Annual Report for Award Number NA14OAR4310242
17 June 2015

Using a co-development process to improve, integrate and encourage use of drought information and adaptive management of livestock grazing on National Forests

Funded by National Oceanic and Atmospheric Administration, Climate Program Office FY 2014 Funding Opportunity NOAA-OAR-CPO-2014-2003692, and specifically addressing the CSI-SARP: Coping with Drought Initiative in support of the National Integrated Drought Information System (NIDIS).

Prepared by

Principal Investigator:
Mitchel P. McClaran, University of Arizona, School of Natural Resources and the Environment, Biological Sciences East Building #43, Tucson AZ 85721, 520-621-1673, mcclaran@u.arizona.edu

Submitted to

Program Officer:
Nancy Beller, NOAA, OAR Climate Program Office (CPO)
nancy.beller-simms@noaa.gov

Annual Report 2014-15

Starting in August 2014 through May 2015, we accomplished all aspects of the work proposed for that period, and we are prepared to complete the activities and outputs in year 2 of the project.

Graduate Student Kelsey Hawkes and Research Scientist Julie Brugger were hired in August 2014 and are continue to make significant contributions to the project.

In August 2014, all parties from Tonto National Forest and leaders in the Gila County Cattle Growers were successfully engaged to set the date for the first Workshop scheduled for March 2015.

In September through November 2014, a survey was developed by Brugger and McClaran to solicit input from Tonto National Forest District Rangers and their Range Management Staff (n=10) and all ranchers with permits to graze livestock on the Tonto National Forest (n=70). The pre-survey letter and survey were mailed to participants in December 2014. We had a 58% response rate through by the end of January 2014. The survey covered a variety of subjects including assessment of drought threat, activities to prepare and respond to drought, use of drought and climate information sources, familiarity with Forest Service land management policies, and demographic characteristics. See Appendix 1 for survey results.

The survey responses were critical to

1) Selecting participants for the 3 planned workshops,
2) Designing the content and activities for Workshop 1 in March 2014, and
3) Establishing the initial conditions to evaluate the success of our project.

In March 2014, 20 ranchers with grazing permits, 9 Tonto National Forest District Rangers and Range Management Staff, and 4 Tonto National Forest staff from the Supervisors office were invited to the first of three planned Workshops. Each of the invitees were interviewed between January and March 2015. The interviews covered the same topics as the survey, but allowed interviewees to provide more in-depth responses. Like the survey, the interviews were critical in 1) Designing the content and activities for Workshop 1 in March 2014, and 2) Establishing the initial conditions to evaluate the success of our project. The interviews have been transcribed and are being coded for content.

Seventeen ranchers and 11 Tonto National Forest employees attended Workshop I. The workshop provided participants with: 1) an overview of the project; 2) an introduction to basic drought science and drought decision support tools; 3) an introduction to FS livestock management policy related to drought; and 4) an introduction to scenarios and contingency planning. Speakers included member of the project team from the University of Arizona, Mike

Hayes from the National Drought Mitigation Center, and Judith Dyess from Region 3 Headquarters of the US Forest Service.

Overall, the workshop met its intended goals to introduce participants to each other and to the objectives of the project, provide them basic information on background policy conditions and existing decision support tools, and begin the process of identifying common goals. An analysis of transcriptions, workshop notes, and an evaluation survey indicate that significant progress was made in eliciting new ideas to support collaborative drought monitoring and management on the Tonto National Forest and providing the research team with information that will contribute to the scenario planning exercises during Workshop II. See Appendix 2 for the Workshop I Report which was mailed to all invited participants, and Appendix 3 for the text of an article to be published in the Drought Scape newsletter from the National Drought Mitigation Center.

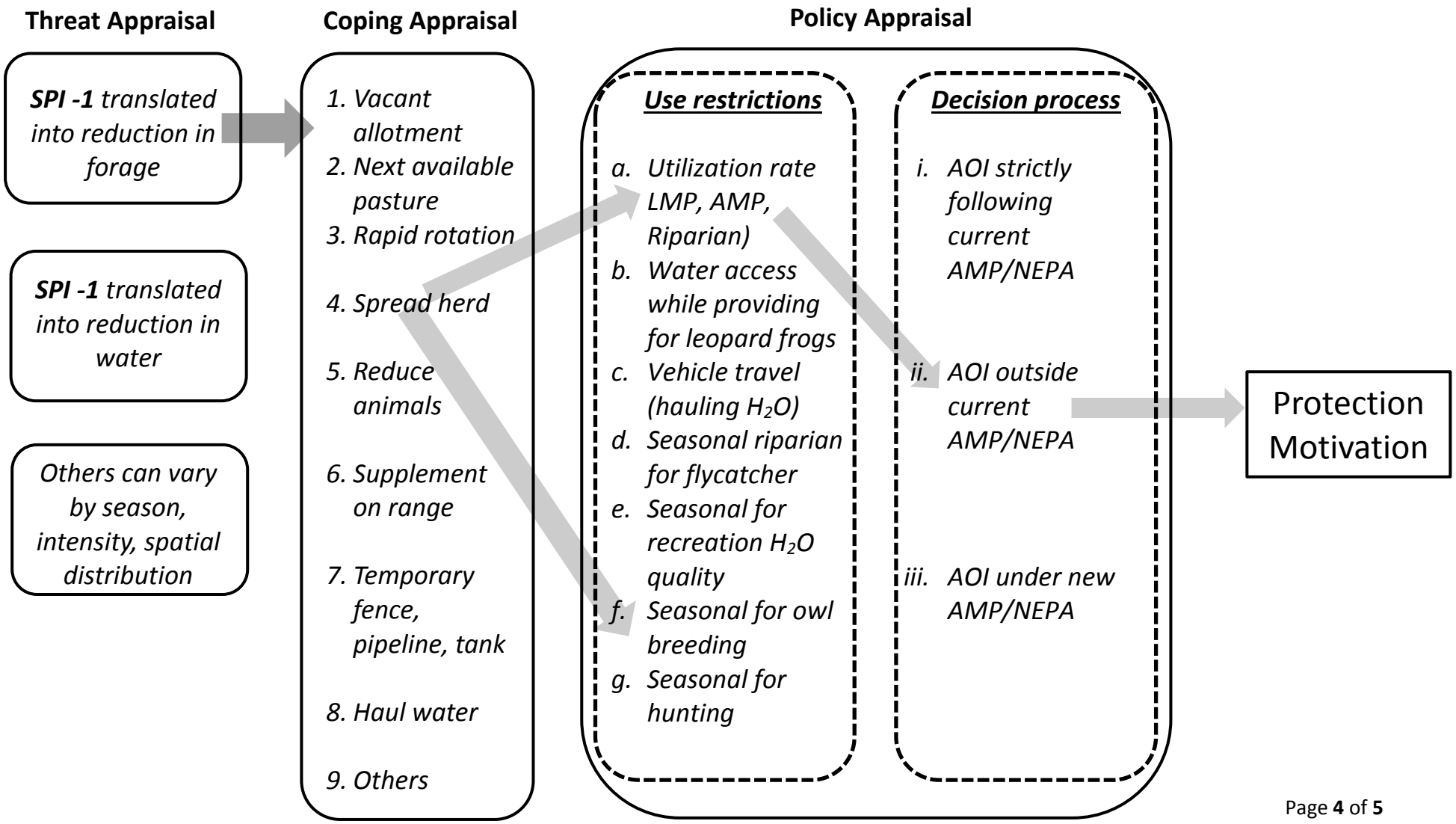
Beginning in April and continuing to the present, we have been making preparations for the second Workshop. It is scheduled for 27 August 2015 in Payson, Arizona. The preparations include the development of a decision-support tool to help participants work through the challenges of different drought scenarios. The scenarios include the impacts from drought as well as the constraints from land management policies established by the National Forest.

We are using the cognitive model of Protection Motivation Theory to frame the structure of the scenarios and decision-processes. See Appendix 4 McClaran et al. *in press* for example of Protection Motivation Theory being applied ranchers increasing their preparation for drought conditions.

Specifically, we are combining the threat and coping assessments typical of Protection Motivation Theory, and adding the administrative constraints of Use Restrictions and Decision Processes to help design the scenarios and the discussions in the second Workshop (Figure 1).

We are optimistic about the success of the scenario activities in the second Workshop to stimulate serious commitment between ranchers and Tonto National Forest to increase preparation for drought well ahead of the next inevitable, yet unpredictable drought. We are poised to adjust the structure and timing of the third/final Workshop based on the evaluations provided by participants in the second Workshop.

Figure 1. Developing scenario activities using the Threat, Coping and Policy Appraisal Processes expected to lead to increased Protection Motivation for livestock management during drought on National Forest lands. Gray arrows show possible solution to increasing preparation for future drought conditions.



Appendix 1 Survey Results.
Appendix 2 Workshop I Report
Appendix 3 Drought Scape newsletter published by the National Drought Mitigation Center
Appendix 4 McClaran et al. *in press*

Perceptions of Drought Survey – Summary of Responses

*values in tables represent percentages of responses; Rancher (n=36), USFS (n=11)

A. These questions ask about how you perceive the risk of drought, how you respond to and prepare for drought, and what drought information you use.

a. Risk of drought

1. Drought is the biggest risk to the success of my livestock operation (ranchers) or successful management of livestock grazing in Tonto NF (USFS).

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	22%	42%	33%	3%	0%
USFS	9%	46%	27%	0%	18%

2. Summer drought presents greater risk to my operation (ranchers) or to livestock grazing in Tonto National Forest (USFS) than winter drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	11%	50%	31%	3%	6%
USFS	18%	9%	36%	9%	27%

3. List up to four factors that create risk for managing livestock grazing in Tonto National Forest in order of importance, with the most important first.

	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Rancher	Forest Service	Drought	Federal Regulations	Public User Behavior	Drinking Water Reliability
USFS	Drinking Water Reliability & Poor Livestock Mgmt (equally ranked)		Drought	Poor Infrastructure and Vegetation	Climate Change

4. In the last 10 years, how much has drought affected livestock grazing in Tonto National Forest?

	Extremely	Strongly	Moderately	Slightly	Not at all
Rancher	22%	44%	25%	8%	0%
USFS	9%	72%	9%	9%	0%

5. In the last 10 years, how has the risk of drought changed?

	Increased Significantly	Increased Somewhat	Not Changed	Decreased Somewhat	Decreased Significantly
Rancher	8%	39%	45%	8%	0%
USFS	9%	82%	9%	0%	0%

6. In the next 10 years, how do you think the risk of drought will change?

	Increase Significantly	Increase Somewhat	Not Change	Decrease Somewhat	Decrease Significantly
Rancher	3%	37%	37%	23%	0%
USFS	27%	64%	9%	0%	0%

b. Strategies for responding to and preparing for drought

7. List 3 management practices that you find to be most effective in **responding to** drought.

	Rank 1	Rank 2	Rank 3	Rank 4
Rancher	Livestock Water	Livestock Distribution & Rotation	Reduce Livestock	Reserve Pastures
USFS	Reduce Livestock	Livestock Water	Livestock Distribution & Rotation	Improve Vegetation

Perceptions of Drought Survey – Summary of Responses

*values in tables represent percentages of responses; Rancher (n=36), USFS (n=11)

8. I have a sufficient variety of practices to **respond to** drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	14%	54%	23%	0%	9%
USFS	9%	64%	18%	0%	9%

9. I would like to learn new ways to **respond to** drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	24%	71%	3%	0%	3%
USFS	46%	55%	0%	0%	0%

10. List 3 management practices that you find to be most effective in **preparing for** drought.

	Rank 1	Rank 2	Rank 3	Rank 4
Rancher	Livestock Water	Livestock Distribution & Rotation	Reduce Livestock	Improve Vegetation
USFS	Reduce Livestock	Livestock Water	Livestock Distribution & Rotation	Improve Vegetation

11. I have a sufficient variety of practices to **prepare for** drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	56%	16%	9%	13%
USFS	0%	46%	27%	9%	18%

12. I would like to learn new ways to **prepare for** drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	24%	73%	0%	0%	3%
USFS	36%	64%	0%	0%	0%

c. Preparedness for drought

13. I am prepared for drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	59%	24%	3%	9%
USFS	0%	36%	18%	9%	36%

14. Compared to 10 years ago, I am more prepared for drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	18%	65%	12%	0%	6%
USFS	0%	64%	9%	0%	27%

15. If you are more prepared than 10 years ago, what are the two most important things that increased your preparedness for drought?

	Rank 1	Rank 2	Rank 3
Rancher	Livestock Water	Livestock Distribution & Rotation	Reduced Livestock
USFS	Improved Knowledge and Experience	Livestock Water, Reduce Livestock, Improve Vegetation, Adaptive Management, Improved Forecasts, EQIP projects (equally ranked)	

16. If you are less prepared than 10 years ago, what are the two most important things that decreased your preparedness for drought?

	Rank 1	Rank 2	Rank 3
Rancher	Livestock Water (N=4)	Lack of weather predictions (N=1)	Federal Regulations (N=1)
USFS	N=0	N=0	N=0

17. I would like to increase my preparedness for drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	29%	62%	3%	3%	3%
USFS	36%	64%	0%	0%	0%

18. Having a drought management plan would make me feel more prepared for drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	18%	56%	15%	0%	11%
USFS	27%	73%	0%	0%	0%

19. I have a drought management plan for my ranch (ranchers) or There is a drought management plan for the Tonto National Forest (USFS).

	Yes	No
Rancher	57%	43%
USFS	78%	22%

d. Use of drought information

Drought **monitoring** information describes current conditions and drought **forecasting** information describes potential future conditions. Drought **monitoring** information can include drought status maps like the U.S. Drought Monitor, web tools available at Drought.gov, newsletters like the Southwest Climate Outlook, news reports, trade publications, and observations by friends, family, and neighbors. Drought **forecasting** information can include forecast maps produced by the NOAA Climate Prediction Center (seasonal climate outlooks), news reports through the newspaper or television like The Weather Channel, outlooks produced by the Farmer's Almanac, and conversations with friends, family, and neighbors.

i. Drought monitoring information

20. How often do you consult the U.S. Drought Monitor to monitor drought conditions in your area?

	Weekly	Monthly	At least once a year	Never
Rancher	14%	17%	25%	44%
USFS	9%	64%	0%	27%

21. List the top three information sources you use to **monitor** drought.

	Rank 1	Rank 2	Rank 3	Rank 4
Rancher	On the Ground Conditions	NOAA (including Drought Monitor)	Television	Cattle industry
USFS	NOAA (including Drought Monitor)	On the Ground Conditions	Forest Service	Southwest Climate Outlook

Perceptions of Drought Survey – Summary of Responses

*values in tables represent percentages of responses; Rancher (n=36), USFS (n=11)

22. I would like more **monitoring** information than these sources provide.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	12%	58%	18%	0%	12%
USFS	0%	64%	9%	0%	27%

23. I use my own collection of precipitation information

	together with other drought **monitoring** information.	in place of other drought **monitoring** information.	I do not use my precipitation information for drought **monitoring**.	I do not collect precipitation information.
Rancher	54%	26%	9%	11%
USFS	54%	0%	0%	46%

24. I use range vegetation measurements to **monitor** drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	31%	61%	8%	0%	0%
USFS	9%	82%	0%	0%	9%

25. I use one or more drought **monitoring** information sources to make management decisions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	14%	67%	17%	0%	3%
USFS	46%	36%	9%	0%	9%

26. I have sufficient information to make management decisions without using drought **monitoring** information.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	31%	44%	8%	11%
USFS	0%	0%	40%	50%	10%

27. I use drought **monitoring** information to improve my **response** to drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	11%	53%	25%	0%	11%
USFS	18%	64%	0%	0%	18%

28. I use drought **monitoring** information to improve my **preparation** for drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	14%	56%	22%	0%	8%
USFS	18%	55%	18%	0%	9%

29. My use of drought **monitoring** information is limited by the time I have available.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	47%	32%	3%	15%
USFS	18%	46%	18%	9%	9%

Perceptions of Drought Survey – Summary of Responses

*values in tables represent percentages of responses; Rancher (n=36), USFS (n=11)

i. Drought forecasting information

30. How often do you consult the NOAA Climate Prediction Center Seasonal Drought Outlook to **forecast** drought conditions in your area?

	Weekly	Monthly	At least once a year	Never
Rancher	9%	17%	29%	46%
USFS	0%	64%	9%	27%

31. List the top three information sources you use to **forecast** drought.

	Rank 1	Rank 2	Rank 3	Rank 4
Rancher	NOAA (including Seasonal Drought Outlook)	Television	On the Ground Conditions	Cattle industry
USFS	NOAA (including Seasonal Drought Outlook)	Television	Forest Service	On the Ground Conditions

32. I would like more **forecasting** information than these sources provide.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	57%	23%	0%	11%
USFS	10%	60%	20%	0%	10%

33. I use one or more drought **forecasting** information sources to make management decisions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	57%	34%	0%	3%
USFS	30%	40%	20%	0%	10%

34. I have sufficient information to make management decisions without using drought **forecasting** information.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	23%	49%	11%	9%
USFS	0%	10%	60%	20%	10%

35. I use drought **forecasting** information to improve my **response** to drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	49%	31%	0%	11%
USFS	20%	50%	20%	0%	10%

36. I use drought **forecasting** information to improve my **preparation** for drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	59%	29%	0%	3%
USFS	10%	70%	10%	0%	10%

37. My use of drought **forecasting** information is limited by the time I have available.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	29%	44%	6%	15%
USFS	20%	40%	20%	10%	10%

e. Use of new information

38. I am likely to use the newest technology and information to make livestock management decisions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	23%	40%	20%	3%	14%
USFS	20%	40%	10%	0%	30%

39. My peers and close associates are likely to use the newest technology and information to make livestock management decisions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	30%	33%	9%	21%
USFS	0%	50%	20%	10%	20%

40. I encourage others to use the newest technology and information to make livestock management decisions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	12%	47%	24%	0%	18%
USFS	20%	60%	10%	0%	10%

B. These questions ask about how well you think drought information fits your needs.

41. It is easy for me to understand drought **monitoring** information.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	46%	40%	0%	9%
USFS	20%	40%	10%	0%	30%

42. The drought **monitoring** information I use does a good job of representing the conditions in my area.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	34%	43%	0%	17%
USFS	0%	40%	10%	10%	40%

43. Range vegetation **monitoring** data is all that I need to monitor drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	14%	66%	6%	11%
USFS	0%	0%	60%	30%	10%

44. The precipitation information I collect provides a better characterization of local drought conditions than other drought **monitoring** information.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided	I do not collect precipitation information
Rancher	17%	64%	8%	3%	8%	0%
USFS	0%	20%	30%	10%	0%	40%

45. I need drought **monitoring** information that describes differences in drought conditions **among** grazing allotments in Tonto National Forest.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	8%	53%	28%	0%	11%
USFS	30%	40%	20%	0%	10%

Perceptions of Drought Survey – Summary of Responses

*values in tables represent percentages of responses; Rancher (n=36), USFS (n=11)

46. I need drought **monitoring** information that describes differences in drought conditions **within** a grazing allotment in Tonto National Forest.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	63%	23%	0%	9%
USFS	20%	60%	10%	0%	10%

47. I need drought **monitoring** information that can distinguish between winter and summer drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	17%	71%	9%	0%	3%
USFS	50%	40%	0%	0%	10%

48. It is easy for me to understand drought **forecasting** information.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	56%	22%	6%	11%
USFS	10%	40%	20%	0%	30%

49. In my experience, drought **forecasts** for the Tonto National Forest are accurate _____ percent of the time. *Fill in the blank.*

	25-30% accuracy	*40-45% accuracy*	*50% accuracy*	*60-65% accuracy*	*70-80% accuracy*
Rancher	19%	11%	48%	11%	11%
USFS	13%	-	38%	25%	25%

50. Drought **forecasts** must be accurate _____percent of the time before I will use them to make management decisions. *Fill in the blank.*

	≤50 accuracy	*60% accuracy*	*70-75% accuracy*	*80-85% accuracy*	*90% accuracy*
Rancher	19%	4%	27%	35%	15%
USFS	-	-	43%	57%	-

51. I need drought **forecasting** information that can distinguish between winter and summer drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	15%	71%	12%	0%	3%
USFS	30%	40%	10%	0%	20%

52. **Forecasting** drought is more important than forecasting wet conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	51%	20%	3%	17%
USFS	11%	56%	11%	0%	22%

C. These questions ask about your interactions with ranchers, Forest Service staff, and producers of drought information.

53. I have interacted with producers of drought information.

	Yes	No
Rancher	58%	42%
USFS	60%	40%

54. I would like more interactions with producers of drought information.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	56%	14%	0%	25%
USFS	0%	70%	0%	0%	30%

Perceptions of Drought Survey – Summary of Responses

*values in tables represent percentages of responses; Rancher (n=36), USFS (n=11)

55. I communicate with the Forest Service (Rancher) / with ranchers (USFS) on a regular basis.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	17%	63%	20%	0%	0%
USFS	40%	60%	0%	0%	0%

56. My communications with the Forest Service (Rancher) / with ranchers (USFS) provide the information I need.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	34%	40%	14%	11%
USFS	0%	44%	22%	11%	22%

57. I have a good working relationship with the Forest Service (Rancher) / with ranchers (USFS).

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	22%	61%	14%	3%	0%
USFS	30%	70%	0%	0%	0%

58. The Forest Service staff (Rancher) / Ranchers (USFS) interact(s) with me about drought conditions on my/their grazing allotment(s) in Tonto National Forest.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	38%	35%	6%	12%
USFS	20%	60%	10%	0%	10%

59. During those interactions about drought, the Forest Service staff (Rancher) / ranchers (USFS) genuinely consider(s) my suggestions for changing livestock management practices.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	50%	16%	3%	22%
USFS	0%	40%	10%	20%	30%

60. During those interactions about drought, I genuinely consider the Forest Service staffs' (Rancher) / ranchers' (USFS) suggestions for changing livestock management practices.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	12%	55%	12%	6%	15%
USFS	10%	80%	0%	0%	10%

61. I would like these interactions with Forest Service staff (Rancher) / ranchers (USFS) to happen more often.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	39%	21%	6%	33%
USFS	0%	80%	0%	0%	20%

62. I interact with other ranchers (Rancher) / Forest Service staff (USFS) about how drought affects livestock management practices.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	24%	62%	12%	0%	3%
USFS	10%	70%	0%	0%	20%

63. I would like these interactions with ranchers (Rancher) /other Forest Service staff (USFS) to happen more often.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	50%	15%	0%	27%
USFS	11%	78%	0%	0%	11%

D. These questions ask about how drought information interacts with the administration of livestock grazing on National Forests.

a. Administration of grazing regulations on National Forests

64. Drought **monitoring** information is used to develop the Annual Operating Instructions for grazing allotments at the start of each calendar year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	32%	47%	0%	18%
USFS	0%	50%	30%	0%	20%

65. Drought **monitoring** information should be used to develop the Annual Operating Instructions for grazing allotments at the start of each calendar year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	9%	39%	30%	3%	18%
USFS	0%	80%	10%	0%	10%

66. Drought **monitoring** information should be used more often than just at the start of each calendar year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	12%	52%	18%	0%	18%
USFS	0%	90%	0%	0%	10%

67. Drought **forecasting** information is used to develop the Annual Operating Instructions for grazing allotments at the start of each calendar year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	12%	55%	12%	18%
USFS	0%	30%	50%	0%	20%

68. Drought **forecasting** information should be used to develop the Annual Operating Instructions for grazing allotments at the start of each calendar year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	24%	35%	9%	27%
USFS	0%	50%	20%	10%	20%

69. Drought **forecasting** information should be used more often than just at the start of each calendar year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	36%	33%	3%	21%
USFS	0%	60%	10%	10%	20%

70. A single Forest-wide drought index should be used to decide when to evaluate grazing allotments for drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	9%	41%	41%	9%
USFS	0%	20%	30%	40%	10%

71. In Tonto National Forest, managing livestock grazing in the face of recurring drought is limited more by livestock grazing policy than information about drought.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	24%	55%	9%	0%	12%
USFS	0%	30%	50%	10%	10%

b. NEPA (National Environmental Policy Act) administration on National Forests

72. I understand how NEPA applies to decisions about livestock management on National Forests.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	6%	69%	20%	0%	6%
USFS	50%	50%	0%	0%	0%

73. NEPA assessment and review of Allotment Management Plans improves the condition of rangelands in Tonto National Forest.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	9%	37%	31%	20%
USFS	10%	50%	20%	0%	20%

74. A drought management plan should be part of an Allotment Management Plan.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	42%	31%	3%	25%
USFS	10%	70%	10%	0%	10%

75. Forest Service involvement in rangeland management has helped ranchers.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	26%	37%	23%	14%
USFS	30%	50%	0%	0%	20%

c. Management flexibility to address drought

76. Flexibility in selecting the management practices to address drought can reduce impacts to livestock production.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	44%	53%	3%	0%	0%
USFS	10%	80%	0%	0%	10%

77. The NEPA process allows enough flexibility to respond to drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	11%	51%	20%	17%
USFS	0%	50%	20%	0%	30%

78. Only NEPA-approved livestock management practices can be used to respond to drought conditions in Tonto National Forest.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	9%	32%	32%	24%
USFS	0%	20%	50%	20%	10%

79. Allotment Management Plans allow enough flexibility to respond to drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	3%	40%	37%	9%	11%
USFS	10%	60%	10%	0%	20%

80. Annual Operating Instructions allow enough flexibility to respond to drought conditions.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	0%	42%	47%	3%	8%
USFS	30%	40%	10%	0%	20%

81. District Rangers can decide whether to change Annual Operating Instructions during the year.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	8%	61%	11%	14%	6%
USFS	40%	60%	0%	0%	0%

E. These questions ask you about your background and your career in ranching.

82. What year were you born?

	Average age
Rancher	63 years
USFS	46 years

83. How far did you go in school?

	High School	Some College	4-year College Degree	Graduate Degree
Rancher	14%	37%	26%	23%
USFS	0%	0%	50%	50%

84. How many years of experience do you have in ranching (Rancher) or administering livestock grazing permits (USFS) in a National Forest?

	Average
Rancher	37 years
USFS	10 years

Note: The questions below apply only to ranchers.

85. How many years of experience do you have in ranching the Southwest?

	0-15 years	16-30 years	31-45 years	46-60 years	61-75 years	76-90 years
Rancher	27%	16%	27%	11%	14%	5%

86. How many generations has your family been in ranching (not counting your generation)?

	0	1	2	3	4	5-6
Rancher	26%	11%	29%	14%	14%	6%

87. I have a succession (inheritance) plan for my ranch after I retire.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Undecided
Rancher	12%	41%	21%	9%	18%

Workshop I Report

12 March 2015
Globe, AZ

Organizers
Mitch McClaran, Julie Brugger, Mike Crimmins, Jim Sprinkle, Doug Tolleson, George Ruyle, Larry Howery, and Kelsey Hawkes

Supported by NOAA SARP Grant: Using a co-development process to improve, integrate and encourage use of drought information and adaptive management of livestock grazing on National Forests

Prepared 22 May 2015

Executive Summary

This report documents the rationale, activities, and outcomes of the first of three workshops that are part of a research project, titled *Using a co-development process to improve, integrate and encourage use of drought information and adaptive management of livestock grazing on National Forests*, which is funded by the National Oceanic and Atmospheric Administration's (NOAA) Sectoral Applications Research Program (SARP). The goal of the project is to improve livestock management during drought on the Tonto National Forest. To that end, the research team is applying a "co-development process" to identify opportunities to use drought information and to increase management flexibility while maintaining consistency with the Forest Service (FS) policy for administering livestock grazing. The groups involved in the "co-development" are FS District Rangers and Range Staff, and ranchers with grazing permits on the Tonto National Forest, drought information developers from the National Drought Mitigation Center at the University of Nebraska Lincoln, and faculty, staff and students from the University of Arizona. The process will include three workshops for the participants to learn from each other, and to set directions and goals for future activities.

Workshop I provided participants with: 1) an overview of the project; 2) an introduction to basic drought science and drought decision support tools; 3) an introduction to FS livestock management policy related to drought; and 4) an introduction to scenarios and contingency planning.

Overall, the workshop met its intended goals to introduce participants to each other and to the objectives of the project, provide them basic information on background policy conditions and existing decision support tools, and begin the process of identifying common goals. An analysis of transcriptions, workshop notes, and an evaluation survey indicate that significant progress was made in eliciting new ideas to support collaborative drought monitoring and management on the Tonto National Forest and providing the research team with information that will contribute to the scenario planning exercises during Workshop II.

Using a co-development process to improve, integrate and encourage use of drought information and adaptive management of livestock grazing on National Forests

Workshop I Report

I. Introduction

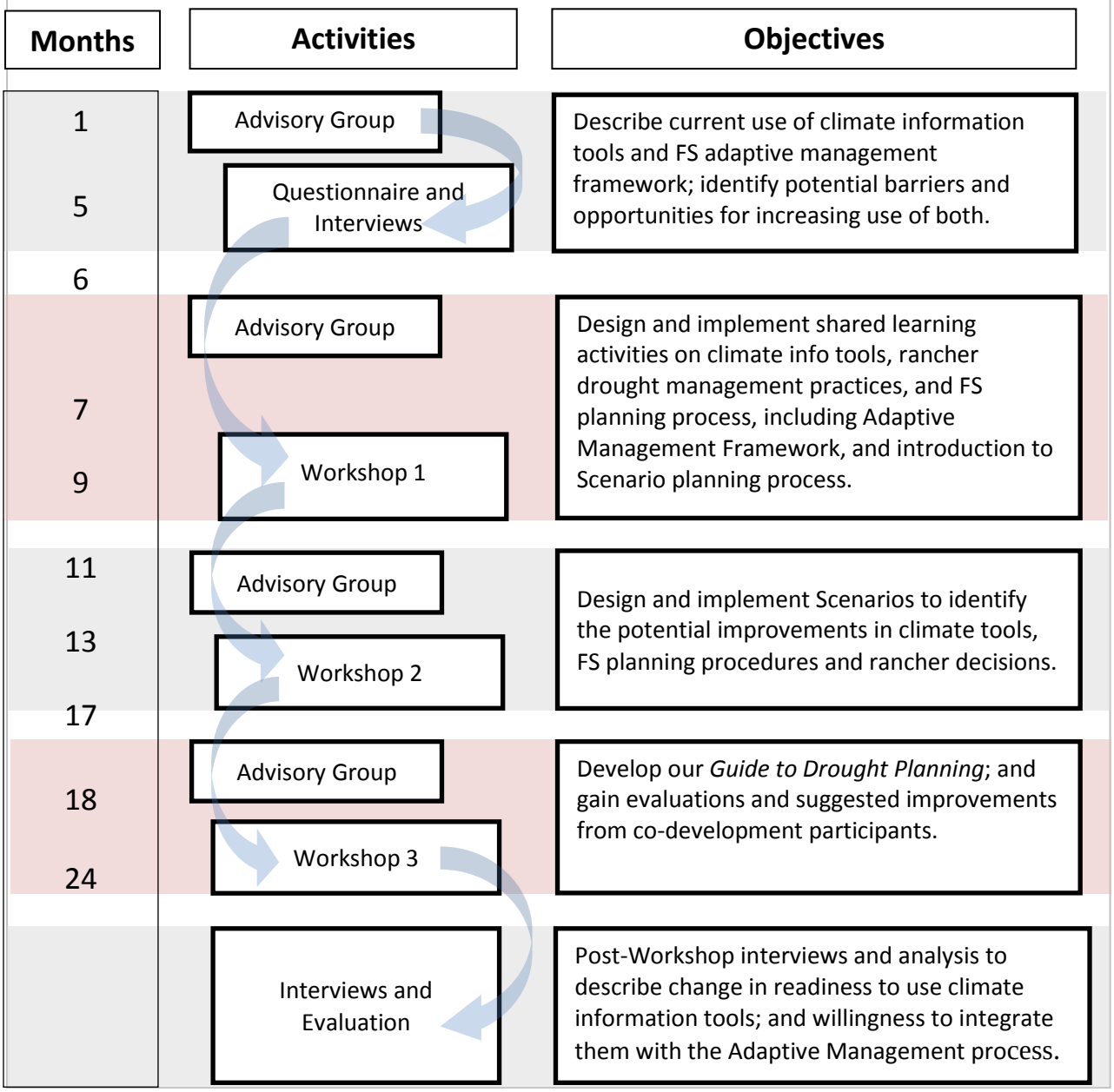
This report documents the rationale, activities, and outcomes of the first of three workshops that are part of a research project, titled *Using a co-development process to improve, integrate and encourage use of drought information and adaptive management of livestock grazing on National Forests*, which is funded by the National Oceanic and Atmospheric Administration's (NOAA) Sectoral Applications Research Program (SARP). The report also reviews the information provided in Workshop I and the ensuing discussions in order to refresh and clarify them in participants' minds and prepare them to participate in Workshop II. The project is being conducted by a team from the University of Arizona (UA) which includes: Mitch McClaran, Professor of Range Management and the Director for Research at the Santa Rita Experimental Range; Julie Brugger, Research Social Scientist with the Institute of the Environment; Mike Crimmins, Climate Science Extension Specialist; Jim Sprinkle, Area Extension Agent Animal Sciences and Gila County Extension Director; George Ruyle, and Larry Howery, Professors and Range Management Extension Specialists; Doug Tolleson, Range Management Extension Specialist, and Kelsey Hawkes, graduate student in Range Management.

a. Overview of the project

The goal of the project is to improve livestock management before, during, and after drought on the Tonto National Forest. To that end, the project team is organizing a "co-development process" to identify opportunities to use drought information and to increase management flexibility while maintaining consistency with the Forest Service (FS) policy for administering livestock grazing. The groups involved in the "co-development" are FS District Rangers and Range Staff, ranchers with grazing permits on the Tonto National Forest, drought information developers from the National Drought Mitigation Center (NDMC) at the University of Nebraska Lincoln, and faculty, staff and students from the UA. The process will include three workshops for the participants to learn from each other and set directions and goals for future activities. Figure 1 shows the proposed timeline for the project and the objectives of each workshop.

Project outputs will include Workshop Reports and a Guide to Drought Planning and Response for Livestock Management on FS Lands similar to the publication, *Managing Drought Risk on the Ranch: A Planning Guide for Great Plains Ranchers*, produced by the NDMC, but taking into account that ranchers on FS Lands must manage their livestock in accordance with FS land use policies. Anticipated outcomes include: improved level and quality of interaction between ranchers and FS managers; increased understanding of climate and drought management information and their potential uses among ranchers; and FS managers and increased capacity of ranchers and FS managers to plan for, cope with, and adapt to recurring drought.

Figure 1. Co-development process to identify opportunities to use drought information and to increase management flexibility during drought. Connecting arrows represent research team's integration of the cumulative information.



b. Preparation for the workshop

To gather information that would help the project team design the first workshop, the team conducted a mail survey of all grazing permittees on the Tonto National Forest (n=70) and the District Rangers and Range Staff in its six districts (n=11). The survey was designed and tested

with the help of an Advisory Group consisting of FS staff, ranchers, and faculty and students from the UA. The overall response rate for the survey was 58%. The survey questions were designed to help the team understand perceptions of drought and drought information, the practices currently used to respond to and prepare for drought, and the constraints faced in trying to respond to and prepare for drought by ranchers and FS personnel, and also to establish a baseline for evaluating the impacts of the series of workshops after they have concluded. Survey results are discussed briefly in Section IIa.

All of the FS personnel surveyed were invited to participate in the workshops, along with the Forest Supervisor, Deputy Supervisor, and the Forest Range Staff Officer. To reduce the number of rancher participants to a manageable number, the team first considered ranchers who indicated they were interested in participating in the workshops in their completed mail survey, and then considered recommendations from the District Rangers and Range Staff, research team members, and other ranchers. Twenty-two ranchers were invited and twenty accepted.

The survey was followed by interviews with the same FS personnel (n=10) and with the ranchers who accepted the invitation (n=19). The interviews covered the same topics as the survey, but allowed interviewees to provide more in-depth responses. Some of the major insights provided by the interviews include the following. All interviewees but one mentioned the destocking of the Tonto during the 2002 drought, whether they were present at the time or not, indicating the significance of the event for both groups. Both groups also expressed the desire to avoid such an outcome of drought in the future. All but two of the ranchers interviewed mentioned that they participated in the Reading the Range monitoring program organized by UA Cooperative Extension. It also became apparent that ranchers were not aware of the Region 3 Drought Policy which triggers FS action during drought. Only one rancher correctly identified the drought index used to trigger actions in that Policy. FS interviewees, on the other hand, expressed uncertainty about FS policies for some rangeland management practices.

Based on the project design and insights from the survey and interviews, Workshop I was designed to: 1) provide an overview of the project; 2) provide an introduction to basic drought since and drought decision support tools; 3) provide an introduction to FS livestock management policy related to drought; and 4) provide an introduction to scenarios and contingency planning. This information plus discussion following each segment will help the team design the scenario planning exercises that will take place in Workshop II, in which participants will collaboratively explore how to improve response and preparation for drought under a variety of conditions.

II. Workshop Summary

Workshop I was held March 12, 2015 in Globe Arizona. There were 37 participants, including 17 ranchers, 11 FS personnel from the Tonto National Forest and 1 from Region 3; two researchers from the NDMC, the eight members of the research team from the UA, with Lisa Page, an Extension Program Coordinator, assisting. McClaran acted as the Workshop Master of Ceremonies. A copy of the meeting agenda is in the Appendix.

a. Introduction and Background (McClaran)

As an ice-breaker, McClaran opened the workshop by asking participants to introduce themselves and respond to the question, "What is your favorite drought indicator?" Rancher responses focused on forage conditions, cattle condition, and stock water availability, while FS participants also mentioned drought indices, or water levels in Roosevelt Lake.

Figure 2: Mitch McClaran opens the workshop.

To illustrate why this particular group was selected and how they could interact to co-develop better understanding and solutions to drought management, McClaran discussed the slide in Figure 3. Specifically, livestock management decisions on National Forests are made by the FS in consultation with ranchers, but each group brings different concerns to the decision-making process. Drought impacts livestock and rangelands and increases tensions that already exist as a result of contrasting concerns. McClaran emphasized that the decision-making processes before, during, and after drought could be improved if ranchers and the FS could work together with the UA and NDMC to co-develop information and technical assistance.

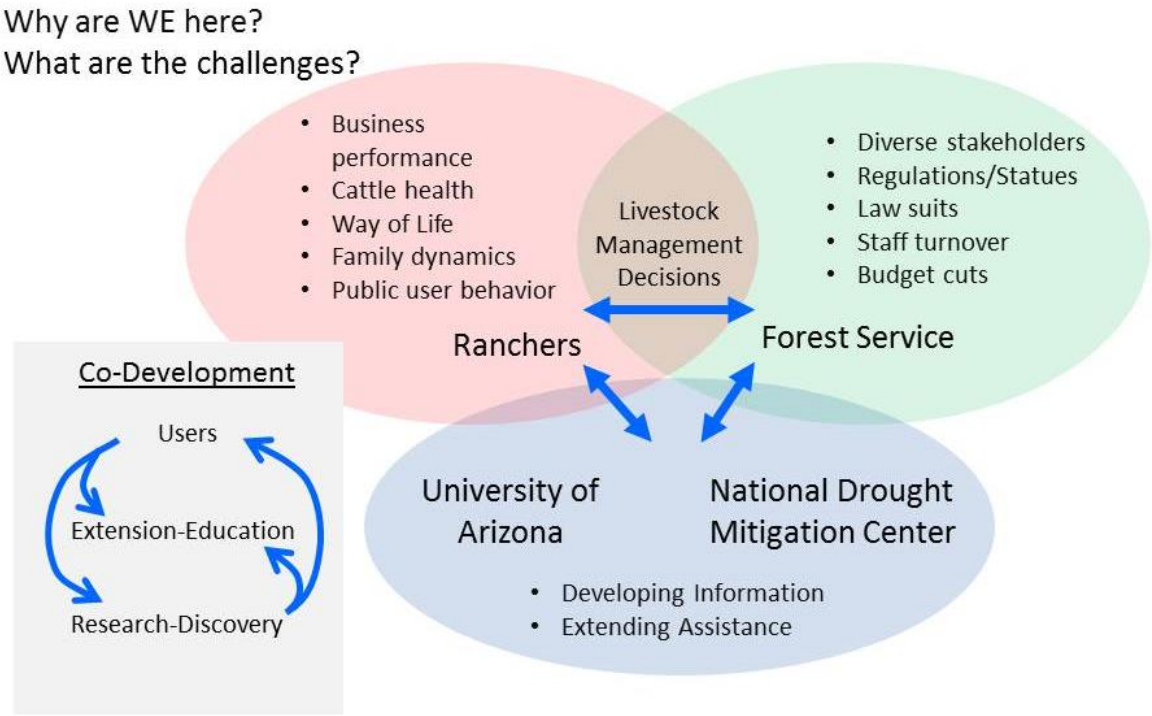


Figure 3: Why are we here, what are the challenges and how does "co-development" involve all parties?

McClaran explained that from the surveys, we learned that there are both challenges and opportunities for working together. One of the challenges is that ranchers and the FS perceive each other as creating risk for managing livestock in the Tonto National Forest. For ranchers, the top three risks were the FS, drought, and federal regulations. For the FS, the top risks were drinking water reliability, livestock practices, and drought. Some of the opportunities are: 1) both groups want to learn more about drought information sources, drought management practices, and the FS administrative process; 2) both groups feel that management flexibility can help and drought plans can help, and; 3) and both groups want to participate in these workshops to improve livestock management during drought.

The discussion following McClaran's presentation highlighted another of the challenges.

- While ranchers support the concept of a drought plan, they are concerned that a plan might not allow the management flexibility they need, that a plan formulated at a Region- or Forest-wide scale might be applied indiscriminately rather than on an allotment-by-allotment basis, or might be based on indicators that do not reflect conditions on their allotment.

b. Drought/Climate Decision Support Tools (Hayes and Crimmins)

The purpose of this segment of the workshop was to familiarize participants with drought information tools currently available. Mike Hayes, Director of the NDMC, discussed drought science basics and drought information at the regional level, while Mike Crimmins from the UA discussed information at the local scale.

Hayes explained drought risk management and how the NDMC was created in 1995 to deal with the risk of drought specifically. He emphasized the importance of drought monitoring and early warning systems for empowering stakeholders to plan so they can prepare for response as well as take action to reduce future risk. The NDMC produces the US Drought Monitor (http://droughtmonitor.unl.edu/), which combines a variety of information sources, such as: precipitation, streamflow, remote sensing, soil moisture, actual data and model data, and a volunteer observation network (CoCoRaHS). What makes it unique is that it has the ability to incorporate observations from experts from all entities and levels of government dealing with drought around the county. The US Drought Monitor gives a good visual representation of drought around the country, and you can bring it into a regional, state, and sub-state scale. Because of its national scope it is effective for policy and national level decision making and is used, for example, by the USDA Farm Bill, IRS livestock tax deferral, EPA water quality monitoring, so it can have impact on local scale. It comes out weekly and is a joint effort of NOAA, USDA, the Western Regional Climate Center (WRCC), and NDMC. It is also used to create the Seasonal Drought Outlook produced by the NOAA Climate Prediction Center which projects temperature and precipitation three months into the future. Hayes emphasized that partnerships and networks are fundamental to dealing with drought because it is complex. He described how the NDMC worked with ranchers in the Great Plains to produce a handbook for *Managing Drought Risk on the Ranch*, and concluded with a quote from one of the ranchers: "Planning makes the problem more palatable and manageable. It doesn't solve the problem but makes you proactive not reactive."

Crimmins presented the idea of a web-based "drought monitoring dashboard" for the Tonto NF that would provide easy access to a variety of drought monitoring information. He emphasized that "you can't hang your hat on any one thing," because tracking drought across Arizona is complex due to the high level of spatial and temporal variability in precipitation and temperature in its climate. Drought monitoring tools differ in spatial and temporal resolutions as well as measures of drought, and provide different types of information about drought. The "dashboard" for the Tonto NF would display the drought monitoring tools that ranchers and FS agreed were most useful (see Figure 4 for an example of a dashboard). Having all these drought monitoring tools in one location could improve communication because all parties would be looking at the same information.

Crimmins then described some of the tools that he uses to track drought in Arizona, and that could be included in the dashboard.

- ***U.S. Drought Monitor*** (http://droughtmonitor.unl.edu/): National-scale drought status map produced weekly by a team of experts from across the country. The Arizona Governor's Drought Task Force contributes information to help in the production and refinement of the map each week.
- ***NOAA Climate Prediction Center Seasonal Drought Outlook*** (http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.html): A drought information product that is an intersection of the U.S. Drought Monitor map and the NOAA Climate Prediction Center long-lead, 3-month temperature and precipitation outlooks. The outlook will give an indication if drought conditions may develop, intensify or improve over the next three months. Skill and accuracy varies depending on season and location across the Southwest, but can still be useful and used opportunistically (e.g. El Nino winter situation). Updated once a month.
- ***Westwide Drought Tracker*** (http://www.wrcc.dri.edu/wwdt/): Tool to access and explore maps and time series of several different drought and climate indices for the western U.S. Gridded climate data (PRISM) are used to capture fine scale variation in temperature and precipitation caused by elevation gradients making the tool especially well-suited for the complex climate of the western U.S. Data are updated once a month.
- ***Multi-scale Standardized Precipitation Index Plots*** (http://cals.arizona.edu/climate/misc/spi/spi_contour.html): Experimental plot showing all scales of the Standardized Precipitation Index at once to illustrate potential differences in both short and long-term drought conditions. Plots are created once a month for all climate divisions (multi-county areas) in Arizona and New Mexico.
- ***DroughtView*** (http://droughtview.arizona.edu/): Tool to access and visualize maps and time series animations of remotely sensed 'greenness' or vegetation condition information. Remote sensing data are captured daily by a satellite at a resolution of 500m and summarized as a two-week average. Data are updated about every two weeks with data available back to 2000.
- ***Rainlog.org*** (http://rainlog.org): Rainlog is a volunteer rainfall monitoring network comprised of volunteers across Arizona. Over 2000 observers contribute rainfall observations to Rainlog each day, helping to fill in gaps in official precipitation monitoring networks across Arizona. Consider signing up and sharing rainfall observations from your gauge.

- ***Climate Assessment for the Southwest*** (http://www.climas.arizona.edu/): CLIMAS is a research and outreach program at the University of Arizona focused on conducting applied research and providing regional climate information to users in Arizona and New Mexico. CLIMAS produces a monthly report called the Southwest Climate Outlook that details regional climate conditions and discusses upcoming forecasts. The Outlook is available by clicking on the 'Library' link.

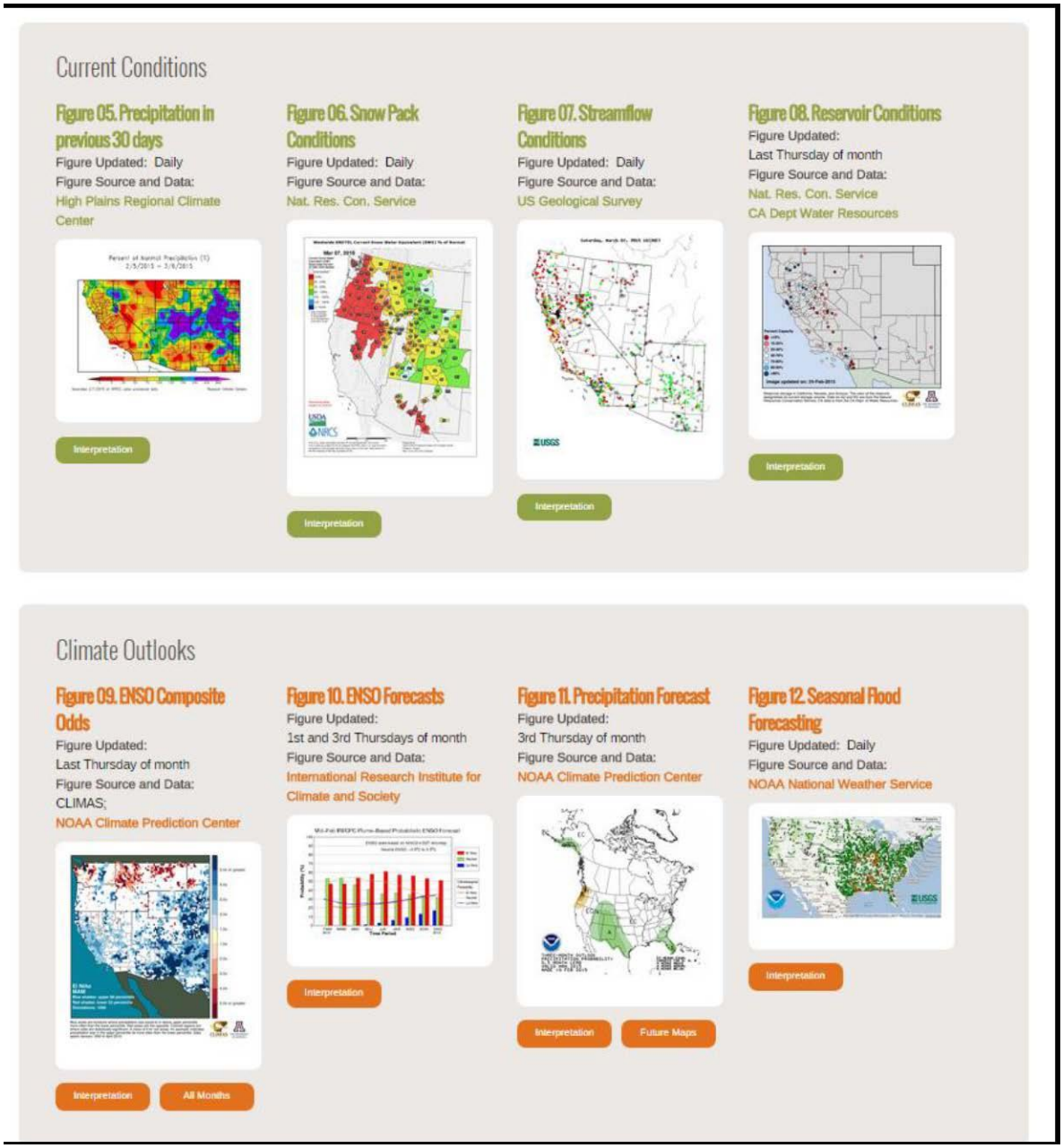


Figure 4: Example of a drought information dashboard

Crimmins concluded by asking participants to provide suggestions for what they would ideally like to see on a Drought Information Dashboard for the Tonto NF. The suggestions included:

- Adding more interpretative layers like allotment and pasture boundaries and soil types to tools like DroughtView
- Flood control precipitation gauges
- Existing fire weather and climate monitoring and forecasting tools
- Online calculator for cumulative monsoon precipitation
- Collecting and sharing local rainfall by pasture
- Tools and data to track the timing of precipitation as well as totals
- Forage production predictions based on antecedent summer and winter precipitation for the following year
- Temperature
- Wind
- Hard freezes
- Observations of forage growth and relating to remote sensing information.

c. Forest Service Livestock Management Policy Related to Drought (Dyess)

The purpose of this segment of the workshop was to familiarize participants with the FS administrative framework for managing livestock grazing on national forests so they can understand where and how to incorporate the flexibility needed to manage before, during, and after drought. Judith Dyess, Assistant Director of Rangeland Management for the FS Southwestern Region (Region 3) described the framework as consisting of the Land and Resource Management Plan (LMP or Forest Plan) for the Forest, the authorization of grazing and issuance of a term grazing permit and Allotment Management Plan (AMP), and the Annual Operating Instructions (AOI). The framework is hierarchical, so that objectives and management at each level must be consistent with the level above. There is an opportunity to incorporate flexibility for managing grazing at each level, therefore, grazing permittees should be involved in developing the LMP, AMP, and AOI. However, since LMPs and AMPs are developed every ten to fifteen years, the opportunity to incorporate flexibility into them doesn't come along very often.

The highest planning level is the LMP or Forest Plan for the Forest. Under the 1976 National Forest Management Act, each Forest in the National Forest System is required to have such a plan, which should be revised every ten to fifteen years. The LMP provides general direction such as Standards and Guidelines for Management. All projects, including the authorization of grazing and proposed grazing management, must be consistent with the LMP. Consistency is determined by examining whether project level decisions implement the goals, objectives, desired conditions, standards and guidelines and monitoring requirements from the LMP. The Tonto National Forest is currently in the process of revising its LMP, which was written in 1985, and is encouraging the public to participate in all phases of the process. This is an opportune time for permittees to provide input about incorporating flexibility to manage before, during, and after drought into the LMP.

To implement the LMP the Forest Service, Southwestern Region, uses a planning triangle. In the first leg, called Plan-to-Project, existing conditions and desired conditions are compared to determine whether there is a need for change and possible management activities are identified. This process helps to develop the objectives of the project and ensure consistency with the LMP. In the second leg of the triangle, called NEPA Project, proposed actions, including the authorization of livestock grazing, follow a process required by the National Environmental Policy Act of 1969 (NEPA). Rationale for a proposed action is supported by the work conducted in the first leg, the Plan-to-Project phase. The third leg of the planning triangle called Feedback and involves monitoring and evaluation of the effects of implementation of the proposed action, and making adjustments if necessary.

The authorization of grazing is considered a project level decision that must be analyzed under NEPA. The proposed action generally includes; the authorization of grazing, management including adaptive management, improvements, and monitoring. Typically, grazing management actions are evaluated with an Environmental Assessment (EA), although an Environmental Impact Statement (EIS) may be written, depending upon complexity. The EA specifies resource objectives and the rationale for how management actions, such as timing, intensity, and frequency of grazing, improvements and monitoring, will achieve them. AMPs are developed directly from language in the EA but may provide additional detail needed to implement the project NEPA decision.

There is opportunity to provide management flexibility through the use of an adaptive management framework in the authorization of grazing and the implementation through the grazing permit and AMP. However, that flexibility is limited: 1) by the need to maintain consistency with the LMP; 2) to adjustments supported by rangeland monitoring information, and; 3) to practices that that were approved in the grazing authorization NEPA decision. Figure 5 provides an example of implementation of an adaptive management decision and the use of monitoring to inform management from the Kaibab National Forest. It shows how monitoring could trigger a change in grazing management (Box 12).

Flexibility can also be incorporated into the AOI. The AOI gives specifics for the ensuing calendar year and must generally be consistent with the AMP. The AOI specifies dates and areas of use, utilization guidelines, and improvement maintenance, and construction responsibilities for the year. It should be based on discussions with the permittee and developed jointly. Changes in management can be specified in the AOI without going through NEPA again, if the changes in management were analyzed and incorporated in the deciding document.

In very special circumstances, if something was not analyzed in the current NEPA, FS line officers (Forest Supervisors and District Rangers) have authority and discretion to approve temporary (<2 consecutive years) management changes in the AOI that deviate from the AMP without going through NEPA review and approval process (R3 FSH 2209.13 sec. 16.16; provided in the Appendix). The changes might affect number, kind, and class of livestock; duration, or season of use. However, these changes must be consistent with the LMP and must benefit the rangeland resource. The change can be documented with a letter expressing the rationale for the change in management, and any monitoring that will be done to assess the effects of the change. This is one method for applying short-term temporary flexibility in

management practices to respond to drought conditions. There can be considerable difference among line officers' application of this flexibility because each situation is unique. The Forest Service and permittee must recognize possible scrutiny when adapting management under these conditions.

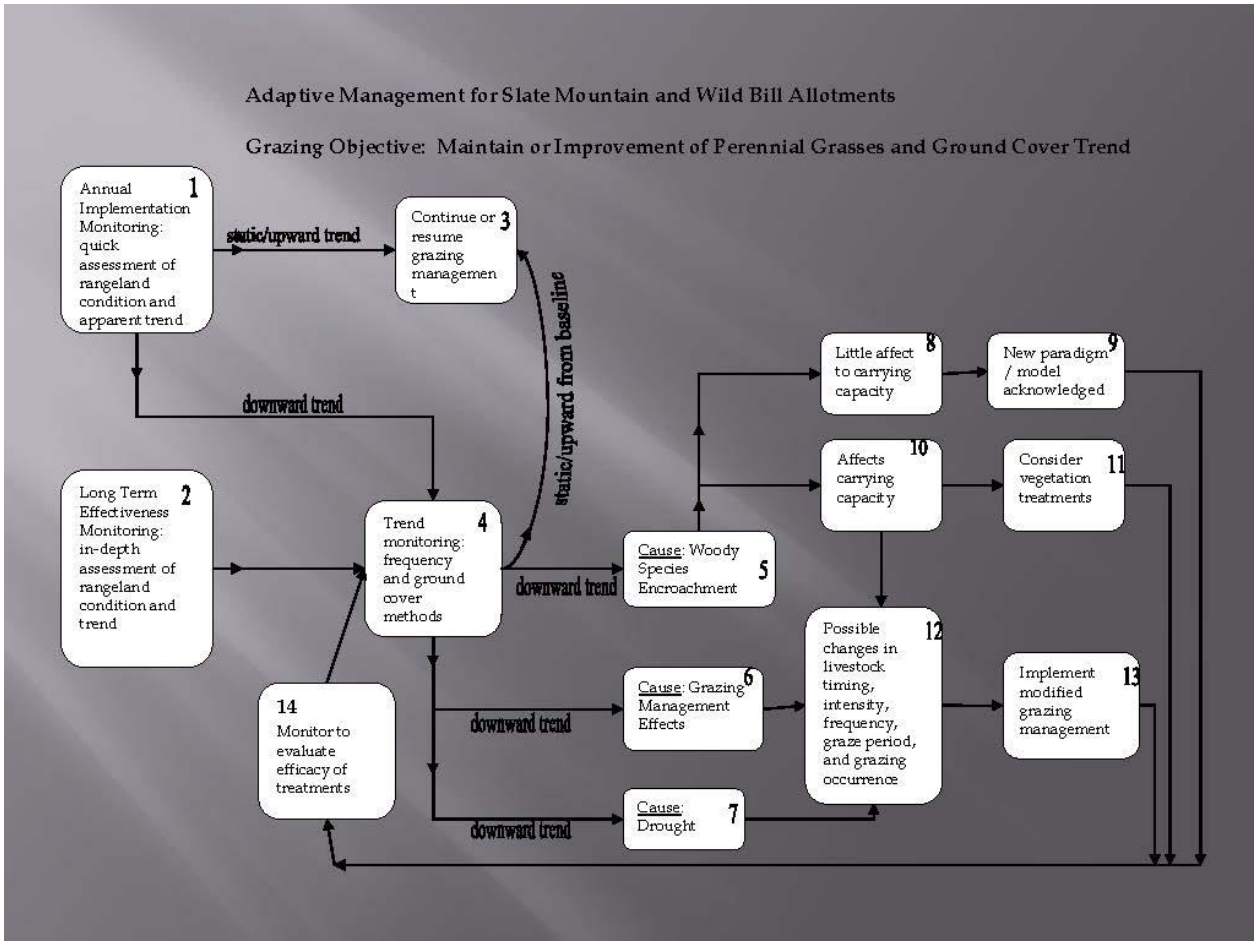


Figure 5: Example of adaptive management in an AMP.

Finally, in "emergency management" situations, such as drought or fire, temporary changes to the terms and conditions of a grazing permit can be made without NEPA review and approval. However, these changes must still be consistent with the LMP.

The Southwest Region has developed a drought policy to help the FS evaluate whether they are in an emergency drought situation. It is the only region with a supplemental drought policy. The drought policy specifies a trigger (SPI -1 or less for a 12-month period) that stimulates evaluation of rangeland resources for the existence of drought conditions at the local level. The goal of evaluation is to provide recommendations for management actions to protect rangeland resources. This should be done in consultation with affected permittees. The drought policy also lists factors that should be considered in evaluation, principles for stocking during and after

drought, and general recommendations for recovery, which include devoting the first year following drought to recovery (see R3 FSH 2209.13 sec. 19.1; provided in the Appendix).

To summarize, there are opportunities to incorporate flexibility to manage before, during, and after drought in the FS administrative framework for managing livestock grazing:

- In the development of the LMP;
- In the authorization of grazing and subsequent development of the terms and conditions of the grazing permit and Allotment Management Plan;
- In the Annual Operating Instructions;
- In emergency situations.

Dyess concluded with the question: What suggestions do you have that will increase the ability to be flexible, while demonstrating responsibility towards managing the resources of National Forest System lands? Suggestions from participants included:

- Develop a list of common adaptive management options, their rationale, and references to appropriate scientific papers that support the rationale that everyone can draw on in their AMP, AOI, or during emergency management, rather than having to do it allotment by allotment. For example: rationale and references to support developing new water sources, or scattering the cattle herd over multiple pastures temporarily.
- For ranchers who will not have a new NEPA analysis for a long time, work one-on-one with FS rangeland specialist now to formulate a plan that will provide the flexibility you need when the next drought happens

d. Introduction to Scenarios and Contingency Planning (Tolleson and Brugger)

This purpose of this segment of the workshop was to introduce participants to the concept of scenario planning and elicit their input for developing the scenarios they will be working with in the next workshop. Doug Tolleson opened this segment by explaining the "time-stress wedge." That is, if you think about what you would do in the future under a variety of conditions now, you will be better prepared to make good decisions when that scenario arises and you are in a stressful situation. Conditions could include timing and amount of precipitation, range conditions, available water, market prices, herd size, quality of the relationship between ranchers and FS range managers, etc. The selection of conditions to look at, indicators for those conditions, and what values of the indicators will trigger action, should be relevant to a specific area and should be made by people who are knowledgeable about the range of conditions for that area. The forward thinking done in a scenario planning exercise can be incorporated into a drought plan. You might not follow the drought plan verbatim, but it will provide a template for making better decisions. A drought plan can potentially be incorporated into an AMP and AOI.

Example National/Regional/Local Information Indicator Sources and Management Activities.

Scenario	Std. Precipitation Index	County Flood Control District	On-site Rain Gauge	Key Forage Plant Condition	Management Activity
"Best"	3.0	125% of avg	2.0", "X" Pasture by Aug 1	W. Wheat "green", ~ 12"	Graze stockers
	2.0	110% of avg	1.75", "X" Pasture by Aug 1	W. Wheat "green", ~ 10"	Maintain, normal culling
	1.0	100% of avg	1.5", "X" Pasture by Aug 1	W. Wheat "blue/green", ~ 10"	Maintain, normal culling
"Average"	0.0	90% of avg	1.25", "X" Pasture by Aug 1	W. Wheat "blue/green",~ 8"	Slight decrease, culling group 1
	-1.0	80% of avg	1.5", "X" Pasture by Aug 10	W. Wheat "blue", ~ 8"	Slight decrease, culling group 2
	-2.0	70% of avg	1.25", "X" Pasture by Aug 10	W. Wheat "blue", ~ 6"	Decrease, culling group 3
"Worst"	-3.0	60% of avg	1.0", "X" Pasture by Aug 10	W. Wheat "blue", ~ 4"	Decrease to core herd

Figure 6: Example using regional and local indicators.

Tolleson gave several examples of what drought plans might look like (see Figures 6, 7). Figure 6 shows how you might use a drought index (the SPI), as well as regional indicator (county flood control district data), and indicators specific to an allotment to make stocking decisions. Figure 7 is an actual example from the Kaibab National Forest, developed collaboratively by the FS rangeland specialist, UA Cooperative Extension, and the permittee, that has been incorporated into an AMP. Alternatively, a drought plan could be in the form of a flowchart, similar to the example in Figure 5. In Workshop II, participants will use the concepts presented here to create drought plans that work for a typical allotment on the Tonto NF and take the FS administrative framework into account.

Real-world Adaptive Mgmt Scenario Example, Northern Arizona

Scenario Category	Cool Season Indicator	Warm Season Indicator	Stocking Rate Alternative	Pasture Movement Alternative
"Normal"	Johnson Tank 75% full	C4 perennials green and 4" tall by May 1	Maintain Allotted Numbers	Move from John Flat into Bottom on March 1 then Slide on June 1, back to John Flat November 1
Wet cool season, wet warm season	Johnson Tank 100% full	C4 perennials green and 6" tall by May 1	Maintain Allotted Numbers, add sheep for brome control	Begin moving from John Flat into Bottom on March 1 then Slide on June 1, back to John Flat November 1
Wet cool season, dry warm season	Johnson Tank 75% full	C4 perennials green and 4" tall by May 1	Maintain Allotted Numbers	Move from John Flat into Bottom on April 1 then begin moving to Slide on May 1, begin moving back to Bottom August 1, back to John Flat November 1
Dry cool season, wet warm season	Johnson Tank 50% full	Some C4 perennials green, only 3" tall by May 1	Cull dry cows at branding	Move from John Flat into Slide on May 1 then Bottom on September 1, back to John Flat December 1
Dry cool season, dry warm season	Johnson Tank 50% full	Some C4 perennials green, only 3" tall by May 1	Cull dry, older, and thin cows	Graze John Flat and Kane Trap till April 1, move to Slide. Then to Bottom and Bottom Trap on August 1, back to John Flat and Kane Trap on December 1

Figure 7: Example used in an actual AMP

Tolleson posed a series of questions, the responses to which the project team will use to help design the scenarios for Workshop II. Participants wrote their responses on index cards (see Figure 8), which were collected and transcribed. The questions and a summary of responses follow.

Figure 8: Participants writing responses.

1) Based on your personal experience, provide three "**on the ground**" drought indicators that **you use** on **your own** ranch, allotment, or management area, ranked by strength of reliability or usefulness.

The most frequent response categories are listed in order below.

Ranchers	Forest Service
• Stock water availability • Vegetation • Cattle body condition • Timing and amount of precipitation	• Vegetation • Stock water availability • Various drought monitors • Timing and amount of precipitation

The categories vegetation and stock water availability included more specific details. For vegetation these included: annuals growth in the spring, forage availability at designated key areas, forage production, and leader growth on browse. These responses suggest that FS personnel and ranchers are in basic agreement about the most important types of indicators, which is a prelude to agreement on allotment- or pasture-specific triggers for these indicators.

Discussion of the responses revealed that FS personnel would not be comfortable using body condition as an indicator.

2) What 3 suggestions do you all have that will increase the ability to be flexible, while demonstrating responsibility towards managing the resources of National Forest System lands?

The responses to this question were more diverse and difficult to categorize. We list some categories below to illustrate their diversity.

Ranchers	Forest Service
• Better relationship with FS (e.g. communication, trust, brainstorming, empathy, viewing allotment) • Education – ranchers and FS so they know how they can be flexible. • Ability to utilize best pasture available rather than just follow rotation • Ability to scatter over multiple pastures	• Plan ahead (e.g. consider and analyze scenarios in NEPA to apply adaptive management, develop triggers, rationale for change in management) • Better relationships with permittees (communication, visit allotment) • Conservative stocking

These responses suggest that FS personnel and ranchers are in basic agreement that better communication is needed, however they differ in whether they see planning (FS) or taking action (ranchers) as more important.

Suggestions that participants provided during discussion of the responses included:

- Organize a working group of ranchers, FS, and UA scientists to run through drought scenarios during non-drought time to plan for drought. When drought happens call the group together to provide input on management options.
- Develop a Forest-wide drought plan which can be agreed on by the FS, permittees, the Gila County Cattle Growers, and UA researchers.
- Provide input into the Forest Plan, which is currently in the early stages of revision, to provide flexibility to manage during drought and insure flexibility will be maintained in the face of FS staff turnover.
- Build a grass bank into each allotment that can be used during drought.

e. Closing activities

During the last fifteen minutes of the workshop participants completed evaluation forms and indicated their preferred time period of the next workshop. McClaran thanked everyone for coming and the workshop adjourned.

III. Evaluation of Workshop I

a. Participant evaluation of workshop

Nineteen participants completed evaluation forms. Sixteen agreed that the workshop met their expectations and three were undecided. Nine felt that the workshop structure was fine and four said they would prefer a different structure that included more discussion, breaking into smaller groups, and more on specific on-the-ground actions to deal with drought. Comments about what was missing from the workshop were similar to those about the structure of the workshop. One respondent commented that FS participation in discussion was lacking. All respondents expressed interest in attending the next workshop. They ranked the end of August as the highest preferred time for the next workshop. It is now scheduled to take place August 27 in Payson.

b. Outcomes

Overall, the workshop met its intended goals to introduce participants to each other and to the objectives of the project, provide them basic information on background policy conditions and existing decision support tools, and begin the process of identifying common goals. An analysis of transcriptions, workshop notes, and an evaluation survey indicated that significant progress was made in eliciting new ideas to support collaborative drought monitoring and management on the Tonto National Forest and providing the research team with information that will contribute to the scenario planning exercises during Workshop II.

The research team will create a website to post workshop materials and PowerPoints and to host a prototype drought dashboard.

IV. Attachments to the Report include:

1. Workshop Agenda
2. List of workshop participant names by Group
3. Notecard responses to questions in Planning section of Workshop.
4. List of management practices from surveys and interviews prior to the workshop.
5. R3 FSH 2209.13 section 16.16 and Changes in Grazing Permits and section 19.1 Region 3 Drought Guidelines

Improving livestock management during drought on the Tonto National Forest
Workshop 1: 12 March 2015, Globe, AZ

Program

Time	Leaders	Topic
8:00-8:30		Registration and Refreshments
8:30-9:45	McClaran	Introduction and Background What is your favorite indicator of drought? Why are we here? What are the challenges? What are the opportunities? What lies ahead?
9:45-10:15		Coffee Break
10:15-12:00	Crimmins and Hayes	Drought/Climate Decision Support Tools Tools at the national and local levels Current USFS Region 3 Drought Policy What information are you using and looking for?
12:00-1:00		Lunch Provided by Copper Bistro 2118 US-60, Globe, AZ 85501
1:00-2:30	Ruyle, Dyess and Davis	Forest Service Livestock Management Policy related to Drought Current USFS Region 3 Drought Policy Options for flexibility within administrative policies
2:30-3:00		Coffee Break
3:00-4:00	Brugger and Tolleson	Introduction to Scenarios and Contingency Planning Identifying variables of concern These will be used in Workshop 2
4:00-4:15	McClaran	Schedule Workshop 2 and Evaluate Workshop 1

Sponsor: NOAA Sectoral Application Research Program

Organizers: Julie Brugger, Mike Crimmins, Kelsey Hawkes, Larry Howery, Mitch McClaran, George Ruyle, Jim Sprinkle, and Doug Tolleson are all from the University of Arizona

Workshop I Participants

Forest Service	Ranchers	National Drought Mitigation Center
Kelly Bedson	Bob Benne	Tonya Haigh
Neil Bosworth	Lori Brown	Mike Hayes
Louise Congdon	Jeremy Burk	
Gary Hanna	Bill Conway	
Eric Hoskins	Tyler DalMolin	
Kelly Jardine	John Fowler	
Kelly Kessler	John Griffin	
Chandler Mundy	Mike Hemovich	
Rick Reitz	Therese Hicks	
Doug Ruppel	John Holbrook	
Jamie Wages	Arthur Lyman	
	George and Lynn Martin	
	Pete Oddonnetto	
	Steven Siemoneit	
	Ray Tanner	

Notecard responses to questions in Planning Section (Brugger and Tolleson) of the Workshop

Question 1: Based on your personal experience, provide three "on the ground" drought indicators that you use on your ranch, allotment, or management area, ranked by strength of reliability or usefulness (i.e. highest to lowest, but they can still be "useful")

Summary of Responses to Question 1	FS	Rancher
Precipitation: timing and amount	3	3
Stock water availability	5	12
Vegetation (including annuals growth in the spring, appearance, forage availability at designated key areas, forage production, leader growth on browse, vigor on herbaceous)	10	12
Various drought monitors	5	
Cattle Condition		8

Forest Service Responses

Rank 1

- SPI
- Timing and amount of precipitation
- Stock water availability by pasture and allotment
- ERC (Energy Release Component of 1000-Fuels)
- Annuals growth in spring time
- Timing/Intensity of rain events
- Springs/tanks dry up
- Appearance of vegetation (i.e. cactus) water availability
- Forage availability at designated key areas

Rank 2

- Availability of upland water (dirt tanks) vs. Just riparian waters
- Forage production in pounds/acre
- Forage availability and growing conditions (i.e. wet & warm or dry & cool)
- Soil moisture monitoring
- Leader growth on browse species
- Leader growth on browse
- SPI
- Various drought monitors
- Water level in tank (maybe choose a specific tank)

Rank 3

- Vigor of upland indicator plants/forage
- Availability of water sources, springs/tanks
- Last year's conditions or last season's conditions with regard to precipitation
- Frequency and intensity of winter precipitation
- lbs/acre Forage Production

- Plant vigor on herbaceous
- How many fires (plant moisture)
- Info. from permittee
- Cattle body condition

Additional Forest Service Responses

- Cows on their feet all day looking for feed…not settled
- Eat up mineral supplements quicker (body condition)
- Roosevelt Lake level
- SPI
- Drought Palmer Index
- Number of springs going dry and timing

Rancher Responses

Rank 1

- Water use for dust abatement
- Dirt tank water level
- Water level in tanks
- Available drinking water in springs
- Cool season annuals green up / Tobosa green May/June
- Rain fall totals
- Spring outputs
- Height of grass
- Forage condition - landscape
- Tank percentage, full --> low
- Grass growth - green or brown
- Overall forage production
- Condition of animals
- Condition of cows

Rank 2

- Rate of new well drilling
- Cow body condition
- Amount of available forage
- Length of time cattle are up feeding
- Summer perennial grass green up
- Lbs/acre
- Forage quantity/quality
- Distribution (availability) of water
- Cattle condition - body score
- Condition of cows / wildlife reproduction
- Water in Tonto Creek (Irrigation ditch)
- Level of water in steel tanks and streams

- Depth - amount of water in springs and hand-dug wells
- How much feed and browse

Rank 3

- Spring failures on Bohme
- General ground cover condition
- Flow in existing streams and springs
- Rain gauges
- Tank water
- BCS of cattle
- Cattle condition
- Overall health of ranch from one end to other
- Published drought indicators
- Range vegetation conditions / landscape
- Soil moisture
- Body condition of cattle
- Amount of precipitation
- Depth of wells, tanks, and springs

Additional Rancher Responses

- Pit lake evaporation rates

Question 2: What 3 suggestions do you all have that will increase the ability to be flexible, while demonstrating responsibility towards managing the resources of National Forest System lands?

Summary of Responses to Question 2	FS	Rancher
Planning (consider and analyze scenarios in NEPA to apply adaptive management, develop triggers, rational for change in management	12	
Better relationship between ranchers and FS (including viewing allotment together, building trust and empathy, brainstorming together)	4	5
Conservation Stocking	3	
Education		4
Best Pasture		4
Drought triggers to change management		2

Forest Service Responses

Rank 1

- Optimize water distribution
- Prepare contingency table together to cover 95% of risk situation
- Different types of grazing animals
- Ensure all improvements are functional
- Plan ahead
- Set a series of triggers that you will expect to see over time, more triggers is better than fewer
- Documentation that indicates why the change is needed
- Advanced planning with permittee to know where sensitive areas are (TES) so in the event that conditions necessitate early pasture moves - that critical areas are not impacted
- Allow conservative stocking below permit numbers without regard to use requirements

Rank 2

- Consider and analyze scenarios in NEPA to apply adaptive mgmt.
- Stock at lower levels to increase time in pasture
- ID how management will occur - the contingency
- Early conversation between permittee / F.S. on resource issues each have
- Triggers do NOT dictate action, but dictate evaluating condition which may require action (based on the planning ahead)
- Allow adaptability in documents for unforeseen circumstances
- Outlining clearly what is and what is not flexible (outside of laws, policy)
- Additional waters
- Communication with permittee about options on other vacant allotments

Rank 3

- Plan for forage changes that may occur during long-term drought with livestock designed to take maximum advantage of new situation

- Visit the ground with them and visit areas of concern - past use - future pastures
- Ranchers choice - manage stocking conservatively so that changes in conditions, drought do not affected the herd as fast
- Early communication of actions that need to be taken or can be taken
- Riparian pastures
- Decide early to adjust stocking to improve recovery when the drought is over

Additional Forest Service Responses

- Disclosing the degree of flexibility through the NEPA process

Rancher Responses

Rank 1

- It's the way your AOI is worded i.e. next available pastures, instead of Pasture A > B > C
- Eliminate edicts from higher HQ's that prevent decision making at the local level
- Use vacant allotments
- Training to range cons on how flexible they can be
- Better communication!
- Move more often
- Ability to split pasture density
- Open pastures in wilderness areas during extreme drought (take an act of Congress…)
- Make it clear the full flexibility allowed to the decision maker and teach them that they are a PARTNER with the rancher to produce a high output renewable resources and not crumble under the pressure of environmental radicals. Reduce USFS fear, increase their accountability and pride in partnership with ranchers.
- Temporary infrastructures (pipelines, tanks, fence)
- FS guidelines need to be updated to reflect current knowledge, tools, and range science
- Adaptive management
- Brainstorm with Forest Service
- Allow deepen tanks to hold more water

Rank 2

- Come up with triggers of when to react so not do damage resource
- Utilize university/scientific assets to moderate discussion between rancher and USFS
- Utilize multiple pastures
- Giving parameters to ranchers on how flexible the Forest Service can be
- Try to standardize, or simplify the discrepancy in interpretation of FS regulations/rules between districts. FS could compare in-house interpretations between districts
- The measurement for precipitation is too broad, each pasture is different
- Be able to move to more desirable pastures
- Allow scattering for temporary periods
- Best pasture use even if out of rotation
- Be reasonable and empathetic
- Move soon/stay longer, use multiple pastures at same time

- Ability for local FS people to make those flexible decisions so they can be implemented in a timely manner
- Make time in pasture flexible based on forage conditions

Rank 3

- During drought decision must be made quickly - on the spot - eliminate the need for written modifications and changes to AOI, AMPs, etc.
- Supplement on range
- Establishing triggers to when flexibility can be initiated
- Improve trust issues between ranchers and the FS
- FS should come out to view the allotment
- Develop better waters
- Enable temporary waters through regulation
- Spread herd over multiple pastures
- Use real science and data, not ocular assessments or USFS directives
- Add water troughs
- Education - rancher and FS, so they know they can be flexible
- Not close any pastures to use

Additional Rancher Responses

- Speed up the NEPA process by cutting off litigation against the FS/BLM
- Sell public lands to ranchers/loggers/miners with stipulation for continued multiple use
- Dig a canal to the Gulf of Mexico and put in a multi-national desalinization plant that can be used in drought circumstances and for groundwater recharge

Management practices from questions about preparing for and responding to drought, and practices that increased preparedness for drought, from surveys and interviews before the workshop.
Listed by category, ranchers and Forest Service responses combined. Many practices were given in response to two or all three of these questions.

Livestock water development and management	Stocking rate/herd management	Livestock distribution and rotation	Vegetation improvement and monitoring	Planning/collaboration
Develop new waters to improve distribution	Conservative/moderate stocking rate	Flexible rotation	Knowledge of the land and plants on it	Forward planning/always plan for drought
Quickly be able to complete water projects	Have a plan for herd reduction	Allow for recovery of forage plants	Monitoring/Reading the Range	Drought monitoring and forecasting tools
Water storage	Selectively cull to reduce herd size	Rest pastures/rest pastures for a full growing season	Rain gauges	El Niño/La Niña forecasting
Have water improvements in good condition	Reduce or eliminate yearling carry-over	Drought reserve pastures	On the ground observation	Adaptive management/flexibility in grazing plan
Have water available from wells	Early weaning	Allow for grass banks	Reduce vegetation density	Improvements “as necessary” in NEPA for permit renewal
Pumping water through pipeline	Sell calves	Leave forage behind in grazed pastures	Juniper reduction	Contingency plans built into AOI
Have all tanks cleaned out and ready for moisture	Narrow calving window	Identify pastures most likely adversely affected in drought	Return fire to ecosystems	Collaboration among permittees and FS
Deepen and seal dirt tanks	Ability to buy and use supplements	Increase pasture moves, decrease intensity	Seed and feed certified weed-free on “dead spots” to put nutrients and biomass back into soil	Pre-summer meetings between permittees and FS

Fence tanks to control livestock distribution	Placement of salt and supplement	Scatter herd over multiple pastures		Complete projects waiting for NEPA
Solar pumps	Be able to keep core herd	Have pastures (fences, water) ready to move into		Plan for restocking after drought
Work with NRCS and AZ Fish and Game on water development	Have a place off the allotment where cows can be moved	Increase number of pastures		
		Expand grazeable area		
		Graze riparian areas in winter		
		More flexible distribution of salt and minerals		
		Irrigated pastures		
Practices given only in response to questions about responding to drought				
	Move livestock to another allotment	Prepare backup pastures for use		
	Allow feeding of certified weed-free	Use reserve/rested pastures		
		Continuous grazing across entire ranch at low density		
		Temporarily share an allotment with another permittee		

Excerpts from R3 FSH 2209.13 – Grazing Permit Administration Handbook, Chapter 10 – Permits with Term Status. Supplement 2209.13-2015-1. Effective Date February 23, 2015.

R3 Supplement to 2209.13.16

16 - Changes In Grazing Permits.

The following supplements advice in the parent text:

Changes in term grazing permit terms and conditions may be made by modification, suspension, or cancellation. Such changes are most commonly made to:

1. Achieve resource management objectives.
2. Comply with requirements of or changes to applicable laws, regulations, national forest or national grassland LMPs, NEPA-based decisions, AMPs, agency policies and procedures, and other legally binding documents.
3. Adapt to changed rangeland resource conditions.
4. Enhance permittee compliance with permit terms and conditions.

If the proposed changes are within the scope and range of effects considered in a current NEPA analysis and decision for the authorization of grazing, additional or new NEPA analysis is not required. If there are any question relating to consistency of the NEPA decision, Chapter 10, Section 18 of FSH 1919.15 provides guidance for review of the original NEPA analysis, documentation, and decision. R-3 form R3-2200-27 (Review Of Existing Grazing Allotment, Project –Level NEPA-Based Decisions), has been provided as a tool for completing Section 18 reviews of existing NEPA analyses and decisions for grazing allotments. If a proposed modification or issuance of a new or revised term grazing permit is outside these parameters, then an updated NEPA analysis and decision may be needed in accordance with FSH 2209.13, Chapter 90, and the current R-3 supplement to this FSH directive.

R3 FSH 2209.13 section 16.16

16.16 – Annual Changes In Grazing For Trial Periods.

A temporary change in number, kind, class of livestock, grazing management, or season of use from that shown on the term permit may be approved by the Authorized Officer if determined to be consistent with the Forest Land Management Plan and if the changes are determined to benefit management of the rangeland resource. Annual changes of this nature should be authorized through the annual operating instructions, annual application for grazing, and subsequent annual Bill for Collection for trial periods normally not to exceed 1-2 consecutive years. This period of time should be sufficient to determine if the changes should be made on a permanent basis and to make estimates of grazing capacity and appropriate permanent changes in the grazing authorization and permit. Within the 1-2 year trial period or shortly thereafter, a NEPA analysis and decision authorizing grazing and incorporating the changes in number, kind, class of livestock, grazing management, or season of use must be completed. Upon completion of the NEPA analysis and decision the term grazing permit should then be modified or reissued to reflect the changes consistent with the NEPA analysis and decision authorizing the revised grazing activity on a permanent basis.

R3 Supplement to 2209.13.19.1

19.1 – Drought Guidelines.

Drought is an inevitable occurrence in the southwestern United States. The question for land managers is not *will* drought occur, but *are land managers prepared for drought*? Land managers and grazing permittees, must plan for drought as a normal part of management and business. The Standardized Precipitation Index (SPI) is a unit of measure that compares recent precipitation values for a period of interest with long term historical values to assess moisture conditions in a given area. In the Southwestern Region, anytime the SPI reaches a value of minus 1.00 or less for the preceeding 12 month period, grazing allotments should be evaluated for existing drought conditions.

It is imperative that land managers understand how drought affects plants, thereby affecting rangeland resources and how management can buffer the consequences of drought. It is equally imperative to communicate the effects of drought and the associated management actions taken to buffer those consequences.

Drought effects are varied, depending upon the attribute being reviewed. On an individual plant basis, vigor and reproductive ability may be hampered. On a landscape scale, various species within a vegetation community may be affected differently, thereby affecting community dynamics amongst plants, soil conditions, and water quantity and quality.

A diversity of factors should be considered when devising management actions on the National Forests in the Southwestern Region. Such factors would include species diversity, past grazing use, timing of grazing, intensity of management, and conditions of improvements to support grazing activities. These factors along with precipitation data provide flexibility to the line officer to make decisions based on recommendations from district rangeland management specialists.

Livestock Grazing Guidelines consist of four elements.

1. <u>Drought Evaluation</u>.

   a. The Regional Forester will monitor trends in the SPI in order to provide Forest Supervisors and District Rangers adequate time to begin discussions with the livestock industry and grazing permittees before viable options for coping with drought conditions are foregone.

   b. Anytime the SPI reaches a value of - 1.00 or less for the preceeding 12 month period, grazing allotments will be evaluated for the existence of drought conditions.

   c. When drought conditions have been identified, Forest Supervisors will evaluate grazing allotments for drought related conditions from an interdisciplinary perspective.

d. Although SPI may not have reached – 1.00, for the preceding 12 month period, Forest Supervisors may evaluate grazing allotments for apparent drought conditions.

e. When the SPI for the preceding 12 month period becomes positive rangeland resources may be evaluated for indications of recovery of drought conditions.

2. Management Process

a. Vegetation resources affected by drought across the Forest will be evaluated from an interdisciplinary perspective.

b. Drought evaluation should result in recommended management actions needed to protect rangeland resources.

c. Factors considered in evaluations include, but are not limited to, local precipitation data and departures from normal, current range management status, current stocking levels, available water, and management intentions of the permittee.

d. District Rangers have the responsibility to consider recommendations from drought evaluations and implement appropriate management in consultation with affected permittees.

e. Drought evaluations should be conducted periodically to reassess conditions and evaluate the need for further action.

3. Stocking During and After Drought

a. District Rangers will consider stocking levels on allotments based on precipitation events, and allotment specific conditions in collaboration with livestock permittees.

b. Stocking levels should consider circumstances such as: drought-induced mortality thereby reducing forage produced per acre, species diversity, plant vigor, condition of range improvements, management intensity, and availability of water.

c. Management following drought should be devoted to allowing for the recovery of the rangeland vegetation.

(1) This means providing for improved plant vigor and restoring soil cover through plant litter.

(2) Focusing on recovery of the resource through rest or incremental restocking will ensure more rapid and longer lasting recovery from drought.

d. General recommendations for drought recovery.

(1) Rest pastures for at least one entire growing season or more following severe droughts.

(2) Use pastures when key forage species are dormant for at least one growing season.

(3) Defer grazing until key forage species have produced mature seed.

(4) Assess various attributes of an allotment prior to making decisions regarding restocking.

(a) Plant vigor- The relative robustness of a plant in comparison to other individuals of the same species.

(b) Current forage production- The amount of forage currently produced usually expressed as pounds of herbaceous forage per acre.

(c) Multiple Use Values- The other values provided for by rangeland resource, i.e. wildlife habitat, and aesthetics.

(d) Permittees ability to restock- The ability of the permittee to place livestock on the allotment. This could be related to such items as current herd size, available labor, and current condition of range improvements.

4. Communication Plan. Most permittees will want to protect the grazing resource, which they are dependent upon. Early communication provides them maximum time to develop alternatives for their operations and provide suggestions to the Forest Service. Consistent effective communication with others, such as NRCS, FSA, BLM, State, Local, and Tribal Governments as well as non-governmental organizations regarding effects of drought, and potential collaborations is essential.

a. Drought related communications involving multiple Forests will be coordinated by Forest Supervisors with assistance from the Regional Forester as requested.

b. Communications concerning rangeland management during and after drought on individual Forests will be coordinated by Forest Supervisors.

c. District Rangers will initiate communication with grazing permittees at the first sign management changes may be needed due to drought.

d. Management due to drought must be approached in a collaborative manner between district personnel and permittees.

19.4 – References. (includes)

Howery, Larry. 1999. Rangeland Management Before, During, and After Drought. University of Arizona Cooperative Extension AZ1136.
http://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1136.pdf

Title:
Ranchers, Forest Service, and University of Arizona are co-developing approaches to improve planning for drought on public lands

Prepared by:
Julie Brugger
Institute of the Environment
University of Arizona
julieb3@email.arizona.edu

and

Mitchel McClaran
School of Natural Resources and the Environment
University of Arizona
mcclaran@u.arizona.edu

Drought threatens livestock and natural resources on rangelands. It reduces rain-fed forage and drinking water for livestock, diminishes the quantity and quality of critical water resources for sensitive wildlife species, and increases wildfire risk. While all agree that improved planning will minimize the impacts from the next drought, agreeing on the best practices to reach that goal is harder. Disagreement can be quite intense on the 90 million acres of rangelands that are federally owned and managed by the U.S. Forest Service (FS) and grazed by livestock belonging to private ranchers with grazing permits.

One case in point occurred in 2002 in the Tonto National Forest in central Arizona, when the Forest Service required the removal of all livestock during what was the worst drought in the historic record. Dialog between the parties was heated, and some animosity remains. But today, both ranchers and land managers want to improve planning for drought in order to avoid a similar scenario in the future. In an interview prior to a March 2015 workshop, a rancher expressed his vision for what should happen when the next severe drought occurs:

> What you would hope for, and hopefully what this drought workshop is working toward, is to bring the proper people together, and each ranch should be treated individually. … If I can sit down with the land management agency, in this case the Forest Service, and say, "Come on out. Let me show you where I intend to go and what I can do, and there's water here," and so forth, then that's the way I believe it should be done. If we're all talking on the same page, if we're all looking at the same data on a national level, from NOAA and so forth, the climatologists, et cetera, and we get them involved, and we have the land management agency, and the ranchers are much more cognizant of what this drought is, you come together and sit down and talk, maybe we can figure out some ways. Maybe we can educate even ranchers about what you should do to prepare for the drought.

To support that desire for better planning, a team from the University of Arizona (UA) is working with ranchers and the Tonto National Forest to co-develop approaches that are 1) feasible for ranchers and 2) consistent with the federal policies that define management options for the National Forest. The project is funded by the National Oceanic and Atmospheric Administration's (NOAA) Sectoral Applications Research Program (SARP) Coping with Drought program.

In this case, co-development is the engagement of ranchers and Forest Service personnel to define the issues and identify possible solutions, rather than the UA or anyone else coming with pre-determined solutions and then convincing the other parties to adopt them.

The UA team conducted surveys and interviews designed to support a series of workshops over the two years of the project. The surveys and interviews identified the different ways that ranchers and the Forest Service perceive threats from drought. Both parties shared interests in learning more about how to better plan for drought. Those responses helped define the activities in the first workshop held in March 2015 with 17 ranchers and 11 managers from the Tonto National Forest.

The first workshop was designed to provide information and stimulate discussion among participants, and that input will help define the drought scenarios that will be analyzed in the second workshop, scheduled for August 2015. A final workshop will occur in April 2016.

The ultimate product will be a *Guide to Drought Planning and Response for Livestock Management on Forest Service Lands in the Southwestern US*, similar to the to the publication, *Managing Drought Risk on the Ranch: A Planning Guide for Great Plains Ranchers*, produced by the National Drought Mitigation Center (http://drought.unl.edu/ranchplan/Overview.aspx). The Guide will provide a framework to facilitate ranchers and the Forest Service working together to explore options to improve planning for drought.

Mitch McClaran, professor of range management at UA, opened the first workshop by explaining the co-development process (see Figure 1) and the challenges and opportunities for ranchers and FS managers working together. One of the challenges is that ranchers and the FS have different concerns and perceive each other as creating risk for managing livestock in the Tonto National Forest. For ranchers, the top three risks were the FS, drought, and federal regulations. For the FS, the top risks were drinking water reliability, livestock practices, and drought. Some of the opportunities are: 1) both groups want to learn more about drought information sources, drought management practices, and the FS administrative process; 2) both groups feel that management flexibility can help and drought plans can help, and; 3) both groups want to participate in these workshops to improve livestock management during drought.

Mike Hayes, director of the National Drought Mitigation Center, and Mike Crimmins, UA Climate Extension specialist, gave a presentation on drought information tools. Hayes gave an

introduction to drought risk management and the U.S. Drought Monitor (see Figure 2), and Crimmins presented the idea of a web-based "drought monitoring dashboard" for the Tonto National Forest that would provide easy access to a variety of drought monitoring tools that ranchers and the FS agree are most useful. In the workshop evaluations, one of the FS participants said she "learned a lot about data sources for monitoring changes in temp, precip, climate change, and drought conditions."

Judith Dyess, assistant director of Rangeland Management for the FS Southwestern Region, described opportunities for incorporating flexibility into the FS administrative framework for managing livestock grazing on national forests. Finally, Doug Tolleson, Range Management Extension specialist at UA, gave an introduction to scenario analysis and led a discussion of livestock management practices that can increase flexibility during drought (see Figure 3).

Overall, the first workshop met its goals. It introduced participants to each other and to the objectives of the project, provided them basic information on background policy conditions and existing drought decision support tools, and began the process of identifying common goals. Analyses of transcriptions, workshop notes, and an evaluation survey indicate that significant progress was made in eliciting new ideas to support the co-development of practices to improve drought planning for the Tonto National Forest.

Figure 1: Co-development process

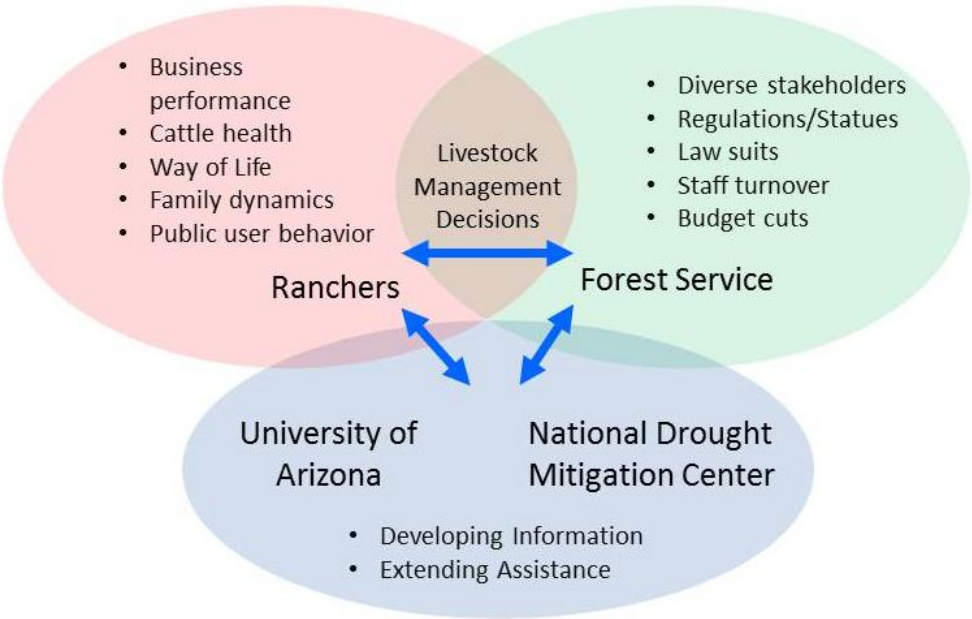


Figure 2: Mike Hayes presentation.

Figure 3: Participants writing responses to questions about livestock management practices.

Nat Hazards
DOI 10.1007/s11069-015-1834-3

ORIGINAL PAPER

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

Mitchel P. McClaran[1] · Greg J. Butler[1] · Haiyan Wei[1] · George D. Ruyle[1]

Received: 31 December 2014 / Accepted: 30 May 2015
© Springer Science+Business Media Dordrecht 2015

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

Electronic supplementary material The online version of this article (doi:10.1007/s11069-015-1834-3) contains supplementary material, which is available to authorized users.

✉ Mitchel P. McClaran
mcclaran@u.arizona.edu

[1] School of Natural Resources and the Environment, University of Arizona, Tucson, AZ 85721, USA

Published online: 10 June 2015

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.

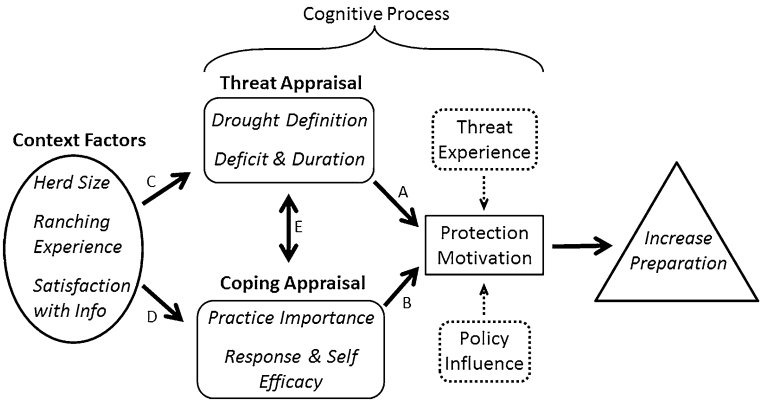


Fig. 1 Protection motivation theory model of cognitive process applied to understanding the motivation to increase preparation for drought by livestock ranchers (modified from Grothmann and Reusswig 2006; Stewart 2009). Variables in *italics font* were measured in this study. Variables in *dashed boxes* 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

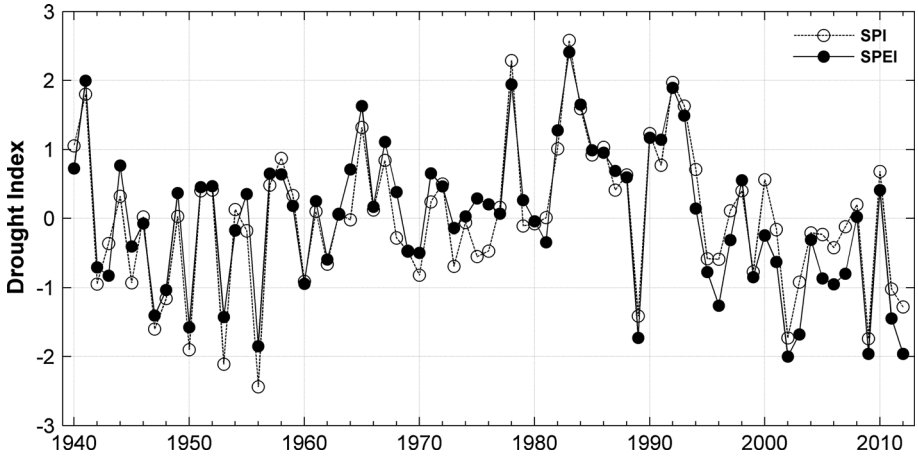


Fig. 2 Yearly values of Standardized Precipitation Index (SPI) and Standardized Precipitation and Evapotranspiration Index (SPEI) for southeastern Arizona, USA, 1940–2012. Values within 31.3° and 33.8° North, and 109.0° and 111.6° East were obtained from PRISM Climate Group (2014) to calculate these 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 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
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

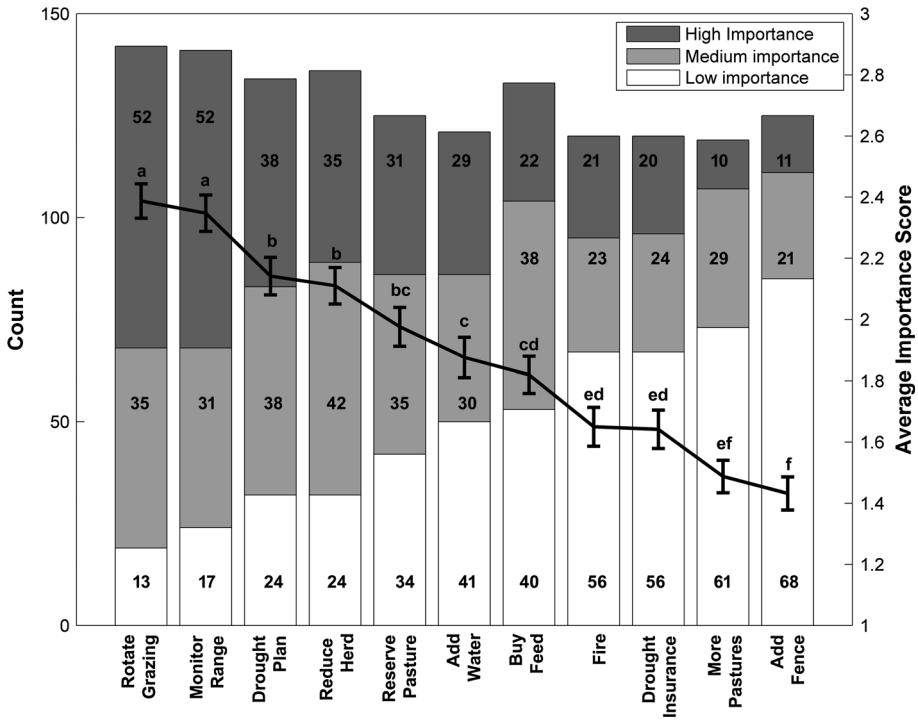


Fig. 3 Count and weighted average importance for 11 coping practices to prepare for drought. Values within columns show the proportion of responses in the *High, Medium* and *Low Importance categories*. Weighting values were "1", "2," or "3" to Low, Medium, and High Importance, respectively. Vertical 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 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
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.

Acknowledgments Research funded by US Department of Agriculture (USDA)-Cooperative State Research, Education, and Extension Service Conservation Effects Assessment Project (CEAP) Program, USDA-Agricultural and Food Research Institute Climate Change Program, and Arizona Agricultural Experiment Station. A. Bowen provided especially helpful suggestions about the Protection Motivation Theory, and M. Crimmins provided helpful suggestions on the manuscript. Two anonymous reviewers provided constructive comments that improved the manuscript.

References

Alllison PD (2012) Logistic regression using the SAS system: theory and application, 2nd edn. AS Institute, Cary 339

Ashraf M, Routray JK, Saeed M (2014) Determinants of farmers' choice of coping and adaptation measures to the drought hazard in northwest Balochistan, Pakistan. Nat Hazards 73:1451–1473

Bartlett ET, Torell LA, Rimbey NR, Van Tassell LW, McCollum DW (2002) Valuing grazing use on public land. J Range Manag 55:426–438

Bastian CT, Mooney S, Nagler AM, Hewlett JP, Paisley SI, Smith MA, Frasier WM, Umberger WJ (2006) Ranchers diverse in their drought management strategies. West Econ Forum 5(2):1–8

Beguería S, Vicente-Serrano SM (2009) SPEI calculator. http://digital.csic.es/handle/10261/10002. Accessed in Aug 2014

Briske DD, Sayer NF, Huntsinger L, Fernandez-Gimenez M, Budd B, Derner JD (2011) Origin, persistence, and resolution of the rotational grazing debate: integrating human dimensions into rangeland research. Range Ecol Manag 64:325–334

Butler GJ (2012) Perceptions of drought: how ranchers in Arizona prepare for and respond to drought. MS Thesis, University of Arizona

Coles AR, Scott CA (2009) Vulnerability and adaptation to climate change and variability in semi-rural southeastern Arizona, USA. Nat Resour Forum 33:297–309

Coppock DL (2011) Ranching and multiyear droughts in Utah: production impacts, risk perception, and changes in preparedness. Rangel Ecol Manag 64:607–618

Dagel KC (1997) Defining drought in marginal areas: the role of perception. Prof Geogr 49:192–202

Dillman DA (2000) Mail and internet surveys: the tailored design method. Wiley, New York

Dunn B, Smart A, Gates R (2005) Barriers to successful drought management: why do some ranchers fail to take action? Rangelands 27(2):13–16

Eakin H, Conley J (2002) Climate variability and the vulnerability of ranching in southeastern Arizona: a pilot study. Clim Res 21:271–281

Fernandez-Gimenez ME, Ruyle G, McClaran SJ (2005) An evaluation of Arizona cooperative extension's rangeland monitoring program. Rangel Ecol Manag 58:89–98

Floyd DL, Prentice-Dunn S, Rogers RW (2000) A meta-analysis of research on protection motivation theory. J Appl Soc Psychol 30:407–429

Foran BD, Stafford Smith DM (1991) Risk, biology, and drought management strategies for cattle stations in central Australia. J Environ Manag 33:17–33

Gates RN, Dunn BH, Davis J, Arzeno A, Beutler M (2007) Strategic and scenario planning in ranching: managing risk in dynamic times. In: EC924. South Dakota State University Extension Service

Grothmann T, Patt A (2005) Adaptive capacity and human cognition: the process of individual adaptation to climate change. Glob Environ Change 15:199–213

Grothmann T, Reusswig F (2006) People at risk of flooding: why some residents take precautionary action while others do not. Nat Hazards 38:101–120

Hayes MJ, Wilhelm OV, Knutson CL (2004) Reducing drought risk: bridging theory and practice. Nat Hazards Rev 5:106–113

Kerna A, Frisvold G, Tronstad R, Teegerstrom T (2014) The contribution of the beef industry to the Arizona economy. University of Arizona Cooperative Extension. http://cals.arizona.edu/arec/pubs/beefindustryeconcontrib.html

Koerth J, Vafeidis AT, Hinkel J, Sterr H (2013) What motivates coastal households to adapt pro-actively to sea-level rise and increasing flood risk? Reg Environ Change 13:897–909

Le Dang H, Li E, Nuberg I, Bruwer J (2014) Farmers' assessment of private adaptive measures to climate change and influential factors: a study in the Mekong Delta, Vietnam. Nat Hazards 71:385–401

Lubbell MN, Cutts BB, Roche LM, Hamilton M, Derner JD, Kachergis E, Tate KW (2013) Conservation program participation and adaptive rangeland decision-making. Rangel Ecol Manag 66:609–620

Marshall NA, Smajgl A (2013) Understanding variability in adaptive capacity on rangelands. Rangel Ecol Manag 66:88–94

Marshall NA, Gordon IJ, Ash AJ (2011) The reluctance of resource-users to adopt seasonal climate forecasts to enhance resilience to climate variability on the rangelands. Clim Change 107:511–529

McClaran MP, Wei H (2014) Recent drought phase in a 73-year record at two spatial scales: implications for livestock production on rangelands in the southwestern United States. Agric For Meteorol 197:40–51

Miller MM (2005) Drought efects on the ranching industry in southeastern Colorado. Rangelands 27(2):17–18

National Agricultural Statistics Service (2014) U.S. Agricultural Census, 2012. Cattle and Calves—Inventory and Sales. US Department of Agriculture. http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/Arizona/st04_2_011_011.pdf

NDMC (National Drought Mitigation Center) (2012) Program to Calculate Standardized Precipitation Index. http://drought.unl.edu/MonitoringTools/DownloadableSPIProgram.aspx. University of Nebraska-Lincoln, National Drought Mitigation Center

NDMC (National Drought Mitigation Center) (2013) Managing drought risk on the ranch: a planning guide for great plains ranchers. University of Nebraska-Lincoln, National Drought Mitigation Center

Olsson U (1979) Maximum likelihood estimation of the polychoric correlation coefficient. Psychometrika 12:443–460

PRISM Climate Group (2014) PRISM climate data. Oregon State University. http://prism.oregonstate.edu. Accessed Aug 2014

Reynolds JF, Stafford Smith DM, Lambin EF, Turner BL II, Mortimore M, Batterbury SPJ, Downing TE, Dowlatabadi H, Fernandez RJ, Herrick JE, Huber-Sannwald E, Jiang H, Leemans R, Lynam T, Maetre FT, Ayarza M, Walker B (2007) Global desertification: building a science for dryland development. Science 316:847–851

Safriel U, Adeel Z, Niemeijer D, Puigdefabregas J, White R, Lal R, Winslow M, Ziedler J, Prince S, Archer E, King C (2005) Dryland systems. In: Hassan R, Scholes R, Ash N (eds) Ecosystems and human well-being: current state and trends: findings of the condition and trends group. Island Press, Covelo, pp 346–623

SAS (2013) SAS software, version 9.4 for Windows. SAS Institute Inc., Cary

Stafford Smith DM, McKeon GM, Watson IW, Henry BK, Stone GS, Hall WB, Howden SM (2007) Learning from episodes of degradation and recovery in variable Australian rangelands. Proc Natl Acad Sci 104:20690–20695

Stewart AE (2009) Psychological perspectives on adaptation to weather and climate. In: Ebi KL, Burton I, MacGregor G (eds) Biometeorology for adaptation to climate variability and change. Springer, New York, pp 211–232

Tolleson DR (2013) Strategic drought scenario planning. Arizona Cattlelog 67(4):12–14

Torell LA, Murugan S, Ramirez OA (2010) Economics of flexible versus conservative stocking strategies to manage climate variability risk. Rangel Ecol Manag 63:415–425

Webb NP, Stokes CJ, Marshall NA (2013) Integrating biophysical and socio-economic evaluations to improve the efficacy of adaptation assessments for agriculture. Glob Environ Change 23:1164–1177

Weber E (2006) Experience-based and description-based perceptions of long-term risk: why global warming does not scare us (yet). Clim Change 77:103–120