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RESEARCH ARTICLE

It is Always Dry Here: Examining Perceptions about Drought and Climate Change in the Southern High Plains

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ABSTRACT
Drought is defined, experienced, and communicated about in multiple ways. This case study examines individual definitions of drought (timing, impacts, and severity) and attitudes about climate change. Household surveys ($n = 120$) were conducted in Cimarron County, Oklahoma and Union County, New Mexico using a stratified random sampling method to select farmers, ranchers, and town residents. Information about drought is primarily communicated between neighbors, friends, and family, as well as media and local governing agencies. Residents perceive the recent drought to be the worst drought on record, regardless of previous drought experiences. Residents reported widespread drought-related impacts on agriculture, environment, and society. Most residents see drought as cyclical and driven by natural causes, rather than human causes. We recommend adaptive drought communication engage more fully with identity, place, and history. Climate information should be presented in a relevant manner to diverse agricultural stakeholders with differing attitudes about climate change, management, and climate information.

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Drought vulnerability; environmental perceptions; agriculture; climate change; Southern High Plains

Introduction

Megadroughts, defined as unprecedented decadal and multi-decadal drought conditions, are projected to increase in the Southwest and Central Plains of North America in the coming decades due to the rapidly changing global climate (Cook, Smerdon, & Ault, 2015; Shafer et al., 2014; Udall & Overpeck, 2017). Drought has widespread and devastating impacts on humans and the environment, including property loss, financial and emotional hardships, systemic damages to rural communities, wildfires, and rapid land-use and land-cover change (LULCC) (Cutter, Gall, & Emrich, 2008; Mann & Kump, 2015). Megadroughts will result in increasingly complex impacts on agriculture and inevitable conflicts over natural resources. Rural agricultural communities that are dependent on natural resources will need to enhance their capacity to adapt to the impacts of future megadroughts that lie outside their coping range (Howden et al., 2007; MacDonald, 2010; Tompkins & Adger, 2004).

Our research project investigates the materiality of individual and household experiences with drought risks and recovery in two adjacent counties in the Southern High Plains that have a historical record of severe drought. This article synthesizes findings related to individual perceptions about drought causes, impacts, and timing. Two research questions guided our inquiry, (a) how do people define drought, and (b) in what ways do drought perceptions influence attitudes about climate change?

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Literature review

The "hydro-illogical cycle," as defined by the National Drought Mitigation Center, describes a cycle of concern and apathy that characterizes public attitudes about drought (NDMC, 2017). In this cycle, general apathy about drought occurs mainly during non-drought periods. Only in drought do people become more aware, concerned, and increasingly panicked. When drought conditions end, the public returns to apathy, forgetting to learn from or reflect on their experiences (Wilhite, 2011), hence the term "hydro-illogical". During long-term experiences with drought impacts, individuals may begin to ignore or wish away the problem. For example, in South Australia, long-term drought led to general acceptance and a sentiment of blind hope for the future (Pearce, Willis, Wadham, & Binks, 2010).

On a larger scale, the "hydro-illogical cycle" manifests as an institutional barrier in drought management and public outreach efforts. Periods of drought recovery following crisis often lead to a waning of funding and public communication. A number of drought management guides exist to help different stakeholders plan, respond, and adapt to agricultural drought (for e.g. Knutson, Hayes, & Phillips, 1998; NDMC, n.d.; Svoboda et al., 2010; Wilhite, Hayes, Knutson, & Smith, 2000). The central idea is to proactively plan for drought rather than respond to crisis. The temporal challenge becomes how to generate a sense of immediacy and support planning prior to a drought disaster. Improved risk communication between analysts and agricultural stakeholders about drought is vital to enacting policies that respond to drought in a timely and relevant manner (Laughlin & Clark, 2000).

Environmental perceptions and climate change

Most simply understood as the absence of water, the complexity of drought phenomena actually makes it quite difficult to define in agricultural settings (Dagel, 1997; Wilhite, 2000). For instance, people may have different perceptions about the nature, timing, and location of droughts (Porter, 2012). In turn, drought perceptions have an effect on how individuals and their communities communicate and respond in crisis (Taylor, Stewart, & Downton, 1988). Different perceptions and representations of human-environment relations can have the symbolic power to create individual meaning, different views, and different actions (Milstein, 2009). Definitions of drought are subject to memory, shared knowledge, lived experience, and expectations about climate conditions (Taylor et al., 1988). Other "site-specific" factors such as place attachment, local level awareness about impacts, and beliefs about climate change can influence attitudes about drought risks and rewards (Bishop, 2013; Brownlee, Hallo, Moore, Powell, & Wright, 2014, p. 964). The unique spatiotemporal characteristic of each drought period generates "shadows of experience" that can shape different perceptions about drought impacts and adaptation (Howe, Boudet, Leiserowitz, & Maibach, 2014, p. 381).

Exploring the ways rural agricultural communities talk about climate information, beliefs, and perceived risks can inform strategies for communicating about adapting to future mega-droughts (Arbuckle, Morton, & Hobbs, 2015). Research about the links between perceived drought vulnerability and climate change often use broad based regional or national surveys, sometimes paired with remotely sensed climatological data. In one study of Midwest agricultural advisors, beliefs about climate change and attitudes about adaptation remain unchanged by experiences with recent drought (Carlton et al., 2015). Another study indicates that long-term drought strongly affects attitudes about water supply, but not climate change, whereas short-term drought and daily environmental cues are more likely to affect opinions about severity of future water-related climate change (Evans et al., 2015). While informative, both studies use aggregate regional data and do not explore the reasons for the lack of correlation between experiences with long-term drought and attitudes about climate change. Very little work focuses on the role of place and proximity in shaping climate change perceptions (Brody, Zahran, Vedlitz, & Grover, 2008) or the role of context in the use of climate information (Flagg & Kirchhoff, 2018). To improve climate risk communication, research is needed to explore the sociocultural influences of climate change attitudes at a local level (Arbuckle et al., 2013) and capture variations in household perceptions about drought, and other hazards (Pidgeon, 2012).

Background

This article presents findings from a research project investigating household adaptations to drought in Cimarron County, Oklahoma and Union County, New Mexico. The study area is a culturally and economically connected region with a common drought history (Duncan & Burns, 2012; Egan, 2006). Geographically located along the former Santa Fe Trail, the region is steeped with history, and many family farms and ranches have early 1900s homestead heritage. Notably, the study area is considered the epicenter of the 1930s Dustbowl (McLeman, Mayo, Strebeck, & Smit, 2008; Porter, 2012). Since the 1930s, the population of these counties has continued to decline (Vadjunec & Sheehan, 2010). Many of those who stayed in the region are "Dust Bowl survivors" or the offspring of "Dust Bowl survivors." Consequently, experiences with long-term drought shape the cultural, economic, historical, and agricultural landscape (Figure 1).

The climate of this region is highly variable due to its location east of the Rocky Mountains and north of the Mexican Deserts and Gulf of Mexico. The study area in general is subject to low average precipitation, receiving 381 mm (15 in.) to 508 mm (20 in.) between May and August. Additionally, there are high average growing season temperatures, with summer maximum temperatures averaging 31.5° C (88.7° F) (Lindsey, 2008). Drought histories are largely meteorologically defined by state and climate region, leading to some discrepancy between the droughts records in the two counties in our study area. Figure 2 provides comparison of the annual precipitation and temperature record in two regional climate divisions: Northeast Plains of New Mexico and the Panhandle of Oklahoma. The 1930s and 1950s are "droughts-of-record" for both the Panhandle of Oklahoma region and Northeast Plains of New Mexico due to intense heat and long-term dry conditions (South Central Climate Science Center [SCCSC], 2013a, 2013b). A prolonged wet period in the

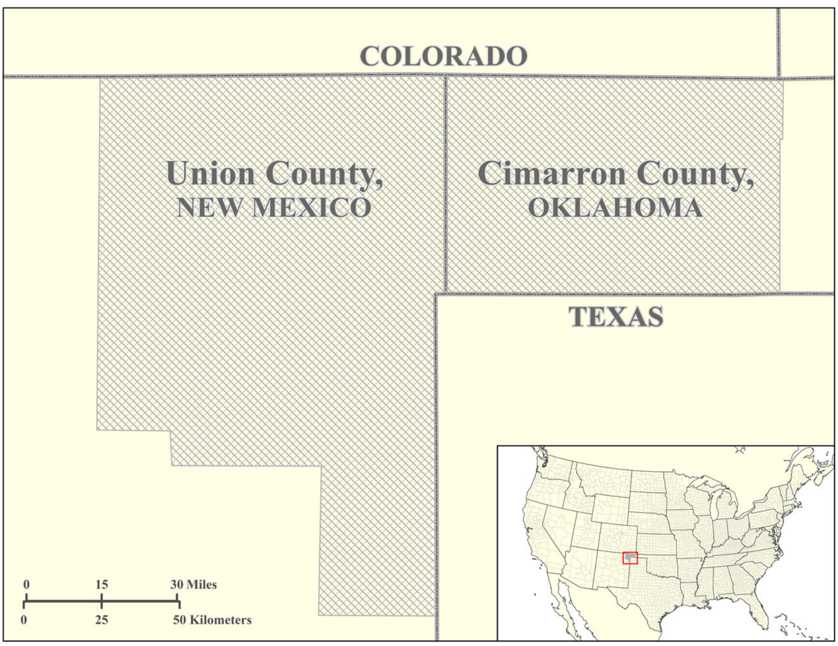

Figure 1. Study area map.

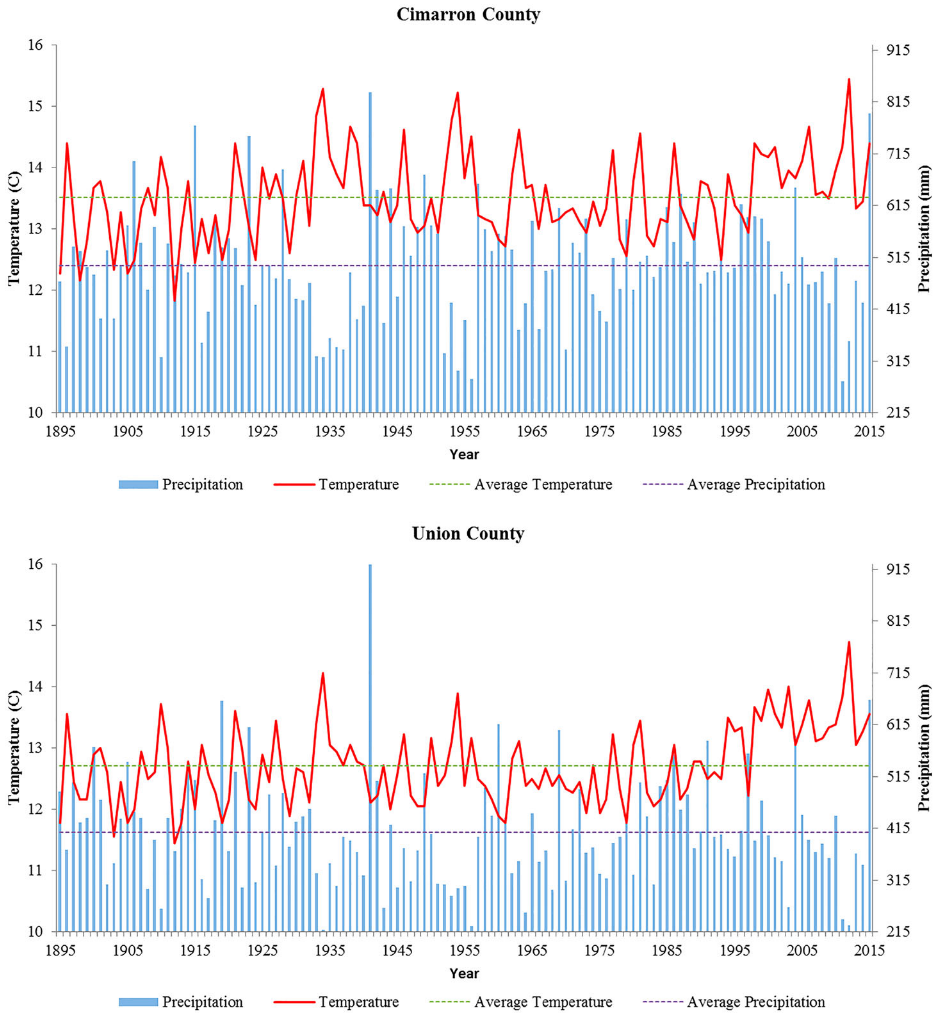

Figure 2. Historical record of total annual precipitation and annual average temperature. Data source: National Oceanic and Atmospheric, National Centers of Environmental Information (NOAA NCEI), 2017.

1980s and early 1990s was followed by a dry cycle starting in the early to mid-2000s (OWRB, 2012). Notably, the most recent drought period was characterized by less rainfall than the Dustbowl era droughts of the 1930s and 1950s.

Figure 3 maps the frequency and intensity of long-term drought in the study area and surrounding region from 2000 to 2015. The maps compile the weekly U.S. Drought Monitor (USDM) classifications to illustrate the frequent occurrence of drought building in intensity over time. At the height of the most recent drought (approximately) 2010 and 2014, the weekly classification map from the USDM reported sustained D2 (severe) to D4 (exceptional) drought in Cimarron County, OK and Union County, NM. Short-term severe droughts were reported in the Panhandle of Oklahoma region in 2006 and from 2011 to 14 (SCCSC, 2013a) and in the Northeast Plains of New Mexico region in 2003, 2006, and 2011 (SCCSC, 2013b).

Within the study area, 2011 was a notably harsh year with high temperatures and lack of rainfall. The severity of this drought was followed by policy actions in both states. In 2012, Oklahoma state legislators passed the *Water for 2060 Act* that aims for the state to consume no more water in 2060 than was consumed in 2012 (Oklahoma Water Resources Board (OWRB), 2012, 2017). In the same

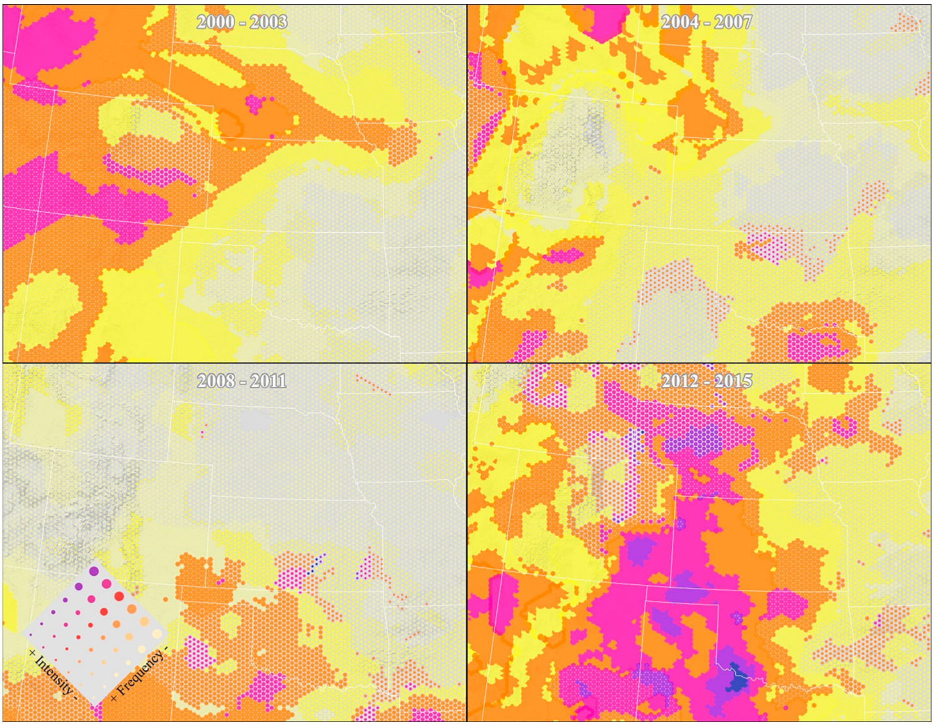

Figure 3. Drought frequency and intensity from 2000 to 2015. Darker colors indicate higher drought severity, whereas larger points indicate greater frequency. The bivariate mapping thereby shows both drought severity and frequency. Data source: U.S. Drought Monitor, based on Nelson (2016).

year, the New Mexico Governor Susana Martinez issued a drought declaration across the entire state, citing the second driest water year on record, and ordering recommendations from the New Mexico Drought Task Force (Martinez, 2012). Both states have established drought task forces that issue monthly online newsletters including common monitoring tools from state and federal organizations and agencies (e.g. US Drought Monitor, National Weather Service (NWS) Seasonal Drought Outlook, and NOAA Crop Moisture Index).

During the most recent drought, residents experienced rolling dust storms similar to the 1930s and a range of drought-related land management issues (e.g. invasive and nuisance species, wildfire, and wind erosion). Agriculturalists were forced to adapt to an intensified and prolonged drought; for example, ranchers, struggling with limited forage for their livestock, were often forced to purchase feed or, in extreme cases, sell off livestock. Farmers adapted Center Pivot Irrigation (CPI) to ensure crop security; others changed their crops all together in order to reduce their vulnerability to drought. Long-term drought impacted land-use and land-cover change (LULCC) differentially due to variations in the local and regional governance of public lands and management under drought conditions.

Methods

This research is part of a long-term study on adaptation to drought in the region (Fagin, Vadjunec, Colston, Wenger, & Graham, 2016; Vadjunec, Frazier, Kedron, Fagin, & Zhao, 2018; Wenger, Vadjunec, & Fagin, 2017). While we draw specifically on household surveys for the bulk of this analysis, our results are also informed by approximately 10 years of ethnographic and participatory research in the region by the study team, as well as an oral history project. Additionally, we draw on rich discussions with farmers and ranchers from four open-forum adaptive co-management meetings held throughout the study region in 2016.

Household survey

The research team developed the household survey in spring 2014 based on previous research in the region. After pilot testing the survey in May, the field team completed 120 household surveys in both Union County, NM and Cimarron County, OK ($n = 60$ each) in summer 2014 through fall 2014. The face-to-face household survey typically took between 1.5 and 3 hours to complete, and was conducted to the greatest extent possible with both the male and female heads of household present, although we asked one household member to self-identify as the head/lead in charge of the discussion (while noting any divergences of opinion). The survey included themed questions about: (i) household demographics, (ii) agricultural operation characteristics and production, (iii) current land holdings and land use, (iv) water use and vulnerability (household and agricultural), (v) drought impacts, and (vi) adaptive management practices (individual and community). To ensure confidentiality of research subjects, all results from the household surveys are presented anonymously. For the purposes of this paper, we focus on a series of open-ended and closed-ended questions related to drought and climate change perceptions (section v). Table 1 lists the primary questions used in this analysis.

Since the broader project has a large spatial mapping component, our goal was to link the household surveys to satellite imagery (Fagin et al., 2016). As such, our sampling framework is more geographical than sociological in nature. In other words, for the broader purposes of this project, our sampling universe was the land and then the people attached to it (Foo, McCarthy, & Bebbington, 2018; Stone-Jovicich, 2015). To complete the household survey and to develop a sampling framework, county-level plats (property maps) were acquired from local County Assessor's Offices and digitized for both Cimarron County, OK and Union County, NM. We used ArcGIS 10.4 to generate random X, Y coordinate map points equally dispersed throughout geographically stratified regions in each county (4 quadrants in each county). We then determined the property owner of the parcels in which each randomly generated point occurred. To ensure diversity, we sampled 45 rural and 15 urban (city, town, or village level) households in each county ($n = 120$ total). The stratification insured that we sampled a diverse geographic region and consequent land use (i.e. urban/other, ranching, irrigated, and/or dryland agriculture). In cases where we could not locate the parcel owner, the land was public land, or if the parcel owner did not want to participate, we utilized a standard nearest neighbor approach (based on closest adjoining land parcel). This sampling strategy is common in human-environment studies combining regional-scale data such as remote sensing land-use land-cover imagery with household-scale research (Fox, Rindfuss, Walsh, & Mishra, 2003). This approach helps to connect "people" (household studies) with "pixels" (satellite imagery) and prevents issues with spatial-autocorrelation (where a household, especially one's land-use activities, is more likely to be similar to neighbor, than one farther away) due to environmental issues such as topography, vegetation, soils, hydrology, among other things (Liverman, Moran, Rindfuss, & Stern, 1998; Liverman & Ramon Cuesta, 2008). As a result, such sampling approaches attempt to represent the range of diversity of not only the households, but also the surrounding environment.

Table 1. Household survey items.

Communicating about drought
Where do you get information related to water and drought? (select from list)
In comparison to previous drought cycles, the current drought has not been as bad (5 pt. scale)
How would you describe the current "drought" situation? (provide 3 adjectives)
Definitions and indicators
How do you define "drought" in your own words?
What are three main environmental clues you look for in determining drought?
Timing
In your opinion, when (year) did the current drought cycle begin?
How many drought periods have you personally experienced while living in this area?
Climate knowledge
In my opinion, I believe that drought is linked to overall climate change.
If yes, is it human-caused, natural, or both?

As our sampling stratification was based on land (via X,Y coordinates on a map) and the households attached to those coordinates, we estimate that we had an initial 40–50% response rate in our counties, with the inclusion of the nearest neighbor approach, our sampling response rate was approximately100%. This means that approximately 100% of all households fell within the plat parcel initially selected or that parcel's nearest neighbor (next section).

Data analysis

We employed both deductive and inductive approaches to data analysis (Table 1 lists the household survey items). First, existing literature on drought perceptions informed a deductive approach to understanding how respondents define drought. Responses to closed-ended questions about the timing of drought, number of drought experiences, sources of information about drought, and links to climate change were compiled using basic descriptive statistics. Additionally, descriptions of the severity of the drought were entered into a qualitative coding program to note the frequency and pattern of specific word choices.

Household survey respondents provided definitions of drought in their own words. These responses were coded using the Wilhite and Glantz (1985) drought typology: meteorological (defined by degree of dryness and duration), agricultural (defined by susceptibility of crops, pasture, or cattle), hydrological (defined by surface or subsurface water supply), and socioeconomic (defined by broader human impacts). The Wilhite & Glantz typology reflects disciplinary clusters of drought research and conceptually the drought definitions represent a progression of intensifying impacts over time. As such, in the instance of multiple responses, a single response category was assigned according to the most progressive impacts identified.

Second, an inductive approach aimed to capture emergent perceptions about the timing, impacts, and severity of recent drought. Using a grounded theory approach, the open-ended responses were compiled into the question categories and relevant themes devised. Structural coding aided a thematic analysis of perceptions about drought (Guest, MacQueen, & Namey, 2012) using the following text segmentations: (1) communicating about drought, (2) definitions and indicators, (3) timing, and (4) climate knowledge.

Household survey respondents described three environmental clues for determining drought. Open coding of these drought indicators revealed six emergent categories of perceived environmental impact. In contrast to the Wilbite & Glantz typology described above, emergent coding allowed us to explore how respondents' identify drought impacts through personal experience (rather than as defined by scientific discipline).

Results

Demographic profile

According to the United States Census Bureau (2018), Union County has an estimated population of 4187 and a population density of 1.095 people/mi^2 (0.42 people/km^2). The population is largely white (91.6%) with 41.8% reporting Latino or Hispanic descent (53% reporting white only with no Latino or Hispanic descent). The majority of the population (61.7%) is between 18 and 65. Twenty percent of the population is over 65 years old. Cimarron County has an estimated population of 2154 and a population density of 1.17 people/mi^2 (0.45 people/km^2). The population is largely white (94.8%) with 22.8% reporting Latino or Hispanic descent (72.8% reporting white only with no Latino or Hispanic descent). The majority of the population (51.7%) is between 18 and 65. 24% of the population is over 65 years old.

Household basic demographics collected from our household survey show a similar but in some ways divergent pattern. Our surveys reveal that the majority of household heads are male, white; with some college education (45% hold a Bachelor's degree and 8% a Master's

Table 2. Basic respondent demographics ($n = 120$).

Household Demographic Variables	Mean Percent *(frequency n)*
Percent female (%)	0.28 *(33)*
Percent identifying as racial or ethnic minority (%)	0.24 *(29)*
Average age (years)	60.37
Average length at current residency (years)	23.02
Previous residency in county (%)	0.65
Percent with some college or greater (%)	0.73 *(87)*
Occupation	
Total percent involved in white-collar employment (%)	0.27 *(32)*
Total percent involved in blue-collar employment (%)	0.04 *(5)*
Total percent retired (%)	0.14 *(17)*
Total percent involved in agriculture (%)	0.52 *(62)*
Of those in agriculture, percent involved in cattle production?	0.82 *(72)*
Of those in agriculture, percent involved in other livestock production?	0.16 *(14)*
Of those in agriculture, percent involved in crop production?	0.37 *(32)*

degree). However, considerable diversity is noted (see Table 2). Just over $1/4^{th}$ of self-identified household heads are female, and approximately $1/4^{th}$ of household heads self-identified as a racial or ethnic minority, mainly Hispanic and/or Native American. Household heads averaged 60 years old, with over 20 years at their current residence, and the majority living in the county previous to their current residency as well, indicating an aging agricultural population with a long-term and well-established history in the area. Although more than a quarter of the population is involved in some form of white-collar employment, the majority of the population is involved in agriculture, mainly cattle ranching and crop production. Since in our sample, we focused mainly on farmers and ranchers, one can expect some difference from the county level demographics (above). However, the study sample is consistent with known population and agricultural dynamics in the region. For instance, agricultural census data shows that over 60% of agricultural operators were 55 or older (National Agricultural Statistics Service [NASS], 2012).

Communicating about drought

Respondents report that information about drought is more often communicated between neighbors, friends, and family, but also via the media and local governing agencies. In terms of sources of information about drought, respondents rely on family and friends (53%), Internet (40%), soil and water conservation districts (39%), government agencies (36%), local newspapers (34%), and church (22%). Self-reports indicate that more experienced farmers/ranchers can influence others' perceptions about the impacts and severity of drought. For example, respondents rely on the comparisons and recollections of family members and older friends to make sense of current severity of drought conditions in context to past drought events.

Table 3. 10 most commonly used words to define drought ($n = 120$).

Word	Mean Percent (frequency *n*)
Year(s)	0.27 *(32)*
Rain / Lack of Rain	0.22 *(26)*
Devastating	0.11 *(13)*
Hard	0.10 *(12)*
Bad	0.10 *(12)*
Severe	0.09 *(11)*
Depressing	0.08 *(10)*
Dry	0.08 *(10)*
Extreme	0.07 *(8)*
Tough	0.07 *(8)*
Worse	0.07 *(8)*

Respondents overwhelmingly agreed about the severity of the recent drought. When asked to compare recent drought to previous experienced droughts in the area, 3 of 4 respondents agreed that current drought is worse than past droughts. Words used in defining drought directly reflect the resulting hardships. One survey item asked for three descriptive adjectives to describe the current drought situation, but the majority of residents often described drought impacts in full sentences. According to frequency counts (Table 3), the top word used in open-ended answers regarding the severity of drought was surprisingly a noun – "year" ($n = 24$) or "years" ($n = 8$). In other words, roughly 1/3rd of residents defined drought in a way that suggests duration. Another noun, "rain" ($n = 21$), or the absence of rain ($n = 5$), was the second most used word (22%). Other top frequency adjectives are generally negative and include words such as "devastating" ($n = 13$), "hard" ($n = 12$), "bad" ($n = 12$), "severe" ($n = 11$), "depressing" ($n = 10$), "dry ($n = 10$), "extreme" ($n = 8$), "tough" ($n = 8$), and "worse" ($n = 8$). These and other adjectives used to a lesser extent describe the drought were often used in conjunction with "year" or "years" (above) and reflect the true severity of the drought, including bleak, dire, miserable, painful, unrelenting, harsh, horrible, lousy, costly, detrimental, terrible, hellish, sickening, nasty, and alarming. Such descriptive words reflect a general tone of the sample population suggesting overall difficult times.

Definitions and indicators

When initially asked, *how do you define "drought" in your own words*, respondents ($n = 120$) most often defined drought as meteorological (54%) rather than agricultural (20%), hydrological (4%), or socioeconomic (22%). Table 4 defines these categories and provides a summary of responses related to each type of drought. When describing meteorological drought, respondents often added qualifications about the lack of precipitation in relation to their needs and uses (such as inadequate, prolonged, insufficient, and unsubstantial). Agricultural definitions of drought reflected the impacts on farming and ranching practices. Most often noted are the impacts of extended drought on grasslands and water for stock. As one respondent reminded us, "cattle ranchers are really grass farmers". Very few respondents initially identified the hydrological implications of drought on natural surface water (lakes, springs, and creeks) or groundwater resources integral to irrigation and stock wells. More often respondents provided socioeconomic definitions of drought that described the human impacts in terms of broader yet interconnected problems of livelihood, land ownership, and rural community decline.

Additional prompting suggests interviewees observe a range of drought impacts in their daily lives. Specifically, respondents were asked, *what are three main environmental clues you look for in determining drought?* Emergent coding of environmental cues revealed six primary impact categories. Figure 4 illustrates the percentage of responses in each category ($n = 353$). A wide variety of indicators were identified beyond lack of rain (27%), including agriculture impacts to cattle (23%) and crops/plants (20%), and native and nuisance species (21%). A few respondents cited socioeconomic (5%) and surface and ground water resources (5%) indicators.

Table 4. Types of drought and sample responses.

Type of drought	Defined by	Sample responses
Meteorological	Degree of dryness and duration	Absence or lack of precipitation (rain and snow), extreme heat, dry winds, dust, soil erosion, extended period
Agricultural	Susceptibility of crops, pasture, or cattle	Lack of grazable forage, decline of grasslands, lack of soil moisture, decline in cattle ponds, failure of crops, problems sustaining ground cover
Hydrological	Surface or subsurface water supply	Shortage of water, well decline, lack of recharge, dried up creeks and springs
Socioeconomic	Human impacts	Loss of land, increase in land prices, economic hardship on community, negative impacts on livelihood

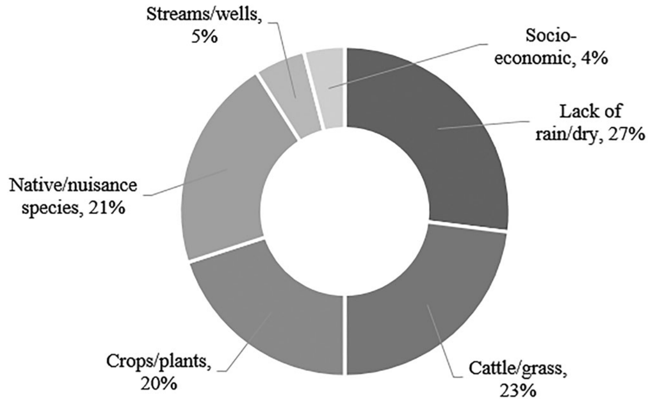

Figure 4. Drought indicators by frequency ($n = 353$).

Timing

The household surveys were conducted in 2014 as the drought was still on going, but perceived to be ending. When asked about when the drought started, 18 respondents (of 120) described the drought as starting before the 2000s, as early as the 1970s. The remaining respondents ($n = 102$, 85%) varied in their perceptions about when the current drought started during the period of 2000–2011. The cluster chart in Figure 5 illustrates that the beginning of drought is not easily defined. Respondents had a variety of opinions about the timing of the latest drought period. For some survey respondents the timing of drought defined in terms of notable precipitation (deficits and occurrences) and extreme weather events. For example, there was extremely low rainfall in 2006 and a winter white out in 2007 followed by another hot and dry growing season.

The perceived timing of drought is also relative to the experienced impacts of drought. The respondents had a wide range of experience with drought in the study area (experiencing one drought 22%, two droughts 24%, three droughts 29%, or four or more droughts 21%). For residents not directly engaged in agriculture, drought often only becomes visible first in terms aesthetics (e.g. brown grass) and then later observable systemic impacts on the community (e.g.

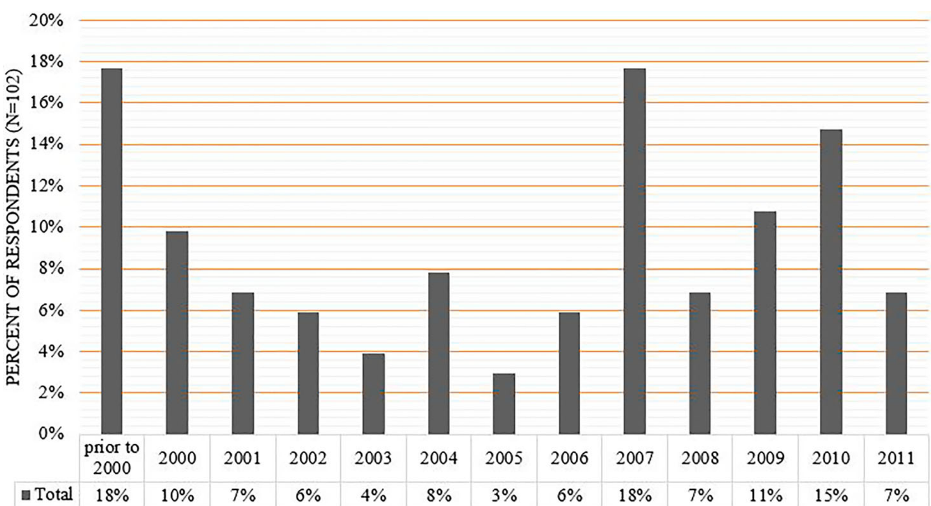

Figure 5. Respondents' opinions about the start of the drought cycle.

the feedlots closed) or on the environment (e.g. the trees in the park died). For an agriculturalist, the comparative severity of droughts impacts can be relative to their social life and responsibilities during each particular drought period. For example, whether you were a child versus an adult, whether the family could afford annual vacation, or whether a spouse was able to acquire a second job in town.

Agricultural households cite both economic and social impacts when identifying the timing of drought. The need to pump water before planting or failure to raise a dryland crop (for farmers) and the forced sale of cattle (for ranchers) are relative markers of drought periods. Other times, inability to recover between dry periods influences perceptions about the length of drought. Significant financial events and serious problems with livelihood (e.g. the cycles of debt to the bank or the consolidation of farms) similarly act as markers of drought timing. A host of financial decisions influence perceptions about the severity of drought, including crop and cattle markets, production costs, leasing rates, financial relief/ assistance, and competition with larger operations. In sum, the perceived timing of drought in any given household is influenced by the experienced socioeconomic impacts and financial burden during dry times.

Climate knowledge

When asked about the link between climate change and drought ($n = 120$), 42% of respondents disagreed there was a link, 46% agreed, and 12% remained neutral (see Figure 6). Of those who agreed there was a link between climate change and drought ($n = 52$), only 8 respondents (15%) attributed climate change to human causes alone, 25 respondents (48%) felt climate change was natural, and 19 respondents (37%) felt it was caused by both human and natural causes. Qualifying remarks suggest that drought is commonly viewed as a natural form of climate change operating in cycles (10–30 years). Respondents who recognize the human causes of climate change tend to view technology as an actor in accelerating environmental change. For the few others, the issue of climate change is described as politicized or as a hoax driven by radical environmentalists.

Individual perceptions about the link between drought and climate change are a product of experienced climate. Several themes emerged from the household survey responses related to how respondents understand the climate and the nature of drought. In short, historical and long-term experiences with drought contribute to apathy, whereas the risk generated by the unpredictability and variability of drought contributes to a persistent hope for improved conditions.

It's always dry

In terms of timing, the respondents commonly understand that drought naturally occurs in multidecadal cycles. After reflecting that the study area is always in need of rain, one respondent described drought as happening "since we were born" with an intermittent period of "good rain 13 years ago". As such, it is common in the region to use the more colloquial adjective "droughthy" rather than the

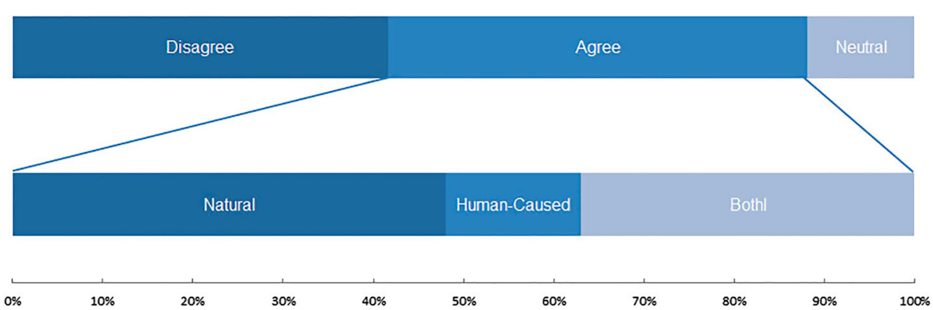

Figure 6. Attitudes about the link between drought and climate change.

noun drought to distinguish dry years from those times "when things really start to dry up". Respondents generally experienced drought as the result of a long-term succession of bad years, often with intermittent good years or breaks in weather. Drought is not over until there is a "string of good, wet years", as the "teaser years don't make up for bad years". The commonly arid weather in the region makes it hard to define the start of drought, as it "sneaks up on you, you don't notice at first." An unfortunate consequence is a sense of community-wide optimism that leads people to "often wait until it's too late to respond". A brief set of rainy days during our data collection process prompted respondents to express being "cautious, but optimistic" that the drought had broken. These types of responses reflect immense power of hope in face of unpredictable times, even after the sparsest rain events.

(Un)predictable drought

To say that drought is a natural occurrence or cycle is not to say that the weather is predictable. When it comes to the weather, longtime residents often say, "There is no such thing as normal" and commonly joke that only a "newcomer or a damn fool" tries to predict the weather. Precipitation deficits are so common and unpredictable, as one respondent aptly noted, "You never know you're in drought until it's over." Inherently a very weather aware community, residents observe the "spottiness" of precipitation as variable not only in timing and amount, but location of precipitation (e.g. across farms and areas of the county). More than quantity of rain, respondents explained that a lot depends on the annual timing of precipitation in relation to grassland management or soil residue needed for farming. To deal with the unpredictability, several respondents imparted this rule of thumb, "every 10 years you can expect 2 bumper crops, 2 over, 2 under, 2 failures, and 2 unknowns". Each year is a gamble and carries rather low production expectations. In sum, despite an acute awareness of long-term risks, hope and faith drive a general acceptance of inevitable and unpredictable hard times ahead.

Discussion

Our research study was conducted in 2014 at the height of a long-term drought period. This article asks, (a) how do people define drought, and (b) in what ways do drought perceptions influence attitudes about climate change? Seventy-five (63%) of residents perceive the most recent drought to be the worst drought on record, regardless of previous drought experiences. There was community-wide awareness about the problem and deep concern among agriculturalists. While residents define drought in terms of rain, they describe a variety of environmental indicators of drought and their systemic impacts on agricultural production and household finances. Indeed, the timing of drought, as a slow onset of disaster, seems more relative to household impact rather than actual weather history (Shao, 2016). The perceived timing of drought is subject to a wide range of economic and social impacts, not the least of which is the household-level financial burden of dry times.

In the study area, drought is a cyclical, recurrent experience. There is no misunderstanding that the climate is always dry and drought unpredictable. This reality frames an understanding of climate change as a part of a natural cycle. For respondents, the drought cycle is a form of natural climate change. More than half of the residents described no link between climate change and drought, while another third described climate change as natural (rather than human induced). In simple terms, they perceive drought as climate variability, but not caused by climate change. At its core, drought is perceived as a natural event that is inherently hard to predict, even seasonally. While respondents predominantly viewed climate as a natural cyclical process, they still hold a strong environmental ethic and it would be an oversimplification to view this worldview as a form of climate skepticism (Connor & Higginbotham, 2013).

Local climate knowledge about recurrent, persistent, and unpredictable dry times is relative to a host of human-environment concerns (e.g. finances, management choices, and household relationships). Agriculturalists, especially, are always necessarily moving between cycles of accepting the good years and recovering from the bad years. Whether conscious or unconscious, repeat drought survivors embrace a mindset of acceptance of circumstance coupled with a powerful sentiment of hope for the future. The term "hydro-illogical cycle" mistakes this mindset for apathy, lack of reflection, and inaction. Whereas fleeting concerns about drought are framed as a boundary to community resilience, they may actually be a foundational coping mechanism necessary for repeat drought survivors.

Scope and limitations

While our household sampling protocol used a rigorous geospatial random sampling design, some care must be taken with the interpretation and generalizability of the results. A relatively low, but in-depth sample size (n) was employed for the purposes of this study with the intention of going deeper at the household level in order to better understand how drought is perceived, interpreted and acted upon. Since agriculture is the main economic driver of these two counties, agriculturalists made up the predominant part of the sampling stratification. However, roughly a quarter of our sample population could be defined as "urban," many living at the county seat. However, many of our urban residents also were farmers and ranchers who still had and worked their land but lived in the city for a variety of purposes, including better access to schools and health care. Additionally, the findings are purely descriptive rather than inferential. This rich, heavily qualitative data provides a basis for future studies in the region.

Implications for practice and research

Our study raises questions about how to emphasize the predicted influence of climate change on megadroughts and encourage drought planning in already vulnerable arid locations. A recent briefing (Shaw & Corner, 2016) suggests several research-based principles for communicating drought risks in a changing climate. In short, understanding perceptions about drought timing and impacts can help drought risk communicators to find narratives and frame messages that resonate with the lived experiences of our target audiences.

Communicating about drought in a changing climate will require more than scientific facts and must invoke compelling narratives grounded in the values and experiences of our target audiences (Schweizer, Davis, & Thompson, 2013; Shaw & Corner, 2016; National Academies of Science, Engineering, and Medicine [NASEM], 2017). There may be strong personal and social reasons that people may not want to accept the risks of increased and more severe droughts (Marshall, 2014). As one of our survey respondents explained, "How can we give up when your grandparents lived through the Dust Bowl?" Future research should identify narratives that better resonate across grasslands communities experiencing sustained drought. In our study area, listening to and sharing the knowledge of drought survivors may be key to motivating future drought management and adaptation efforts. For example, unveiling cultural narratives about the causes of the Dust Bowl offers a promising context for discussing the human-drivers of regional climate change (Porter, 2012).

It seems that attitudes about climate change are not phenomenologically linked to experienced losses due to drought (Jørgensen & Termansen, 2016). In regions where drought risks are extremely salient, making the connection between long-term drought and global climate change may not be necessary for adaptive actions to take place. Climate change communicators have begun to think more holistically about how to connect climate change risks in familiar ways for agriculturalists (Galmiche-Tejeda, 2004). Keen to avoid the polarizing and politicized discussions about climate change consensus, many agricultural publications, policy advocates, and faith-based organizations are now opting to talk about climate change, without necessarily using the words climate change or emphasizing science (Schwartz, 2016; Tabuchi, 2017). Climate change manifests daily as practical issues about farm and ranch management. For example, extension agents report that confusion and mistrust characterize agricultural discussions about climate change, but that economic, stewardship, and adaptation frames are influential (Bowers, Monroe, & Adams, 2016). Here the goal is to find ways to generate household and community discussions about coping capacity and resiliency, rather than enforce climate change consensus.

Drought is not a new problem in our study area and agriculturalists are necessarily resilient people with important adaptive knowledge systems. Like other disasters (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2013), our research confirms that information about drought is most often communicated interpersonally (between neighbors, friends, family, and, local agencies). In general, this suggests that adaptive drought communication happens at individual household and local community levels (Fontaine, Steinemann, & Hayes, 2014). The livelihoods of agriculturalists are connected to natural resources and subject to weather; making them experts of climate due to their experiences (Clifford, 2014). Drought preparedness and mitigation campaigns must move beyond the development of risk profiles, seasonal forecasts, and early warning systems to more culturally nuanced communication. For example, concrete experiences and in-group communication about climate risks may be more influential to processing climate uncertainty than traditional analytical and statistical approaches (Marx et al., 2007). In other cases, interactions with downscaled and localized climate projections have influenced climate change attitudes regardless of geographic proximity (Herring, VanDyke, Cummins, & Melton, 2017).

Conclusion

Long-term and severe drought will continue to influence many farmers and ranchers in the Southern High Plains. The projected rise of megadroughts due to climate change necessitates a better understanding of how rural agriculture-based communities communicate about drought vulnerability. Drought is defined, experienced, and communicated about in different ways. This case study looked at household perceptions about drought timing, impacts, and severity in Cimarron, County, OK and Union County, NM. Residents perceived the most recent drought to be the worst drought on record, regardless of previous drought experiences. Most residents defined drought as primarily meteorological in nature, although many identified indicators of drought illustrate the systemic impact on agriculture, environment, and society. Across households, the impacts of drought are experienced in different ways and respondents had diverse ways of framing the problem. Multiple, historical lived experiences as drought survivors lead residents to understand drought as cyclical and driven by natural causes, rather than human causes. We recommend that environmental science draws on these rich experiences, rather than ignoring or patronizing such climate change discourses, and design communication that engages more fully with people, their place, lived history and diverse experiences.

Environmental communication scholarship must continue to highlight the particular social and political contexts that influence definitions of drought and attitudes about the link to climate change. The broader societal challenge for communicating about climate science and adaptation continues to be how to generate the social and political capital necessary to generate narratives that represent people's lifeworlds and identities (Leith & Vanclay, 2015). Understanding climate knowledge unique to households and agricultural communities is a key dimension to communicating about drought adaptation in the Southern High Plains. For agricultural contexts, we must begin to present climate information in a relevant manner to stakeholders with differing beliefs about climate change, land management issues, and specialized climate information needs (Prokopy et al., 2015). Future strategies of public engagement should aim to reduce threats to diverse or different worldviews about climate, while enhancing public dialogue between science and society.

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References

Arbuckle, J. G., Morton, L. W., & Hobbs, J. (2015). Understanding farmer perspectives on climate change adaptation and mitigation: The roles of trust in sources of climate information, climate change beliefs, and perceived risk. *Environment and Behavior*, *47*(2), 205–234. doi:10.1177/0013916513503832

Arbuckle, J. G., Prokopy, L. S., Haigh, T., Hobbs, J., Knoot, T., Knutson, C., … Widhalm, M. (2013). Climate change beliefs, concerns, and attitudes toward adaptation and mitigation among farmers in the Midwestern United States. *Climatic Change*, *117*(4), 943–950. doi:10.1007/s10584-013-0707-6.

Bishop, B. (2013). Drought and environmental opinion: A study of attitudes toward water policy. *Public Opinion Quarterly*, *77*(3), 798–810. doi:10.1093/poq/nft034

Bowers, A. W., Monroe, M. C., & Adams, D. C. (2016). Climate change communication insights from cooperative extension professionals in the US Southern states: Finding common ground. *Environmental Communication*, *10*(5), 656–670. doi:10.1080/17524032.2016.1176947

Brody, S. D., Zahran, S., Vedlitz, A., & Grover, H. (2008). Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. *Environment and Behavior*, *40*(1), 72–95.

Brownlee, M., Hallo, J., Moore, D., Powell, R., & Wright, B. (2014). Attitudes toward water conservation: The influence of site-specific factors and beliefs in climate change. *Society & Natural Resources*, *27*(9), 964–982. doi:10.1080/08941920/2014/929768

Carlton, J., Mase, A., Knutson, C., Lemos, M., Haigh, T., Todey, D., & Prokopy, L. (2015). The effects of extreme drought on climate change beliefs, risk perceptions, and adaptation attitudes. *Climatic Change*, *135*(2), 1–16. doi:10.1007/s10584-015-1561-5

Clifford, K. (2014). *Knowing climate: Examining climate knowledges in the Gunnison Basin* (Geography Graduate Theses & Dissertations). University of Colorado Boulder.

Connor, L. H., & Higginbotham, N. (2013). "Natural cycles" in lay understandings of climate change. *Global Environmental Change*, *23*(6), 1852–1861. doi:10.1016/j.gloenvcha.2013.07.002

Cook, B., Smerdon, J., & Ault, T. (2015). Unprecedented 21st century drought risk in the American Southwest and Central Plains. *Science Advances*, *1*(1), e1400082–e1400082. doi:10.1126/sciadv.1400082

Cutter, S. L., Gall, M., & Emrich, C.T. (2008). Toward a comprehensive loss inventory of weather and climate hazards. In H. F. Díaz & R. J. Murnane (Eds.), *Climate extremes and society* (pp. 279–295). Cambridge: Cambridge University Press.

Dagel, K. (1997). Defining drought in marginal areas: The role of perception. *The Professional Geographer*, *49*(2), 192–202. doi:10.1111/0033-0124.00069

Duncan, D., & Burns, K. (2012). *The Dust Bowl: An illustrated history*. Chronicle Books: San Francisco.

Egan, T. (2006). *The worst hard time: The untold story of those who survived the great American dust bowl*. Houghton Mifflin Harcourt: New York.

Evans, J., Calabria, J., Borisova, T., Boellstorf, D., Sochacka, N., Smolen, M., … Risse, L. M. (2015). Effects of local drought condition on public opinions about water supply and future climate change. *Climatic Change*, *132*(2), 193–207. doi:10.1007/s10584-015-1425

Fagin, T., Vadjunec, J. M., Colston, N., Wenger, K., & Graham, A. (2016). Land tenure and landscape change: A comparison of public-private land in the southern High Plains. *Ecological Processes*, *5*(1), 1–14.

Flagg, J. A., & Kirchhoff, C. J. (2018). Context matters: Context-related drivers of and barriers to climate information use. *Climate Risk Management*, *20*, 1–10. doi:10.1016/j.crm.2018.01.003

Fontaine, M., Steinemann, A., & Hayes, M. (2014). State drought programs and plans: Survey of the western United States. *Natural Hazards Review*, *15*(1), 95–99. doi:10.1061/(asce)nh.1527-6996.0000094

Foo, K., McCarthy, J., & Bebbington, A. (2018). Activating landscape ecology: A governance framework for design-in-science. *Landscape Ecology*, *33*(5), 675–689. doi:10.1007/s10980-018-0630-3

Fox, J., Rindfuss, R. R., Walsh, S. J., & Mishra, V. (Eds.). (2003). *People and the environment: Approaches for linking household and community surveys to remote sensing and GIS*. Dordrecht: Kluwer Academic Publishers.

Galmiche-Tejeda, A. (2004). Who is interdisciplinary? Two views, two goals, professionals and farmers. *Interdisciplinary Science Reviews*, *29*(1), 77–95. doi:10.1179/030801804225012464
Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. London: Sage Publishing.
Herring, J., VanDyke, M. S., Cummins, R. G., & Melton, F. (2017). Communicating local climate risks online through an interactive data visualization. *Environmental Communication*, *11*(1), 90–105. doi:10.1080/17524032.2016.1176946
Howden, S. M., Soussana, J. F., Tubiello, F. N., Chhetri, N., Dunlop, M., & Meinke, H. (2007). Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences*, *104*(50), 19691–19696. doi:10.1073/pnas.0701890104
Howe, P., Boudet, H., Leiserowitz, A., & Maibach, E. (2014). Mapping the shadow of experience of extreme weather events. *Climatic Change*, *127*(2), 381–389. doi:10.1007/s10584-014-1253-6
Jørgensen, S., & Termansen, M. (2016). Linking climate change perceptions to adaptation and mitigation action. *Climatic Change*, *138*(1-2), 283–296. doi:10.1007/s10584-016-1718-x
Knutson, C., Hayes, M., & Phillips, T. (1998). *How to reduce drought risk: Preparedness and mitigation working group* (1st ed.). Lincoln, NE: Western Drought Coordination Council. Retrieved from http://drought.unl.edu/portals/0/docs/risk.pdf
Laughlin, G., & Clark, A. (2000). Drought science and drought policy in Australia: A risk management perspective. In D. A. Wilhite, M. V. K. Sivakumar, & D. A. Wood (Eds.), *Early warning systems for drought preparedness and drought management* (pp. 5–7). Geneva: World Meteorological Organization.
Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Howe, P. (2013) *Extreme weather and climate change in the American mind*. New Haven, CT: Yale Project on Climate Change Communication.
Leith, P., & Vanclay, F. (2015). Translating science to benefit diverse publics: Engagement pathways for linking climate risk, uncertainty, and agricultural identities. *Science, Technology, & Human Values*, *40*(6), 939–964.
Lindsey, R. (2008). Devastating drought settles on the High Plains. *NASA's earth observatory*. Retrieved from http://earthobservatory.nasa.gov/Features/OklahomaDrought/
Liverman, D. M., & Ramon Cuesta, R. M. (2008). Human interactions with the earth system: People and pixels revisited. *Earth Surface Processes and Landforms*, *33*(9), 1458–1471. doi:10.1002/esp.1715
Liverman, D., Moran, E. F., Rindfuss, R. R., & Stern, P. C. (Eds.). (1998). *People and pixels: Linking remote sensing and social science*. Washington, DC: National Academy Press.
MacDonald, G. M. (2010). Water, climate change, and sustainability in the southwest. *Proceedings of the National Academy of Sciences*, *107*(50), 21256–21262. doi:10.1073/pnas.0909651107
Mann, M. E., & Kump, L. R. (2015). *Dire predictions: Understanding climate change*. New York: Pearson.
Marshall, G. (2014). After the floods: Communicating climate change around extreme weather. *Climate outreach*. Retrieved from http://climateoutreach.org/resources/communicating-climate-change-around-recent-extreme-weather-events/
Martinez, S. (2012, May 11). *Executive order 2012-006 drought declaration*. Retrieved from http://www.governor.state.nm.us/uploads/FileLinks/5634a3c59b924b1ba8ca6072b986dc45/EO2012006.pdf
Marx, S. M., Weber, E. U., Orlove, B. S., Leiserowitz, A., Krantz, D. H., Roncoli, C., & Phillips, J. (2007). Communication and mental processes: Experiential and analytic processing of uncertain climate information. *Global Environmental Change*, *17*(1), 47–58. doi:10.1016/j.gloenvcha.2006.10.004
McLeman, R., Mayo, D., Strebeck, E., & Smit, B. (2008). Drought adaptation in rural eastern Oklahoma in the 1930s: Lessons for climate change adaptation research. *Mitigation and Adaptation Strategies For Global Change*, *13*(4), 379–400. doi:10.1007/s11027-007-9118-1
Milstein, T. (2009). Environmental communication theories. In S. Littlejohn, & K. Foss (Eds.), *Encyclopedia of communication theory* (pp. 344–349). Thousand Oaks, CA: Sage. doi:10.4135/9781412959384.n130
National Academies of Science, Engineering, and Medicine. (2017). *Communicating science effectively: A research agenda*. Washington, DC: The National Academies Press. doi:10.17226/23674
National Agricultural Statistics Service. (2012). *Census of Agriculture (Volume 1, Chapter 2: County Level)*. United State Department of Agriculture. Retrieved from https://www.nass.usda.gov/Publications/AgCensus/2012/Full_Report/Volume_1,_Chapter_2_County_Level/
National Drought Mitigation Center. (2017). *The hydroillogical cycle*. Retrieved from http://drought.unl.edu/Planning/HydroillogicalCycle.aspx
National Drought Mitigation Center. (n.d.). *Managing drought risk on the ranch: A planning guide for Great Plains ranchers*. Retrieved from http://drought.unl.edu/Portals/2/Ranchplan20Images/Ranchplan20Documents/ranch20plan20handbook20to20print%209.14.pdf
National Oceanic and Atmospheric, National Centers of Environmental Information. (2017). *Climate at a glance*. Retrieved from https://www.ncdc.noaa.gov/cag/time-series/us/
Nelson, J. (2016, December 6). Six Months of Drought in the American Southeast. *ArcGIS Blog*. https://blogs.esri.com/esri/arcgis/2016/12/06/six-months-of-drought-in-the-american-southeast/
Oklahoma Water Resources Board (OWRB). (2012). *Hydrological drought of water year 2011: A historical context*. Retrieved from https://www.owrb.ok.gov/supply/drought/pdf_dro/DroughtFactSheet2011.pdf

Oklahoma Water Resources Board (OWRB). (2017, April 6). *Water for 2060. Oklahoma water resources board*. Retrieved from http://www.owrb.ok.gov/supply/conservation.php
Pearce, M., Willis, E., Wadham, B., & Binks, B. (2010). Attitudes to drought in outback communities in South Australia. *Geographical Research*, *48*(4), 359–369. doi:10.1111/j.1745-5871.2009.00639.x
Pidgeon, N. (2012). Climate change risk perception and communication: Addressing a critical moment? *Risk Analysis*, *32*(6), 951–956. doi:10.1111/j.1539-6924.2012.01856.x
Porter, J. (2012). Lessons from the Dust Bowl: Human-environment education on the Great Plains. *Journal of Geography*, *111*(4), 127–136. doi:10.1080/00221341.2011.624629
Prokopy, L. S., Carlton, J. S., Arbuckle, J. G., Haigh, T., Lemos, M. C., Mase, A. S., … & Hart, C. (2015). Extension's role in disseminating information about climate change to agricultural stakeholders in the United States. *Climatic Change*, *130*(2), 261–272.
Schwartz, J. (2016, October 10). Katharine Hayhoe, a climate explainer who stays above the storm. *The New York Times*. Retrieved from https://www.nytimes.com/2016/10/11/science/katharine-hayhoe-climate-change-science.html
Schweizer, S., Davis, S., & Thompson, J. L. (2013). Changing the conversation about climate change: A theoretical framework for place-based climate change engagement. *Environmental Communication*, *7*(1), 42–62. doi:10.1080/17524032.2012.753634
Shafer, M., Ojima, D., Antle, J. M., Kluck, D., McPherson, R. A., Petersen, S., … Sherman, K. (2014). Ch. 19: Great plains. In J. M. Melillo, T. C. Richmond, & G. W. Yohe (Eds.), *Climate change impacts in the United States: The third national climate assessment* (pp. 441–461). U.S. Global Change Research Program. doi:10.7930/J0D798BC
Shao, W. (2016). Are actual weather and perceived weather the same? Understanding perceptions of local weather and their effects on risk perceptions of global warming. *Journal of Risk Research*, *19*(6), 722–742. doi:10.1080/13669877.2014.1003956
Shaw, C., & Corner, A. (2016). Communicating drought risk in a changing climate. *Climate Outreach*. Retrieved from http://climateoutreach.org/resources/drought-briefing-paper/
South Central Climate Science Center. (2013a). *Drought history for the Oklahoma Panhandle* (1st ed.). Retrieved from http://www.southcentralclimate.org/content/documents/factsheets/Drought_History_OKCD01.pdf
South Central Climate Science Center. (2013b). *Drought history for the northeastern plains of New Mexico* (1st ed.). Retrieved from http://www.southcentralclimate.org/content/documents/factsheets/Drought_History_NMCD03.pdf
Stone-Jovicich, S. (2015). Probing the interfaces between the social sciences and social-ecological resilience: Insights from integrative and hybrid perspectives in the social sciences. *Ecology and Society*, *20*(2): 25.
Svoboda, M., Smith, K., Knutson, C., Sittler, M., Angel, J., & Spiner, M. (2010). *Drought-ready communities: A guide to community drought preparedness*. The National Drought Mitigation Center. Retrieved from http://drought.unl.edu/Planning/PlanningProcesses/DroughtReadyCommunities.aspx
Tabuchi, H. (2017, January 28). *In America's heartland, discussing climate change without saying 'climate change'*. Retrieved from https://www.nytimes.com/2017/01/28/business/energy-environment/navigating-climate-change-in-americas-heartland.html?mwrsm=Email&_r=0
Taylor, J., Stewart, T., & Downton, M. (1988). Perceptions of drought in the Ogallala Aquifer region. *Environment and Behavior*, *20*(2), 150–175. doi:10.1177/0013916588202002
Tompkins, E., & Adger, W. N. (2004). Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society*, *9*(2). Retrieved from http://www.ecologyandsociety.org/vol9/iss2/art10/
Udall, B., & Overpeck, J. (2017). The twenty-first century Colorado River hot drought and implications for the future. *Water Resources Research*, *53*, 2404–2418. doi:10.1002/2016wr019638
United States Census Bureau. (2018). *United States census bureau quickfact*s. Retrieved from https://www.census.gov/quickfacts/fact/table/US/PST045216
Vadjunec, J., & Sheehan, R. (2010). Ranching and state school land in Cimarron County, Oklahoma. *Great Plains Research*, *20*(Fall), 163–177.
Vadjunec, J. M., Frazier, A. E., Kedron, P., Fagin, T. D., & Zhao, Y. (2018). A land systems science framework for bridging land system architecture and landscape ecology: A case study from the Southern Great Plains. *Land*, *7*(1), 27. doi:10.3390/land7010027
Wenger, K., Vadjunec, J. M., & Fagin, T. (2017). Groundwater governance and the growth of center pivot irrigation in Cimarron County, OK and Union County, NM: Implications for community vulnerability to drought. *Water*, *9*(1), 39. doi:10.3390/w9010039
Wilhite, D. (2000). Drought as a natural hazard: Concepts and definitions. *Chapter 1 Drought Mitigation Center Faculty Publications*. Retrieved from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1068&context=droughtfacpub
Wilhite, D. (2011). Breaking the hydro-illogical cycle: Progress or status quo for drought management in the United States. *European Water*, *34*, 5–18. Retrieved from http://www.ewra.net/ew/pdf/EW_2011_34_01.pdf
Wilhite, D. A., & Glantz, M. H. (1985). Understanding: The drought phenomenon: The role of definitions. *Water International*, *10*(3), 111–120.
Wilhite, D., Hayes, M., Knutson, C., & Smith, K. (2000). Planning for drought: Moving from crisis to risk management. *Journal of the American Water Resources Association*, *36*(4), 697–710. doi:10.1111/j.1752-1688.2000.tb04299.x