy designs that rely on increasing risk perceptions to motivate action on climate change may be overestimating the effects of extreme events on feeling at risk, at least in the context of buffered systems such as large commercial agriculture in the US.

It is important to note that, while this drought was an extreme climatic event lasting many months, it was a single-year phenomenon. The relationship between climate change beliefs, feeling at risk, and adaptation attitudes may change over the course of a longer event such the multi-year droughts currently affecting other parts of the U.S. For example, perceived changes in water availability significantly influenced California farmers' intention to take adaptive or mitigative actions (Haden et al. 2012). Similarly, climate change risk perceptions influenced California farmers' willingness to participate in a hypothetical government climate change mitigation or adaptation program (Niles et al. 2013). We found both small changes in risk perceptions after the drought and a small positive association between changes in risk perceptions and changes in adaptation attitudes. Based on these findings, we can speculate that a longer drought might have caused both greater increases in risk perceptions and more favorable adaptation attitudes, similar to the California findings. However, California has an established policy framework to encourage climate change adaptation and mitigation (Haden et al. 2012), unlike the states we studied. Additionally, the prolonged nature of the California drought means that farmers may have been forced to change their water use because of the drought, which had not occurred at a large-scale in the Midwest during the time of our study. Regardless, given the relatively weak associations between risk perceptions and the adaptation attitudes we measured, there are likely other factors that are more important determinants of adaptation attitudes and willingness to adapt. Further research should investigate the relationship between risk perceptions and adaptation attitudes in the agricultural sector, how they change over time, and whether motivated reasoning weakens as drought effects persist.

There are a few limitations that bear mentioning. We have aggregated those who believe in anthropogenic climate change with those who believe in climate change but not an anthropogenic contribution in much of the analysis. Prior research has shown that these groups are heterogeneous (Poortinga et al. 2011); this relationship should be explored in more depth. Additionally, there are characteristics of our study population that may have attenuated the influence of the drought on beliefs and risk perceptions. First, agriculture is an industry that is regularly affected by weather and climate variability, which may make agricultural advisors' beliefs and attitudes more resilient to drought. Agricultural advisors are also more educated than the general public and are experts in their field, though not necessarily climate experts. While one might expect highly educated experts to be more likely to align with scientific consensus, prior research shows this is not necessarily the case (Carlton and Jacobson 2015). Additionally, the instability in climate change beliefs (with around 17 % of respondents changing beliefs, though not in a predictable way) suggests that any climate expertise that agricultural advisors have does not necessarily cause them to uniformly agree with the scientific consensus on climate change. Finally, there is the buffer provided by crop insurance and advances in crop genetics, which together greatly reduced financial losses during the 2012 drought. Current crop insurance policy allows farmers to protect revenues not only from crop loss but also from changing prices. While most producers lost yield from the drought, the increase in prices partially covered their losses during the drought, easing much of the financial burden. These complexities are important and should be explored to increase understanding of this critical sector.

Our findings suggest that even if extreme events make the effects of climate change more cognitively available, climate change beliefs are resistant to change. Overall, 72.8 % of survey respondents believed in climate change in 2012 vs. 73.6 % in 2013. The question remains, then, what is enough to spur a change in climate change beliefs among the remaining holdouts? Are beliefs largely settled, with certain segments of society unpersuadable? Is there something about the agriculture sector that makes it unlikely to change? What about other natural resources sectors that may not be adapting to climate change (e.g., forestry in Carlton et al. 2014)? What is the role of crop insurance in driving climate inaction in agriculture? Given the large role of agriculture in the climate change story, these are important questions to address.

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