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Increased preparation for drought among livestock producers reliant on rain-fed forage

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Abstract Increased preparation for drought among livestock producers reliant on rain-fed forage should reduce the economic losses and environmental degradation when the eventual drought occurs. We surveyed livestock ranchers in southeastern Arizona, USA, to determine their level of increased preparation for drought following 10 very dry years, as well as their level of threat from drought, importance of coping strategies, ranching experience, herd size, and satisfaction with drought management information. We used the protection motivation theory (PMT) model to structure our analysis because it provides a cognitive process approach to understand what motivates people to increase preparation for looming problems and how the likelihood of that behavior is a function of threat and coping strategy assessments. Thirty-seven percent of ranchers reported a high increase in preparedness, and another 31 % reported some increased preparation. Increased preparation was positively associated with three coping practices: reserve pastures, rotate grazing, and drought planning. However, increased preparation was negatively associated with drought threat severity, suggesting that the more prepared ranchers have implemented coping strategies that buffer them from the looming threat of drought. We found no relationship between increased preparation and levels of ranching experience, herd size, or satisfaction with drought information. Structure and content of education and assistance programs for improving rancher preparation for drought should benefit from the PMT-based analysis because it identifies drivers leading to increased preparedness and how those drivers differ among members of the ranching community.

Keywords Protection motivation theory · Stepwise logistic regression · Drought planning

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1 Introduction

Drought is a natural hazard that threatens the production of livestock on the 35 M km^2 of grass-shrub rangelands worldwide (Safriel et al. 2005) by depressing the production of rain-fed forage and availability of drinking water. Economic losses from decreased productivity are magnified by the steep increase in the price of alternative feed and sharp decline in livestock prices that typically follow. These price changes occur when the demand for alternative feed increases because large numbers of producers are trying to sustain their herds, and the supply of livestock being sold increases because those producers are trying to minimize losses. Recovery from drought lags behind the return of rain because natural forage production may require several years to regain capacity and high prices for replacement livestock follow the increased demand from producers trying to rebuild their herds. Unfortunately, this cycle of drought impacts is common and, in some cases, has left legacies of reduced forage production and the collapse of livestock industries (Reynolds et al. 2007; Stafford Smith et al. 2007; Coppock 2011).

Strategies to prevent these drought-related losses focus on increasing preparedness to make early decisions that avoid buying high and selling low, and to diversify sources of feed and income (Gates et al. 2007; NDMC 2013). However, increased preparedness and adherence to a "drought plan" require significant commitment, especially given that drought is a time-delayed risk that is slow to develop and not fully recognized until several consecutive dry months have accumulated (Hayes et al. 2004; Weber 2006). Therefore, understanding what drives and sustains increased drought preparedness among livestock producers can contribute to education and assistance programs that are intended to foster greater levels of preparedness (Marshall and Smajgl 2013; Ashraf et al. 2014). Our study describes levels of increased drought preparedness among livestock ranchers in southeastern Arizona, USA, and how increased preparedness is related to the rancher's (1) assessment of coping strategy efficacy, (2) levels of threat assessment represented by definitions of drought, and (3) financial resources, ranching experience, and satisfaction with drought management information.

1.1 Protection motivation theory and increased preparedness

We use the protection motivation theory (PMT) model to frame our study of increased drought preparedness among ranchers because it provides a description of the cognitive process leading to increased motivation to become prepared. The PMT emerged from the psychological study of motivations to maintain health and adherence to medical directives (Floyd et al. 2000), and has recently been applied to understand motivations to increase preparedness for natural hazards such as earthquakes, floods, droughts, and climate change (Grothmann and Patt 2005; Grothmann and Reusswig 2006; Stewart 2009; Koerth et al. 2013; Le Dang et al. 2014).

The PMT model proposes that motivation to act is the outcome of assessing the severity of threats and the efficacy of coping practices and that those assessments can be influenced by context factors such as social norms, information sources, socioeconomic resources, and previous experience with the threat (Fig. 1). Grothmann and Patt (2005) suggest that threat assessments provide the motivation "energy," leading to adoption of protective practices, and interactions between threat severity and coping efficacy indicate a "co-processing" during the assessments. However, Floyd et al. (2000) suggest that coping practice assessments show stronger relations with increased preparedness than threat assessments.

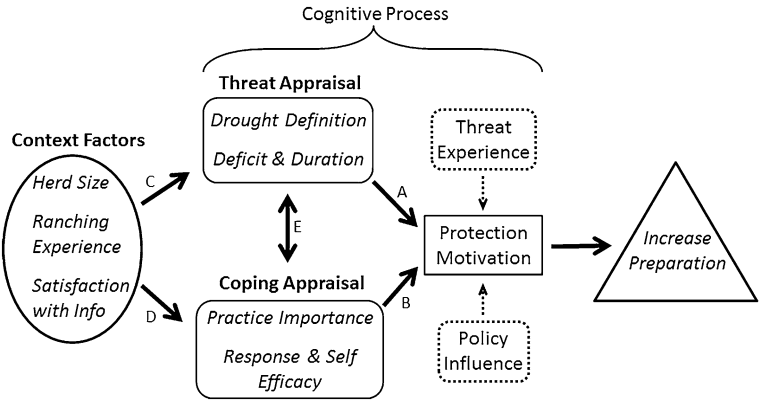

Fig. 1 Protection motivation theory model of cognitive process applied to understanding the motivation to increase preparation for drought by livestock ranchers (modified from Grothmann and Reusswig 2006; Stewart 2009). Variables in *italics font* were measured in this study. Variables in *dashed boxes* were inferred in the interpretation, but no control comparison was performed. Labeled *arrows* provide reference for relationships described in the text

Grothmann and Reusswig (2006) suggest that the assessment of threat severity diminishes after applying protective actions.

Like the PMT model, threat and coping assessments are the basis for the drought risk analysis process described by Hayes et al. (2004). In contrast, the drought risk analysis is a prescriptive tool to improve drought preparedness, whereas the PMT model is an analytical tool to understand why some are more motivated to increase preparedness. Fortunately, the shared fundamentals of threat and coping assessments should facilitate efficient translations between the analytical and prescriptive goals.

Factors associated with the doubling of drought preparedness among livestock producers (cattle ranchers) in Utah, USA, from 14 to 29 % (Coppock 2011) are consistent with the PMT. Increased preparedness was positively associated with the recent adoption of drought-focused practices (affecting efficacy), a stronger perception that drought would become more common (affecting threat), and greater impacts from a recent drought (affecting previous experience). Although the PMT was not used to frame this change in preparedness, the results are consistent with the recognition that the cognitive processing of threat severity, coping practice efficacy, and previous experience can predict increased preparedness for natural hazards.

We asked ranchers in southeastern Arizona, USA, whether their preparedness for drought had increased in the previous 10 years. We used those responses to examine how the rancher's assessments of coping practice efficacy and drought threat severity are related to increased preparedness (Fig. 1).

1.2 Efficacy of coping practices for drought preparation

Preparatory practices are implemented prior to drought with the goal of minimizing exposure to impact when the inevitable, yet unpredictable drought occurs. In contrast, response practices are implemented after the onset of drought and the later timing makes them less likely to avoid exposure to the "drought price-squeeze" than preparatory practices (Dunn et al. 2005; NDMC 2013).

Common preparatory practices address demand and supply of forage and water, insurance against a dry future, and developing a "drought plan" (Foran and Stafford Smith 1991; Eakin and Conley 2002; Dunn et al. 2005; Fernandez-Gimenez et al. 2005; Gates et al. 2007; Coles and Scott 2009; Torell et al. 2010; Coppock 2011; NDMC 2013; Tolleson 2013; Webb et al. 2013). Demand-side practices focus on reducing herd size and shifting herd composition toward greater proportions of yearlings to facilitate quick sales without diminishing the number of cows that produce the marketable calves. Supply-side practices include establishing "reserve pastures" that remain ungrazed until drought, regularly monitoring forage conditions, renting additional pastures, purchasing/storing additional feed, and building additional drinking water systems. Drought plans include an element of contingency by describing the timing and coordination of all these practices as drought conditions develop, and an element of strategy by identifying the infrastructure and organization needed to support those contingency-based decisions. As such, developing a drought plan is clearly a preparatory practice.

The PMT model distinguishes response-efficacy from self-efficacy of coping practices to indicate the difference between a good idea in general (response-efficacy) and a good idea that might work for the responding rancher (self-efficacy; Floyd et al. 2000; Grothmann and Reusswig 2006; Stewart 2009). We asked ranchers in southeastern Arizona, USA, to rate the importance of preparatory coping practices for drought as a measure of response-efficacy. In addition, we assume that self-efficacy of practices is indicated by a positive relationship between the importance rating of a practice and the level of increased preparedness, suggesting that increased preparation followed the adoption of those practices (Fig. 1 arrow B).

1.3 Drought threat severity

Rancher's assessment of drought threat severity is expected to represent both the likelihood and intensity of impacts. We suggest that differences in the threat assessment among ranchers can be estimated by their definition of drought, where greater threat is indicted when drought is defined as smaller deficits or shorter duration of dry periods. For example, greater threat is expected for ranchers perceiving an increase in drought frequency and greater sensitivity to timing (Dagel 1997).

We asked ranchers in southeastern Arizona, USA, to identify the deficit and duration criteria for defining drought. We assume that threat severity is greatest for ranchers who define drought when deficits are smallest and duration is shortest, whereas threat severity is lowest for ranchers that require greater deficits and longer duration of deficits before defining drought (Fig. 1 arrow A).

1.4 Context factors affected assessments and preparation

The PMT explicitly recognizes that assessments of threat severity and coping practice efficacy, and the eventual increase in preparedness can be influenced by context factors including financial resources, social norms, age, education, experience, familiarity with practices, recent experience with the hazard, likelihood of third-party assistance, and information sources (Grothmann and Patt 2005; Grothmann and Reusswig 2006; Stewart 2009; Koerth et al. 2013; Le Dang et al. 2014). For example, older ranchers are less alarmed by drought (Dagel 1997) and increased preparedness follows recent exposure to drought (Miller 2005; Coppock 2011). However, age, education, herd size, and length of ranching experience were not related to increased drought preparation by ranchers in Utah,

USA (Coppock 2011). Low satisfaction with information sources is related to low adoption of seasonal weather forecasts among ranchers (Eakin and Conley 2002; Coles and Scott 2009), but low satisfaction may also be related to a reluctance to embrace new information sources (Marshall et al. 2011). Extending beyond drought, a rancher's likelihood to enter into government-sponsored conservation agreements was associated with both personal/social traits related to early-adoption behavior as well and larger ranch size (Lubbell et al. 2013).

We asked ranchers in southeastern Arizona, USA, to report herd size, length of ranching experience, and satisfaction with drought information to represent potential context factors affecting preparedness. We assume that herd size reflects financial resources; length of experience reflects greater familiarity with long-term drought patterns, impacts, and coping practices; and satisfaction with information reflects confidence in applying best practices (Fig. 1 arrows C and D).

1.5 Objectives and expectations

Our objectives are to describe (1) the level of increased drought preparedness among livestock ranchers in southeastern Arizona, USA, (2) the relationship between increased preparedness and the rancher's (a) assessment of coping practice efficacy, (b) assessment of threat severity represented by criteria for defining drought, and (c) context factors of financial resources, ranching experience, and satisfaction with drought management information, and (3) the relationship between the rancher's assessment of coping practice efficacy, assessment of threat severity, and the context factors.

Based on expectations from previous work, we hypothesize that (a) increased preparedness will be positively associated with appraisals of coping practice efficacy and threat severity (Fig. 1 arrows B and A, respectively), and (b) context factors of increased herd size, ranching experience, and satisfaction with drought management information will be related to coping and threat appraisal, but not directly related to increased preparedness (Fig. 1 arrows D and C, respectively). We also hypothesize that the efficacy of coping practices will increase in combination with threat severity and the context factors, given the expectation of interactions and feedback (Fig. 1 arrows A–E).

2 Methods

2.1 Study area and rancher subjects

The study area covered six counties located in southeastern Arizona (Apache, Cochise, Graham, Greenlee, Pima, and Santa Cruz counties). The total economic contribution to cattle production (sales, employment, and spending multipliers) is estimated at $102 M annually (Kerna et al. 2014). Lands used for cattle ranching receive 300–450 mm annual precipitation, with a distinct bimodal pattern of wet winter and summer, and dry spring and fall and 40–60 % of total precipitation arriving in summer (McClaran and Wei 2014). Very severe dry conditions occurred in 2000–2002 when both winter and summers were very dry, and a general dry trend persisted through 2012 (Fig. 2).

Our survey was sent to 243 ranchers who were members in the Arizona Cattle Growers Association (ACGA) which is the leading trade organization for ranchers in Arizona. ACGA is representative of individuals with significant economic interests in ranching, but

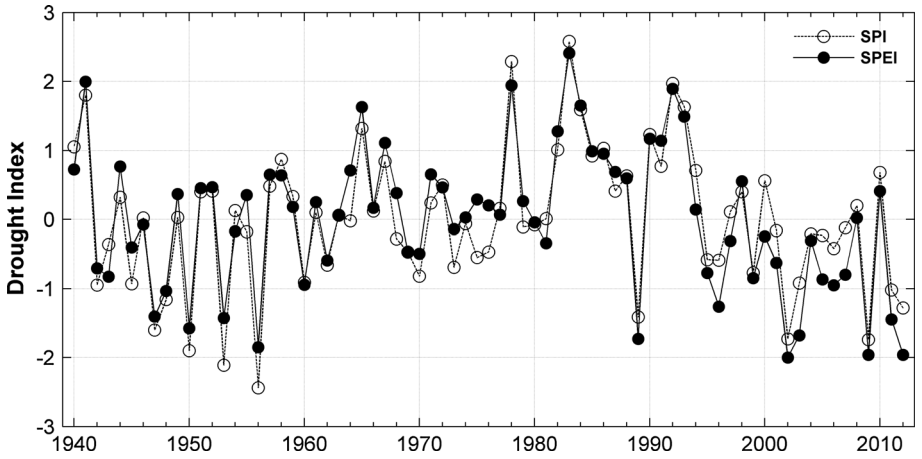

Fig. 2 Yearly values of Standardized Precipitation Index (SPI) and Standardized Precipitation and Evapotranspiration Index (SPEI) for southeastern Arizona, USA, 1940–2012. Values within 31.3° and 33.8° North, and 109.0° and 111.6° East were obtained from PRISM Climate Group (2014) to calculate these indices using online software (SPI from NDMC 2012; and SPEI from Beguería and Vicente-Serrano 2009). Drought conditions persisted in the area during the 10 years before the survey was administered in late 2011. Average SPI and SPEI values for those 10 years were −0.55 and −0.96, respectively

less representative of those with only a small number of cattle. For example, in 2012, the six counties had 1994 beef cattle "farms," but only 631 (32 %) had ≥20 cows and only 327 (16 %) had ≥50 cows (National Agricultural Statistics Service 2014).

2.2 Survey design and questions

The survey was evaluated by experienced ranchers, revised and approved by The University of Arizona Institutional Review Board, before being mailed in November 2011. The tailored design method (Dillman 2000) was used to address validity and reliability. The first contact with ranchers was a personally addressed and signed letter sent several days prior to the survey that described the importance of the survey. The survey was sent with a cover letter and a stamped, self-addressed envelope to return the survey. A follow-up letter and survey were sent to nonrespondents about 2 weeks later. The initial response was 118 completed surveys within 2 weeks of mailings, and the final response was 161 completed surveys for a 70 % return rate.

Survey questions addressed the change in drought preparedness, the importance of 11 coping practices to prepare for drought (measure of practice efficacy), definition of drought deficit and duration (threat severity), and context factors of herd size, ranching experience, and satisfaction with drought management information (Appendix A). Our analysis compressed the original response categories (Butler 2012) to better conform to requirements of logistic regression.

Increased preparedness for drought (no, some, and high categories) was based on the response to the question "Do you feel more prepared for drought now than 10 years ago?" Our no increase category is based on combing answers labeled "no" and "same," our some increase category used the "somewhat" answer, and our high increase category is based on the "yes" answer. Importance of coping practices to prepare for drought asked for

separate ratings of 11 practices, and we report importance in three categories: high, medium, and low. Our high importance category is based on the "very important" response, our medium category used the "important" response, and our low category combines the "somewhat," "slightly" and "not" important responses.

Categories of high and low are used to describe the drought threat severity based on definitions of drought deficit and duration. For deficit, high threat was precipitation <25 % of average (combining <10 and <25 % responses) and low threat was <50 % of average (combining <50 and <75 % responses). For duration, high threat was defined as ≤6 months (combining responses of 1–3 and 4–6 months) and low threat as >6 months (combining responses of 7–12 and >12 months).

Cattle herd size is reported as three categories: large (>200, combining responses of 201–500 and >500), medium (101–200), and small (≤100, combining responses of 51–100 and <50). Ranching experience used two categories: low, defined as <25 years (combining responses of <1, 1–9, and 10–24 years), and high, defined as ≥25 years (combining responses of 25–49, 50–75, and >75 years). Satisfaction with drought management information used two categories: high (combining responses of "very satisfied" and "satisfied") and low (combining responses of "slightly satisfied" and "not satisfied").

2.3 Statistical analyses

We used analysis of variance and Duncan's test for multiple comparisons of weighted mean values to detect differences among the importance ratings of the 11 coping practices, polychoric correlation (Olsson 1979) to describe the relationship in the categories of importance among pairs of coping practices, and Chi-square analyses to assess the relationship between pairs of the five rancher characteristics. Weighted mean values for the importance of coping practices were calculated by applying weights of "1", "2," or "3" to low, medium, and high importance ratings, respectively.

We performed univariate (Chi-square) and multivariate (stepwise logistic regression) analyses (Alllison 2012) to describe the relationship between increased drought preparedness and the importance of the coping practices (practice efficacy), drought threat severity, and the three context factors. The multivariate analyses explored the possibility that a combination of >1 explanatory variables may be related to an increase in preparedness or increased importance of a coping practice. For example, the combination of drought deficit threat assessment and reserve pasture coping practice assessment may be related to the increase in preparedness. For the stepwise logistic regression, the no increased preparedness response served as the reference value for comparison against the likelihood of some and high increase in preparedness responses. Similarly, for the stepwise logistic regression describing the relationships between the importance of coping practices, drought threat severity, and context factors, the low importance response served as the reference value for comparison against the likelihood of medium and high importance responses.

We used SAS software, version 9.4 for Windows (SAS 2013) for all analyses, and $p < 0.05$ for all determinations of significance, $r \geq 0.5$ to describe noteworthy correlations in the importance ratings for coping practices, and $p \leq 0.05$ was the criterion for a variable to enter the stepwise logistic regression. For significant Chi-square relationships, we illustrate the patterns by comparing the actual cell proportions against the expected proportions where the expected is based on the product (multiplication) of the frequency for each member of the pair. For significant logistic regression relationships, we report the

logit equations and describe the likelihood of increased drought preparedness (no vs some, and no vs high) or importance of a coping practice (low vs medium, and low vs high).

Because some respondents did not provide answers to some questions, the sample size varied from 120 to 159 of the possible 161 returned surveys for some analyses. The variable sample size motivated our use of a two-step process to insure that the logistical regression models had the maximum sample size. Step 1 was a stepwise analysis that included all 11 coping practices, the two drought severity definitions, and all three context factors as possible explanatory variables and therefore used the smallest sample size. Step 2 was a logistic regression using only the significant independent variables selected from step 1 and therefore used maximum possible sample size.

3 Results

3.1 Increased preparation for drought

Approximately one-third of ranchers reported no increase in preparation for drought, and the remaining two-thirds were nearly equally split between some (31 %) and the high (37 %) increase in preparation (Table 1).

3.2 Efficacy of coping practices

Rotate grazing and monitor range were rated the most important (highest efficacy) coping practices to prepare for drought, followed by drought plan, reduce herd size, and reserve pastures (Fig. 3). The least important practices were add fence, obtain more pastures, apply for drought insurance, and fire. Importance of only seven pairs of practices had noteworthy correlations ($r \geq 0.5$): rotate grazing with drought plan ($r = 0.68$), with reserve pasture ($r = 0.66$), with monitor ($r = 0.65$), and with fire ($r = 0.50$); monitor with fire ($r = 0.57$) and with drought plan ($r = 0.54$); and add water with add fence ($r = 0.54$). Reduce herd size, the fourth highest rating, did not have a noteworthy correlation with any coping practice.

3.3 Drought threat severity and context factors

Ranchers were about two times more likely to have low than high threat sensitivity to drought deficits and drought duration (Table 1). Small (29 %) and medium (26 %) herd sizes were less frequent than large herds (44 %). Ranching experience was nearly equal for low (49 %) and high (51 %). Seventy-eight percent of ranchers were 50–79 years old, and 10 % were >80 years.

Only one of the three pairs of context factors were related (Table 2). Satisfaction with drought information was negatively related to herd size (χ^2, $p < 0.05$), with greater than expected frequencies for the combination of Low Satisfaction—Large Herd Size (0.17 vs 0.12 expected) and greater than expected frequency for High Satisfaction—Small Herd Size (0.25 vs 0.21 expected).

3.4 Relationships with drought preparation

Using multivariate stepwise logistic regression, only the coping practice of reserve pastures was related to increased preparation. However, when using the separate Chi-square

Table 1 Frequency of responses and pairwise relationships for coping practice efficacy (importance of practice), increased drought preparation, drought threat severity for deficit and duration, and context factors

Coping practice efficacy importance of practices	Increased preparation			Drought threat				Context factors						
				Deficit		Duration		Herd size			Ranching experience		Satisfied with info	
	No	Some	High	Low	High	Low	High	Small	Med	Large	Low	High	Low	High
	0.32	0.31	0.37	0.65	0.35	0.69	0.31	0.29	0.26	0.44	0.49	0.51	0.28	0.72
Rotate grazing														
Low	**0.07**	**0.05**	**0.02**	**0.04**	**0.08**	0.09	0.04	0.06	0.04	0.04	**0.04**	**0.09**	0.06	0.07
Medium	**0.09**	**0.15**	**0.12**	**0.27**	**0.09**	0.24	0.11	0.08	0.07	0.19	**0.13**	**0.21**	0.12	0.21
High	**0.16**	**0.10**	**0.24**	**0.35**	**0.16**	0.36	0.15	0.10	0.17	0.24	**0.30**	**0.22**	0.12	0.41
Range monitor														
Low	0.07	0.04	0.05	0.11	0.06	0.14	0.03	0.02	0.04	0.09	0.07	0.10	0.08	0.09
Medium	0.12	0.11	0.09	0.21	0.10	0.19	0.12	0.08	0.06	0.18	0.15	0.17	0.10	0.21
High	0.13	0.14	0.23	0.33	0.19	0.37	0.15	0.15	0.18	0.20	0.27	0.25	0.11	0.41
Drought plan														
Low	**0.13**	**0.07**	**0.04**	0.14	0.10	0.18	0.06	0.06	0.08	0.11	0.12	0.13	0.10	0.14
Medium	**0.11**	**0.15**	**0.14**	0.27	0.10	0.28	0.10	0.08	0.13	0.18	0.17	0.20	0.11	0.25
High	**0.09**	**0.09**	**0.18**	0.26	0.12	0.24	0.14	0.12	0.08	0.17	0.21	0.17	0.08	0.32
Reduce herd														
Low	0.10	0.05	0.08	0.19	0.05	0.16	0.07	0.06	0.07	0.11	0.13	0.11	0.09	0.15
Medium	0.12	0.17	0.14	0.27	0.15	0.29	0.13	0.10	0.08	0.21	0.22	0.19	0.12	0.29
High	0.11	0.08	0.15	0.21	0.13	0.26	0.09	0.11	0.12	0.13	0.14	0.21	0.08	0.27
Reserve pasture														
Low	**0.14**	**0.14**	**0.07**	0.22	0.12	0.24	0.11	0.08	0.11	0.16	0.12	0.21	0.10	0.23
Medium	**0.13**	**0.08**	**0.13**	0.25	0.11	0.25	0.11	0.11	0.08	0.16	0.18	0.18	0.11	0.23
High	**0.07**	**0.05**	**0.19**	0.23	0.08	0.21	0.09	0.04	0.10	0.17	0.18	0.12	0.07	0.25

Table 1 continued

Coping practice efficacy importance of practices	Increased preparation			Drought threat				Context factors						
				Deficit		Duration		Herd size			Ranching experience		Satisfied with info	
	No 0.32	Some 0.31	High 0.37	Low 0.65	High 0.35	Low 0.69	High 0.31	Small 0.29	Med 0.26	Large 0.44	Low 0.49	High 0.51	Low 0.28	High 0.72
Add drinking water														
Low	0.14	0.14	0.14	0.25	0.17	0.28	0.13	0.12	0.12	0.18	0.19	0.22	0.09	0.32
Medium	0.10	0.10	0.10	0.20	0.09	0.24	0.06	0.06	0.06	0.17	0.14	0.16	0.14	0.15
High	0.08	0.06	0.14	0.23	0.06	0.21	0.08	0.05	0.09	0.15	0.15	0.15	0.08	0.22
Buy feed														
Low	0.14	0.09	0.16	0.25	0.14	0.30	0.10	0.10	0.09	0.20	0.19	0.20	0.10	0.30
Medium	0.11	0.17	0.11	0.27	0.11	0.26	0.12	0.10	0.11	0.17	0.20	0.18	0.12	0.25
High	0.06	0.04	0.12	0.17	0.06	0.15	0.07	0.06	0.06	0.12	0.09	0.13	0.07	0.17
Fire														
Low	0.18	0.17	0.21	0.37	0.19	0.40	0.16	0.16	0.12	0.28	0.22	0.34	0.19	0.37
Medium	0.08	0.06	0.10	0.16	0.08	0.13	0.10	0.07	0.06	0.10	0.13	0.10	0.05	0.19
High	0.03	0.06	0.10	0.15	0.06	0.15	0.06	0.03	0.08	0.10	0.10	0.10	0.07	0.14
Drought insurance														
Low	0.21	0.15	0.20	0.35	0.19	0.43	0.13	**0.18**	**0.17**	**0.19**	0.24	0.30	0.15	0.39
Medium	0.05	0.11	0.08	0.16	0.09	0.15	0.08	**0.04**	**0.05**	**0.17**	0.15	0.10	0.06	0.17
High	0.04	0.05	0.11	0.15	0.06	0.13	0.08	**0.03**	**0.05**	**0.13**	0.10	0.11	0.07	0.15
Rent pastures														
Low	0.19	0.18	0.22	0.42	0.19	0.43	0.19	0.15	0.18	0.29	0.31	0.32	0.19	0.45
Medium	0.11	0.09	0.11	0.19	0.09	0.22	0.06	0.08	0.05	0.15	0.12	0.15	0.07	0.21
High	0.02	0.04	0.05	0.07	0.04	0.07	0.03	0.02	0.04	0.04	0.07	0.03	0.00	0.08

Table 1 continued

Coping practice efficacy importance of practices	Increased preparation			Drought threat				Context factors						
				Deficit		Duration		Herd size			Ranching experience		Satisfied with info	
	No 0.32	Some 0.31	High 0.37	Low 0.65	High 0.35	Low 0.69	High 0.31	Small 0.29	Med 0.26	Large 0.44	Low 0.49	High 0.51	Low 0.28	High 0.72
Add fence														
Low	0.21	0.25	0.24	0.44	0.24	0.46	0.23	0.14	0.19	0.34	0.29	0.39	0.21	0.47
Medium	0.08	0.04	0.08	0.15	0.06	0.17	0.03	0.06	0.08	0.08	0.13	0.08	0.06	0.14
High	0.03	0.03	0.06	0.09	0.02	0.07	0.04	0.03	0.03	0.06	0.04	0.07	0.03	0.09

Bold values indicate significant ($p < 0.05$) differences from the expected distribution using the Chi-square test. Values at the top of each column represent overall frequency for the response

analyses, increased preparation for drought was positively related to the importance of three coping practices (reserve pasture, rotate grazing, and drought plan; Table 1) and negatively related to drought duration severity (Table 2).

The likelihood of having high rather than no increased preparation for drought increased with the importance of reserve pastures, but there was no relationship for the difference between some and no increased preparation (Likelihood Ratio Test, $N = 118$, $p < 0.01$). Ranchers were 2.4 times more likely ($e^{0.87}$) to have high increase in preparation than no increase with each unit increase in the importance of reserve pastures (Eq. 1).

$$\frac{\Pr(\text{High Increased Preparation})}{\Pr(\text{No Increased Preparation})} = e^{0.87 * \text{Reserve Pasture Importance}} \quad (1)$$

The positive relationship between increased preparation and reserve pastures (χ^2, $p < 0.01$) included greater than expected frequencies for combinations of No Increased Preparation—Low Importance (0.14 vs 0.11 expected) and High Increased Preparation—High Importance (0.19 vs 0.12 expected). The positive relationship between increased preparation and rotate grazing (χ^2, $p = 0.03$) included greater than expected frequencies for combinations of No Increased Preparation—Low Importance (0.07 vs 0.04 expected), Some Increased Preparation—Medium Importance (0.15 vs 0.11 expected), and High

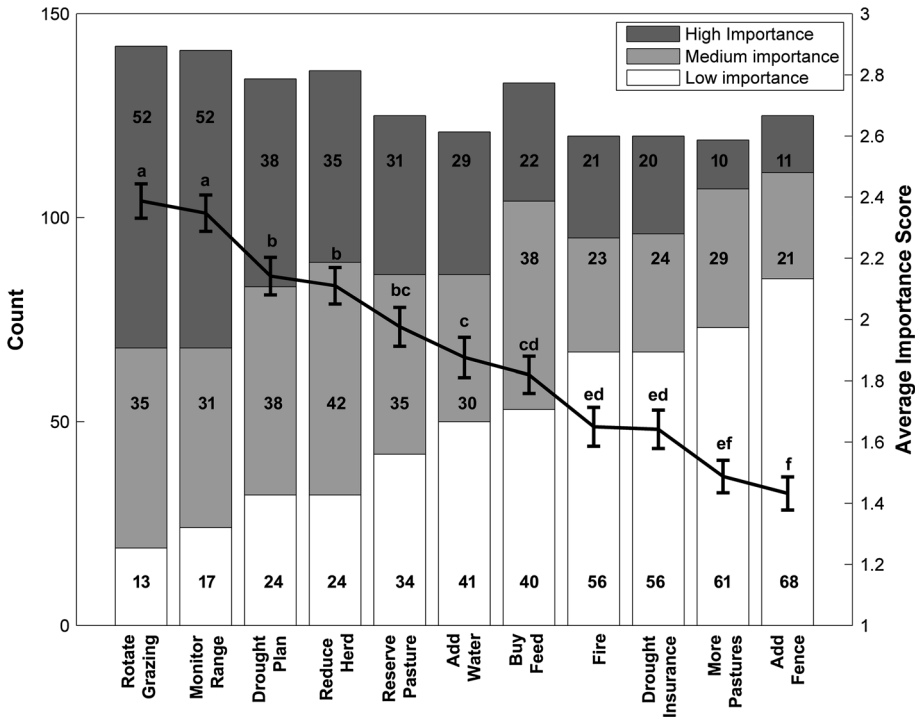

Fig. 3 Count and weighted average importance for 11 coping practices to prepare for drought. Values within columns show the proportion of responses in the *High, Medium* and *Low Importance categories*. Weighting values were "1", "2," or "3" to Low, Medium, and High Importance, respectively. Vertical bars represent ± SE around each mean value, and *different letters* above the mean value indicate differences at $p \leq 0.05$

Table 2 Frequency of responses and pairwise relationships among increased preparation for drought, drought threat severity for deficit and duration, and context factors

	Increased preparation			Drought threat				Context factors				
				Deficit		Duration		Herd size			Ranching experience	
	No	Some	High	Low	High	Low	High	Small	Med	Large	Low	High
	0.32	0.31	0.37	0.65	0.35	0.69	0.31	0.29	0.26	0.44	0.49	0.51
Deficit sensitivity												
Low 0.65	0.18	0.20	0.25									
High 0.35	0.12	0.11	0.13									
Duration sensitivity												
Low 0.69	**0.17**	**0.21**	**0.30**	0.45	0.23							
High 0.31	**0.14**	**0.10**	**0.08**	0.19	0.12							
Herd size												
Small 0.29	0.10	0.09	0.09	0.15	0.14	0.21	0.09					
Medium 0.26	0.10	0.09	0.08	0.19	0.07	0.19	0.07					
Large 0.44	0.12	0.12	0.21	0.30	0.15	0.29	0.15					
Ranching experience												
Low 0.49	0.17	0.13	0.16	0.31	0.18	0.30	0.19	0.16	0.12	0.21		
High 0.51	0.11	0.10	0.06	0.18	0.11	0.19	0.09	0.04	0.06	0.17		
Satisfied with Info												
Low 0.28	0.11	0.10	0.06	0.18	0.11	0.19	0.09	**0.04**	**0.06**	**0.17**	0.11	0.17
High 0.72	0.22	0.20	0.30	0.47	0.25	0.51	0.21	**0.25**	**0.20**	**0.28**	0.39	0.33

Bold values indicate significant ($p < 0.05$) differences from the expected distribution using the Chi-square test. Values at the top of each column and the far left cell in each row represent overall frequency for the response

Increased Preparation—High Importance (0.24 vs 0.19 expected). The positive relationship between increased preparation and drought plan (χ^2, $p < 0.02$) included greater than expected frequencies for combinations of No Increased Preparation—Low Importance (0.13 vs 0.08 expected), Some Increased Preparation—Medium Importance (0.15 vs 0.12 expected), and High Increased Preparation—High Importance (0.18 vs 0.13 expected). Threat severity of drought duration was negatively related to increased drought preparation (χ^2, $p < 0.05$). Greater than expected frequencies occurred for combinations of High Severity—No Increased Preparation (0.14 vs 0.10 expected) and Low Severity—High Increased Preparation (0.30 vs 0.26 expected), and the converse lower than expected frequencies for High Severity—High increased Preparation (0.08 vs 0.12 expected) and Low Severity—No Increased Preparation (0.17 vs 0.21 expected).

3.5 Relationships between coping practices, threat severity, and context factors

Using multivariate stepwise logistic regression, rotate grazing was the only practice related (negatively) to drought threat severity (Likelihood Ratio Test, $N = 136$, $p = 0.01$), and drought insurance was the only practice related to the context variable of herd size (Likelihood Ratio Test, $N = 114$, $p < 0.01$). However, when using the separate Chi-square analyses, the practice of rotate grazing was negatively related to both threat severity of drought deficit and ranching experience, but herd size remained as the only context variable related to the coping practice of obtaining drought insurance (Table 1).

Ranchers reporting high drought deficit severity were 4.0 times less likely ($1/e^{-1.39}$) to place high than low importance, and 5.6 times less likely ($1/e^{-1.73}$) to place medium than low importance on rotate grazing (Eqs. 2 and 3).

$$\frac{\Pr(\text{Medium Importance of rotational grazing})}{\Pr(\text{Low Importance of rotational grazing})} = e^{-1.73*\text{Drought Deficit}} \tag{2}$$

$$\frac{\Pr(\text{High Importance of rotational grazing})}{\Pr(\text{Low Importance of rotational grazing})} = e^{-1.39*\text{Drought Deficit}} \tag{3}$$

The negative relationship between rotate grazing and sensitivity to drought deficits (χ^2, $p = 0.01$) included greater than expected frequencies for combinations of Low Importance—High Sensitivity (0.08 vs 0.04 expected) and Medium Importance—Low Sensitivity (0.27 vs 0.24 expected). The negative relationship between rotate grazing and ranching experience (χ^2, $p = 0.05$) included greater than expected frequency of High Importance—Less Experience (0.30 vs 0.25 expected).

For each unit increase in herd size (Small to Medium, and Medium to Large), ranchers were 2.1 times more likely ($e^{0.75}$) to place high than low importance, and 2.2 times more likely ($e^{0.78}$) to place medium than low importance on the coping practice of obtaining drought insurance (Eqs. 4 and 5).

$$\frac{\Pr(\text{Medium Importance of drought insurance})}{\Pr(\text{Low Importance of drought insurance})} = e^{0.78*\text{Herd Size}} \tag{4}$$

$$\frac{\Pr(\text{High Importance of drought insurance})}{\Pr(\text{Low Importance of drought insurance})} = e^{0.75*\text{Herd Size}} \tag{5}$$

The positive relationship between the importance of obtaining drought insurance and herd size (χ^2, $p = 0.04$) included greater than expected frequencies for combinations of High Importance—Large Herd (0.13 vs 0.10 expected) and Medium Importance—Large Herd (0.17 vs 0.12 expected).

4 Discussion

After experiencing dry conditions for 10 years, about two-thirds of ranchers in southeastern Arizona, USA, reported increased preparation for drought, and 37 % of ranchers reported a high increase in preparedness. This is greater than the doubling of increased preparedness by ranchers in Utah, USA (14–29 %) following a 5-year drought (Coppock 2011).

The five most important coping practices to prepare for drought were rotate grazing among pastures, monitor range forage conditions, prepare a drought plan, reduce herd size, and establish reserve pastures. These ratings are consistent with earlier work in the area (Eakin and Conley 2002; Coles and Scott 2009).

Ranchers expressed extraordinarily low threat severity to dry conditions based on their definition of drought. For about 45 % of ranchers, declaring a drought required a precipitation deficit of >50 % below average that persisted for ≥7 months to define drought. Separately, about two-thirds of ranchers required a >50 % deficit and two-thirds required a ≥7-month duration to define drought. Their joint probability is the simple product of each because deficit and duration were not related. This combination of deficit and duration criteria occurred in about 10 % of years in the historic record but have become more common since 1996 (McClaran and Wei 2014).

4.1 Protection motivation theory and increased preparation

The PMT model provided the framework (Fig. 1) to develop hypotheses about the relationship between increased preparedness and the driving variables of coping practice appraisal, threat severity appraisal, and context factors. Consistent with our hypothesis, the efficacy of three coping practices was positively related to increased preparation for future droughts (Fig. 1 arrow B), and there was no direct relationship between context factors and increased preparedness. Contrary to our hypotheses, we found a negative rather than positive relationship between increased preparation and drought threat severity (Fig. 1 arrow A reversed). In addition, we found no support for the hypothesis that preparation will increase with combinations of coping practices or coping practices with threat severity (Fig. 1 arrows A–C) because no multivariate analyses included more than a single coping practice (reserve pasture) to predict increased preparation. Similarly, we found no support in the multivariate analyses that combinations of context factors and coping practice appraisals will affect increased preparation (Fig. 1 arrows B and D), even though two context factors (ranching experience and herd size) were related to the appraisal of two coping practices (rotate grazing and drought insurance).

4.1.1 Coping practice efficacy

The coping practice of reserve pastures provided the most parsimonious positive relationship with increased drought preparation (Fig. 1 arrow B) based on the stepwise logistic regression, where each unit increase in the importance of reserve pastures resulted in a 2.4

times greater likelihood that ranchers would have high rather than no increased preparation for future droughts. This is consistent with the suggestion that coping appraisals are more strongly related to increased preparation than threat appraisals (Floyd et al. 2000). Correlations among the importance of reserve pasture, rotate grazing, and drought plan likely prevented the practices of rotate pastures and drought plan from being included in the multivariate analysis, even though all were positively related to increased preparation using the univariate Chi-square test. Reserve pastures provide emergency feed options during drought, but also require commensurate reductions in herd size and capability to rotate herds among pastures. These practices have been popular among ranchers in southeastern Arizona, USA, where year-round grazing is possible (Eakin and Conley 2002; Coles and Scott 2009), but reserve pastures may not be practical in colder locations where severe winters limit carryover of forage from previous growing seasons.

The importance of a drought plan, despite not being included in the multivariate model, may illustrate the most fundamental cognitive connection with increased preparedness. A drought plan by definition recognizes the eventuality of drought and establishes practices for diminishing drought impacts. Proponents of drought plans emphasize the combination of continual ongoing activities to prepare infrastructure (e.g., drinking water facilities and reserve pastures), adjust herd composition, and monitor conditions, along with contingency plans to rotate grazing and reduce herds as drought conditions develop (Dunn et al. 2005; Bastian et al. 2006; Gates et al. 2007; NDMC 2013; Tolleson 2013).

We can distinguish between response-efficacy and self-efficacy of practices because only three (reserve pastures, rotate grazing, and drought plan) of the five most important practices were related to increased preparation (Floyd et al. 2000; Grothmann and Reusswig 2006; Stewart 2009). Only response-efficacy is suggested for coping practices of monitoring range conditions and reducing herd size because their high importance was not coupled with a positive relationship with increased preparation. In southeastern Arizona, USA, the importance of monitoring range conditions is likely associated with high adoption rates following an effective cooperative extension program, which increased the self-awareness and self-protective behavior of Arizona ranchers (Fernandez-Gimenez et al. 2005).

4.1.2 Threat severity

Unexpectedly, there was a negative relationship between perceived threat severity and increased preparedness (Fig. 1 arrow A reversed). If, as we assumed, increased threat severity is indicated by a drought definition that requires a smaller deficit and shorter duration of dryness, then the relationship should have been positive. Alternatively, we may be reporting a threat–preparedness feedback relationship that developed after adjustments had been made (Grothmann and Reusswig 2006) rather than observing a situation where threat severity served as the motivation "energy" during the cognitive process of being motivated into action (Grothmann and Patt 2005). If this represents feedback, then ranchers reporting increased preparation over the past 10 years have likely applied practices that reduced the threat of drought, and they now feel buffered from all but the most extreme dry conditions. In fact, we found one such negative relationship between threat severity and the importance of the rotate grazing practice.

This interpretation draws on the interactive cognitive processing of threat severity and coping practice efficacy assessments (Grothmann and Patt 2005; Grothmann and Reusswig 2006; Stewart 2009). In addition, the interpretation recognizes the importance of timing, where threat assessments at the beginning of a drought may positively influence efficacy

assessments, but threat assessments far into or after a drought may be affected by the recent application of coping practices. A "distancing" coping behavior (Stewart 2009) may explain the insensitivity to dryness (based on drought definitions), but this is not consistent with the increased level of preparedness for those with decreasing sensitivity to dryness.

4.1.3 Context factors

The absence of any direct relationship between increased preparedness and the context factors of herd size, length of ranching experience, and satisfaction with drought information is not surprising in light of similar findings on increased preparedness for a variety of natural hazards (Grothmann and Patt 2005; Grothmann and Reusswig 2006; Stewart 2009; Koerth et al. 2013). This general pattern gives strong support for the more fundamental role of the cognitive processing of threat and coping appraisals to increase preparation rather than resource availability and experience (Grothmann and Patt 2005; Stewart 2009). In addition, we did not find a relationship between risk assessments (deficit and duration severities) and any context factor. The sampling bias resulting from limiting respondents to members of the ACGA may have prevented the detection of some relationships because small herd size was underrepresented. However, our findings are fully consistent with no association between increased drought preparedness and herd size or ranching experience of ranchers in Utah, USA, but preparedness was positively related to assessments of threat severity among those ranchers (Coppock 2011).

We did find two context factors related to coping practices (Fig. 1 arrow D): Herd size was positively related to drought insurance, and ranching experience was negatively related to rotate grazing. Overall, drought insurance was not considered an effective strategy for drought preparedness by ranchers in our study, and only 38 % of ranchers in Utah, USA, were purchasing feed insurance (Coppock 2011). However, we found that larger ranches reported greater importance for insurance, but only 30 % of large ranches gave a "high" importance rating, while 43 % gave a "low" rating. The higher rating by larger ranches may indicate a greater vulnerability given the larger exposure as well as greater resources to invest in insurance. Interestingly, larger ranchers were less satisfied with drought information which suggests that a greater sense of uncertainty may motivate the importance of insurance. Higher importance of rotate grazing by less experienced ranchers may reflect a broader pattern of high adoption across the USA because the practice increases flexibility to address the site-specific challenges of spatial and temporal distribution of forage and water resources (Briske et al. 2011).

4.2 Reducing herd size and adding drinking water

Reducing herd size and adding drinking water locations received relatively high ratings for response efficacy (35 and 29 % high importance, respectively) to prepare for drought, but were not identified as having self-efficacy given the lack of a relationship with increased preparation for drought. One reason for differences between response-efficacy and self-efficacy is illustrated by Australian ranchers' views that herd reduction would be highly effective at preparing for potentially drier conditions, but it is not feasible because it decreased flexibility to respond to business opportunities (Webb et al. 2013).

For ranchers in southeastern Arizona, USA, concern about public land grazing policies may explain the difference between response-efficacy and self-efficacy. Over 80 % of the ranchers rely on leases with federal or state land management agencies for access to rain-fed forage. Concern that a reduced herd size would be codified as a permanent reduction in

the lease (Bartlett et al. 2002; Eakin and Conley 2002) may limit self-efficacy of this practice. Similarly, self-efficacy of adding drinking water locations may be limited by the lengthy permitting process required by government policies.

4.3 Education and assistance programs

Using the PMT model to understand increased preparation for drought as an iterative cognitive process of assessing threats and coping strategies provides a fruitful framework for guiding education and assistance programs for livestock ranchers. In contrast to a prescriptive approach such as the drought risk analysis (Hayes et al. 2004), a PMT-based analysis identifies the drivers leading to increased preparedness and how those drivers differ among members of the ranching community. Specifically, the PMT results distinguish between response-efficacy and self-efficacy of coping practices, as well as the feedback between threat assessments and practice efficacy, and threat and increased preparedness.

Drought planning should be a valuable component of education and assistance programs especially given the clear self-efficacy associated with increased preparedness. Drought planning has been advanced as being fundamental to drought preparedness for ranchers (Dunn et al. 2005; Gates et al. 2007; NDMC 2013; Tolleson 2013). Our results suggest clear connections among the importance of the three self-effective practices of drought plan, reserve pasture, and rotation among pastures. Therefore, delivery of programs on drought planning should stress the integration of establishing the contingency triggers for making changes and the necessary infrastructure and organizational capabilities to support those decisions.

Some programs might target select audiences by recognizing the heterogeneity of concerns and priorities (Marshall and Smajgl 2013). Improving the quality and quantity of drought information sources appears to be a greater concern for larger ranches. Similarly, programs related to drought insurance would be directed to larger ranchers. Programs for ranches dependent on leases with public land agencies for access to forage would do well to expand the audience to include employees of those agencies because of their direct role in approving practices and indirect role by constraining the ranchers' assessment of practice efficacy.

Successful cooperative extension programs raised the understanding, support, and practice of performing regular range monitoring in Arizona, USA, among ranchers as well as land management agencies (Fernandez-Gimenez et al. 2005). Given that success, cooperative extension is a promising candidate to lead an education and assistance program to increase drought preparedness for livestock production on rain-fed rangelands in Arizona, USA.

4.4 Confirmation and additional measures of preparation

Our understanding of the cognitive process leading to increased preparedness among ranchers can be improved by measuring the actual application of coping practices rather than the "importance" of practices. The positive relationship between applying practices and feelings of increased preparedness among ranchers in Utah, USA (Coppock 2011) lends support to the assumption that our measure of importance may be related to application of practices. However, our assumption should be confirmed by assessing whether practices identified as self-effective were more frequently applied by ranchers who felt

more prepared for drought and that those response-effective practices were applied as frequently by more prepared ranchers as ranchers that were not more prepared.

Future efforts to confirm that feelings of increased preparation were associated with less impact from the next drought would provide compelling substantiation for those feelings, and for the efficacy of coping practices. Moreover, those investigations could add a measure of satisfaction with current preparation along with levels of increased preparation. This new variable provides analysis of threats, efficacy, and outcomes among a matrix of two measures of preparedness: increased in 10 years (less, same, more) and satisfaction with preparedness (yes, no). Including a measure of current satisfaction accounts for those ranchers who responded as not more prepared in the last 10 years because they already felt prepared 10 years ago.

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