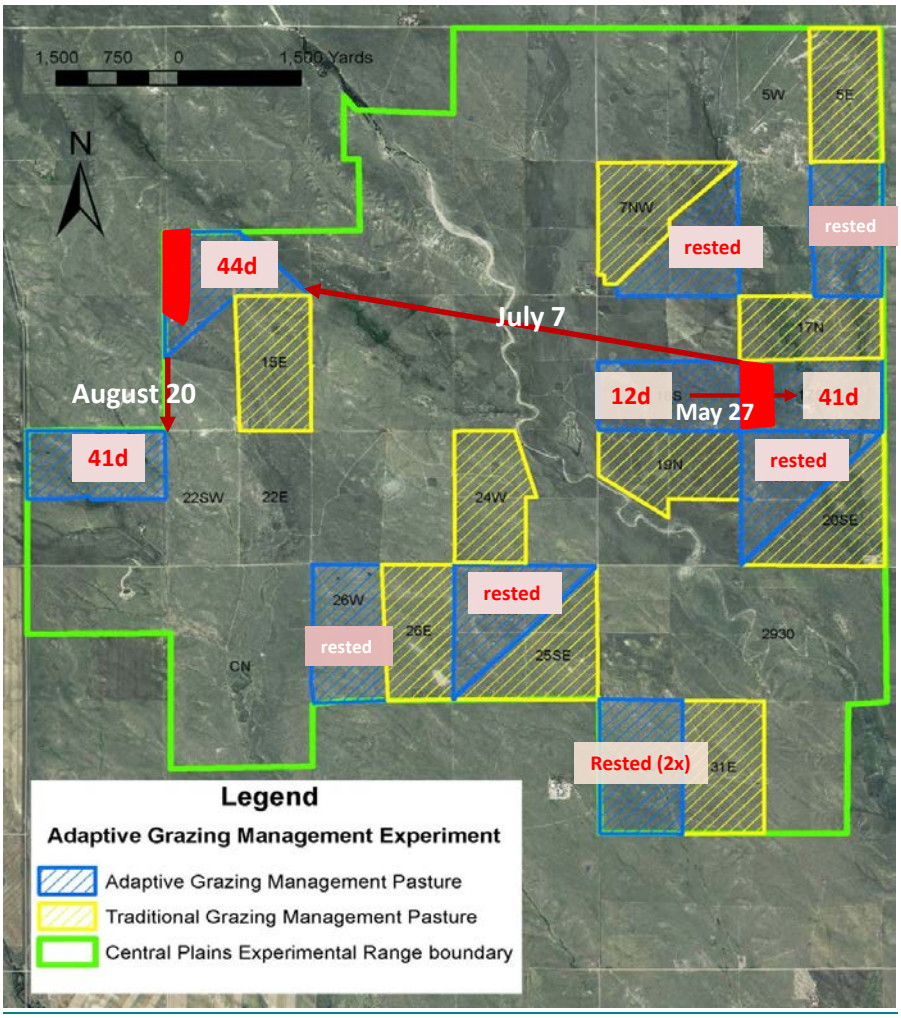
Adaptive Grazing Management Plan:
~~May 1~~October 15, 2015



Pastures of the Adaptive Grazing Management experiment at the Central Plains Experimental Range, near Nunn, CO. Solid red polygons show the locations of patch burns implemented during December, 201~~4~~5.

Adaptive Grazing Management website:
http://www.ars.usda.gov/Main/Docs.htm?docid=24218

Summary

This document provides a current draft (February, 2015) of the Adaptive Grazing Management Plan for the Adaptive Grazing Management (AGM) experiment at the Central Plains Experimental Range (CPER). The research team developed this current draft based on recommendations from the Stakeholder Group that previously met 1) September 18-19, 2012, 2) January 10, 2013, 3) September 10, 2013, 4) January 16, 2014, and 5) April 23, 2014, 6) September 9, 2014, and 7) January 14, 2015, ~~and~~ 8) April 27, 2015, and 9) October 2, 2015.~~.~~

The following list has been agreed upon by the Stakeholder Group in prior meetings and serves to guide further decision-making for this experiment:

1) desired goals and objectives (Figure 1),
2) consideration of management strategies (Figure 2)
3) understanding of the characteristics of the available ecological sites (Table 1),
4) the amount of area of ecological sites in each pasture (Table 2),
5) the ten 320-acre AGM pastures (total of 3,200 acres) will be managed as a single group of pastures, with the acknowledgement that there are some pastures dominated by Sandy Plains ecological sites (which have strong potential to restore desired cool-season species, such as needle-and-thread grass, western wheatgrass and saltbush – likely to emphasize grazing these pastures outside of critical growth periods for cool-season perennial grasses and shrub reproduction when possible), other pastures are dominated by Loamy Plains ecological sites (mostly dominated by blue grama, with less potential for restoration of desired cool-season species but are expected to be resistant to further losses of desired species), and there are some pastures with mixed (combination of Sandy and Loamy),
6) 2 of the 10 AGM pastures each year will be planned for entire rest (no grazing) for accumulating forage (i.e., grassbanking), promoting increased vegetation heterogeneity, and possibly restoring cool-season perennial grasses and saltbush. It is anticipated that rest would be rotated among pastures such that over a 5 year period, each pasture would experience 4 years of grazing with high stock density and 1 year of rest (Figure 4).
7) A decision-tree approach has been determined for triggers for entering and exiting an AGM pasture (Figure 6).
8) A decision-tree approach has been determined for assisting with within-season adaptations to the planned grazing sequence (Figure 5).

Stakeholder Group Decision Making Process

At the April 14, 2014 Stakeholder Meeting, the group discussed an approved a formal process form making decisions concerning the management plan. It was agreed that this process would be used for making strategic (long-term) and tactical (for the upcoming growing season) decisions at stakeholder meetings, with the recognition that some short-term decisions during a given grazing season may need to be addressed quickly through email or made by the CPER cattle managers. The agreed upon decision making process is:

1) Stakeholders will strive for consensus on decisions

2) When consensus is not achieved, discussions should include rationale and reasons for dissent should be recorded.

3) To make decisions based on a vote, a quorum of at least 6 stakeholders must be present.

4) Stakeholders attending by conference call will be counted as present.

5) Decisions decided by a vote will require support from a supermajority consisting of 75% of the stakeholders who are present.

Process for replacement of stakeholders if necessary:

1) If a stakeholder resigns, the research team will ask the organization to appoint a replacement
2) The replacement will participate for a 1-year trial period before becoming a a permanent member
3) If the organization cannot appoint a replacement, the research team will consult with the stakeholder on who to approach in a different organization to fill the role.

Current Stakeholder Board:

Name	Organization	At ~~Jan~~ Oct 2015 Meeting?
Leonard Ball ~~(alt: Andy Lawrence)~~	Crow Valley Livestock	Yes
Dana Bowman	Crow Valley Livestock	Yes
Steve Anderson	Crow Valley Livestock	Yes
Jason Kern (alt: Andy Lawrence)	Crow Valley Livestock	Yes (AL)
Ted Toombs	Environmental Defense Fund	Yes
~~Gillian Bee~~Angela Dwyer	~~Rocky Mtn Bird Observatory~~Bird Conservancy of the Rockies	Yes
Rachel Murph	NRCS	Yes
Terri Schultz	The Nature Conservancy	
Kim Obele	US Forest Service	Yes
~~Casey Matney~~Position vacant	Colorado State Univ. Extension	

To be invited as additional (11th) stakeholder: Matt Pollard, State Land Board

Replacement for Matney to wait until CSU hires a new person for his position.

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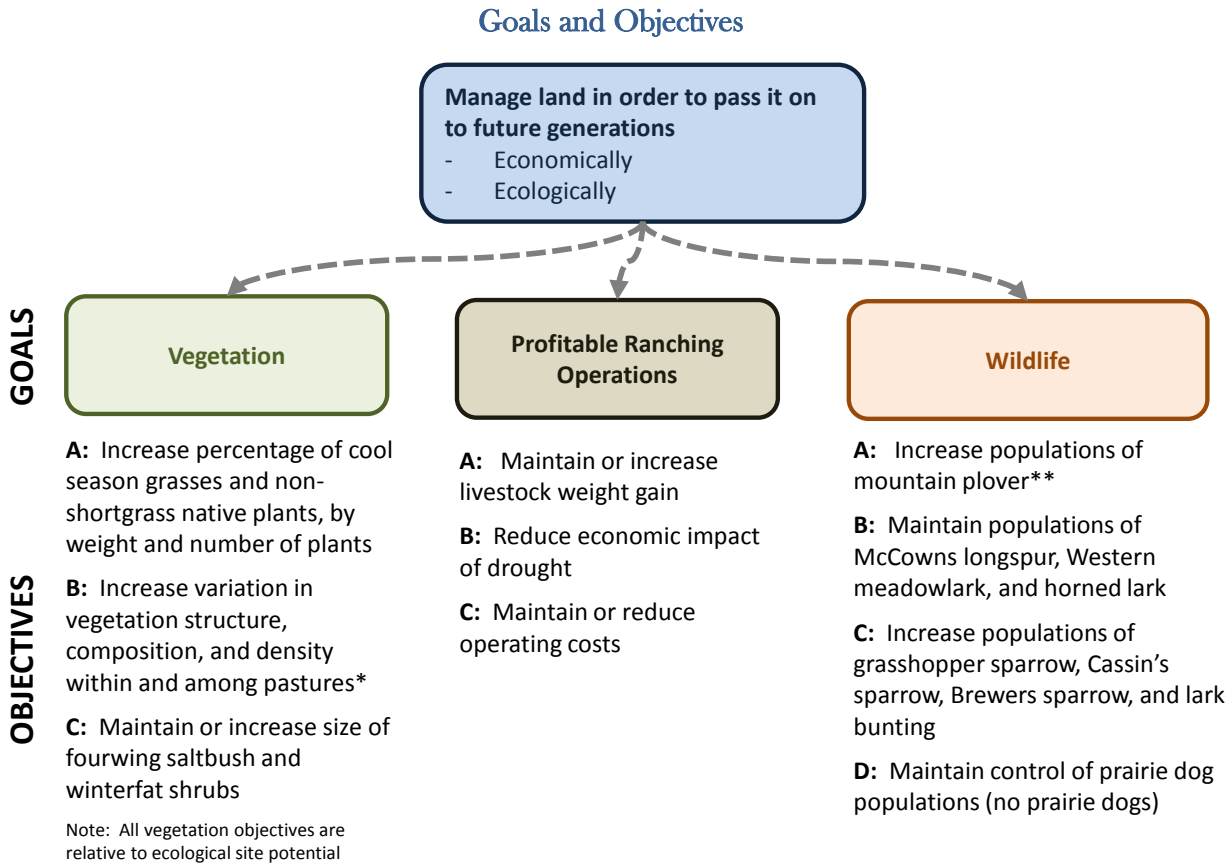


Figure 1

Figure 1. Goals and objectives identified by the Stakeholder Group in the Adaptive Grazing Management Workshops.

* "Composition" was added to this objective here because it was included in the discussion of this objective at the workshops.
** Wildlife objective A was combined with objective B in the workshops, but is split out here because strategies identified for mountain plover habitat were different from those identified for the other three species. Also, while a previous version of this objective read "maintain or increase", it reads "increase" here because many individuals and several of the proposed plans showed commitment to increasing mountain plover habitat in the experimental pastures.

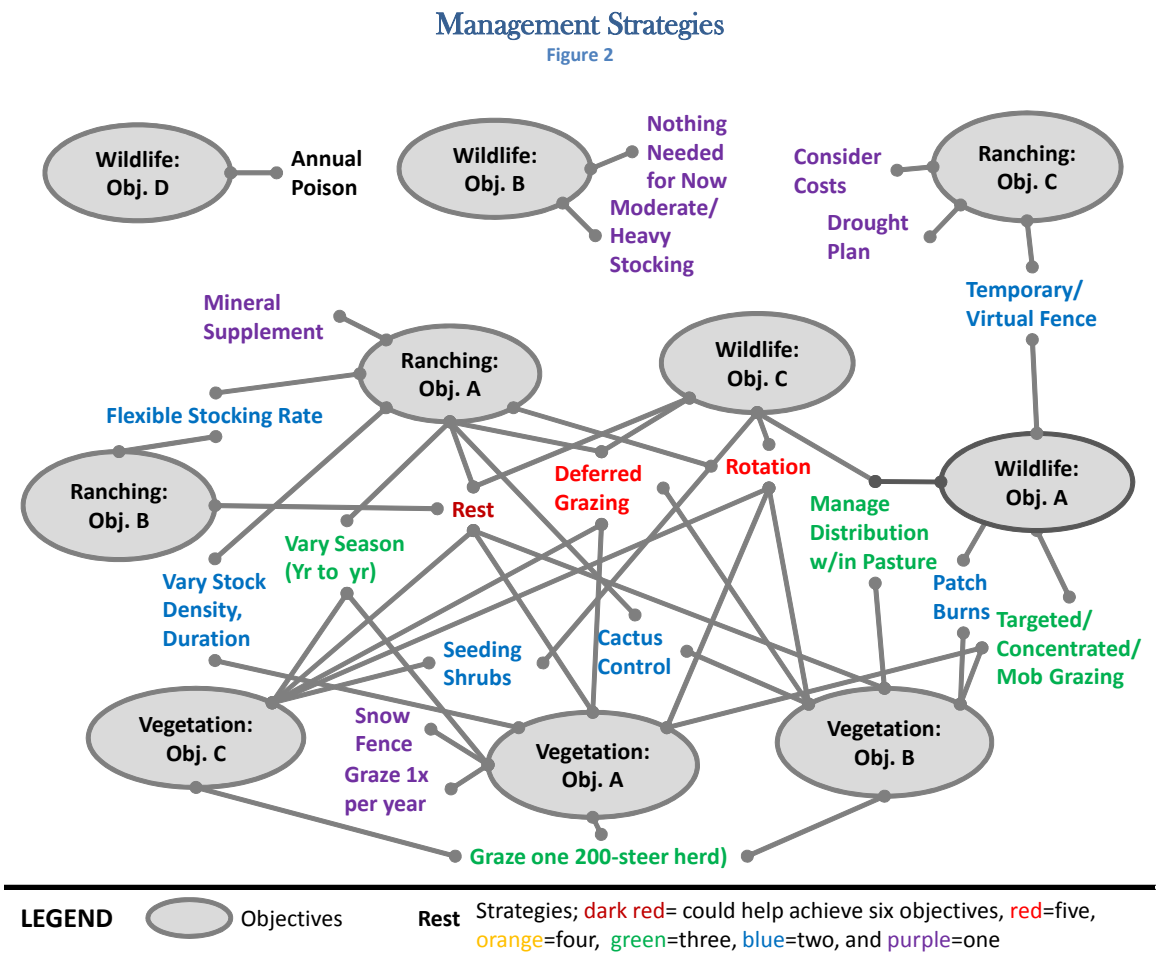


Figure 2. Management strategies suggested for each objective by the Stakeholder Group in the Adaptive Grazing Management Workshops. Strategies are color coded according to the number of different objectives they were suggested for.

Site Characteristics

The 15,500 acre USDA Agricultural Research Service Central Plains Experimental Range (CPER) is the study site. Mean annual precipitation of 12.6 inches, greater than 80% of which occurs from April through September. Soils are primarily Aridic Argiustolls and Ustic Haplargids. Vegetation is dominated by the warm-season grasses blue grama (*Bouteloua gracilis*) and buffalograss (*Bouteloua dactyloides*). Other common species are the cool-season graminoid needleleaf sedge (*Carex duriuscula*), the perennial forb scarlet globemallow (*Sphaeralcea coccinea*) and prickly pear cactus (*Opuntia polycantha*). Desirable cool-season perennial grasses (needle and thread, *Hesperostipa comata*, and western wheatgrass, *Pascopyrum smithii*) and the shrub saltbush (*Atriplex canescens*) represent a minor component of the plant community, and are key species for restoration efforts (Table 1).

Background Information

This long-term (minimum of ten years) planned experiment will use 10 pairs of 320 acre pastures at the CPER (20 pastures total). Pastures were paired on the basis of similarity in the relative amount of different ecological sites (Loamy Plains, Sandy Plains, Salt Flat, see Table 1), mean pasture topographical wetness index (TWI), as well as prior management history of season-long grazing at moderate stocking rates (see Table 2 for summary of pasture pairs). One pasture in each pair was randomly assigned to a traditional grazing management treatment (TGM or control), while the other pasture in each pair was assigned to an adaptive grazing management treatment (AGM).

Objectives

Desired objectives of the AGM treatment, defined as grazing with high stock density (one large herd) grazing and periodic rest (1 in every 5 years), were determined by the Stakeholder Group, and are in three focal areas (see Figure 1):

1) Vegetation
    a. Increase percentage of cool-season grasses and non-shortgrass native plants, by weight and number of plants
    b. Increase variation in vegetation structure, composition and density within and among pastures
    c. Maintain or increase size of four-wing saltbush and winterfat shrubs
2) Profitable Ranching Operations
    a. Maintain or increase livestock weight gains
    b. Reduce economic impact of drought (by having full grazing seasons and not having to remove cattle early due to drought)
    c. Maintain or reduce operating costs
3) Wildlife
    a. Increase populations of mountain plover
    b. Maintain populations of McCown's larkspur, Western meadowlark, and horned lark
    c. Increase populations of grasshopper sparrow, Cassin's sparrow, Brewers sparrow, and lark bunting
    d. Maintain control of prairie dog populations (no prairie dogs)

Adaptive Grazing Management Plan Components

The Stakeholder Group identified common themes for moving livestock among pastures. These include:

1) Pastures (n=2) will be planned to be rested (no grazing) for at least one full growing season; this rest will be rotated among pastures across years. These pastures will serve as grassbanks for drought management, as well as where additional management practices (e.g., prescribed fire) can be implemented (note: same management practices will have to be implemented in the paired control pastures)
2) rotation of 1 herd of cattle (214 head of yearlings for herd size) through the AGM pastures, with timing of grazing in a pasture altered across years(Figure 3)
3) using rested pastures as emergency feed in drought management plans and to achieve conservation goals in normal and wet years (i.e., grassbanks) (Figure 4)
4) incorporating fundamental understanding of the ecological sites (Loamy, Sandy, Saline Flats) for grazing management decisions as these sites have different productivity levels, plant composition and potential for achieving desired objectives (Tables 1 and 2)

Table 1. Ecological site, vegetation state, potential for restoration of dominant cool-season perennial grasses and shrubs (primarily saltbush), and total annual production (air-dry weight, pounds/acre) at the Central Plains Experimental Range. Ecological sites are arranged from most to least productive (from http://esis.sc.egov/usda.gov, Ecological Site Descriptions).

			Total Annual Production (pounds/acre)		
Ecological Site	Vegetation State	Restoration Potential	unfavorable	average	above-above
Salt Flat	Alkali sacaton, western wheatgrass, blue grama, green needlegrass, four wing saltbush	high	500	1100	1800
Sandy Plains	Increased blue grama	high	400	900	1200
Loamy Plains	Blue grama/buffalograss sod with cool-season remnants	low	200	700	900
Shaly Plains	Increased blue grama with remnant mid-warm/cool season grasses and shrubs	low	300	650	950

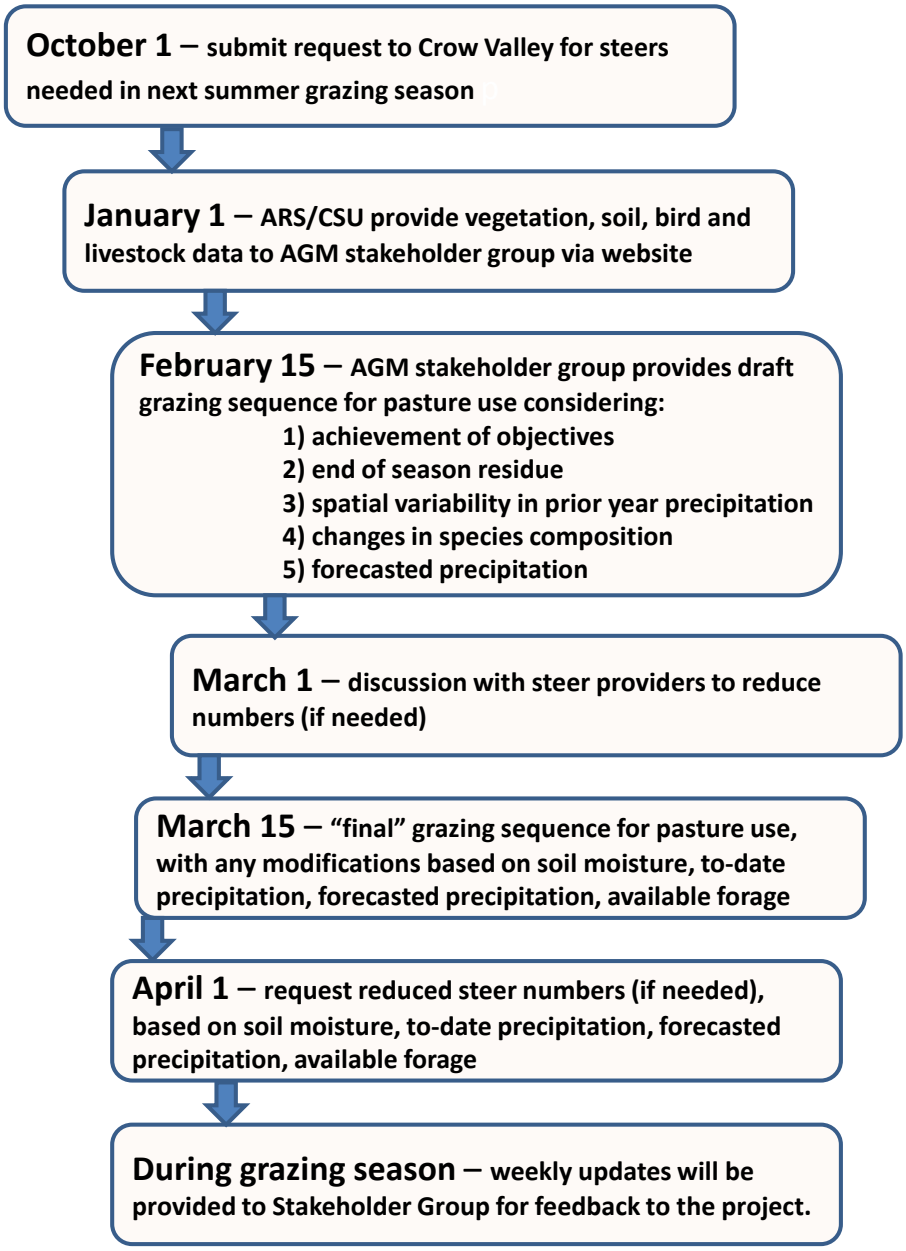
Table 2. Summary of percentage of ecological sites and topographical wetness index (TWI) in each pasture pair. For each pasture pair, the first pasture listed is the TGM (traditionally grazed management); the second pasture listed is the AGM (adaptive grazing management).

	TGM				AGM			
Pasture pair	Loamy /Shaly Plains	Sandy Plains	Salt Flat	TWI	Loamy /Shaly Plains	Sandy Plains	Salt Flat	TWI
1 (15E, Nighthawk)	100	0	0	6.84	95	5	0	6.81
2 (24W, Highway)	100	0	0	6.59	80	20	0	6.49
3 (26E, Hilltank)	77	22	0	7.36	53	47	0	7.64
4 (7NW, Headquarters)	53	35	11	7.79	58	25	17	7.78
5 (19N, Snowfence)	0	100	0	8.51	7	93	0	9.06
6 (25SE, Crossroads)	61	39	0	6.63	48	52	0	6.11
7 (31E, South)	53	47	0	6.00	41	59	0	6.47

8 (5E, Ridgeline)	27	73	0	7.68	39	61	0	6.31
9 (17N, Salt Flat)	31	46	23	6.78	21	53	26	7.10
10 (20SE, Elm)	25	54	21	8.08	2	74	24	8.08

Figure 3

Timeline of Decisions by AGM Stakeholder Group



Adaptive Management Plan with Triggers

The Adaptive Grazing Management (AGM) and Traditional Grazing Management (TGM) treatments are planned to begin in 2014 with the same annual moderate stocking rate (0.24 AUM acre^{-1}, recommended by NRCS for upland ecological sites) and the same targeted utilization rate (50% of "average" annual productivity left as standing crop residue), but will differ in terms of the timing of grazing and stock density. For the TGM treatment, grazing will occur in each pasture the entire grazing season (mid-May to early October) with no rest periods, and stocking density will be maintained at 20-24 yearling steers per 320 acres (0.0625 steers acre^{-1}). In contrast, the AGM treatment will rotate the single herd of 214 yearling steers among the 320 acre pastures resulting in a ten-fold higher stocking density (0.625 steers acre^{-1}) compared to the TGM treatment, and 2 pastures each year planned to be rested (no grazing, with rested pastures rotating each year, Figure 3).

For AGM pastures dominated by the Sandy Plains ecological site, grazing outside of the critical growth windows for desired cool-season perennial grasses (periods other than spring/early summer) and shrub reproduction (periods other than August) will likely increase desired cool-season perennial grass species, saltbush, increase vegetation structure, reduce bare soil exposure, and enhance habitat for bird species requiring taller structure such as Lark Bunting and Grasshopper Sparrow. Three underlying mechanisms contribute to these responses: 1) lack of grazing during critical cool-season growth windows, (2) longer periods of regrowth following a grazing pulse, and (3) altered cattle foraging behavior with the large, single herd compared to smaller herds in the control (TGM) pastures, which should result in a more even distribution of defoliation across all available plants with the pulse grazing events compared to the season-long grazed pastures.

For AGM pastures dominated by the Loamy Plains ecological site, grazing during the critical cool-season perennial grass growth windows and shrub reproduction will maintain cattle weight gains while preventing degradation of current grass species composition (dominated by blue grama with little cool-season perennial grass abundance), prevent any long-term increase in bare soil exposure, and sustain breeding habitat for disturbance-dependent bird species such as McCowns Longspur, Mountain Plover and Horned Lark. Increases in desirable cool-season plant species in these pastures (relative to control pastures, TGM) could arise from only 2 of the 3 mechanisms discussed above: 1) changes in the length of recovery periods following grazing, and 2) shifts in cattle distribution within a pasture arising from differences in herd size.

Stocking Rate

Based on pasture-specific ecological site acreages, the stocking rate for 2014 was 214 steers in the AGM pastures and 214 steers in the TGM pastures. In light of above-average precipitation in 2014 and the fact that 3 pastures were rested, the stakeholders at the January, 2015 meeting decided to increase the 2015 stocking rate by 5% (10 steers) to a total of 224 steers each in the AGM and TGM pastures. The current plan is to maintain the same stocking rate (224 steers) for the 2016 grazing season.

Grazing Sequence

The grazing sequence of pastures for a given grazing season will initially be determined using a suite of criteria including 1) achievement of desired objectives (Figure 1), 2) consideration of management strategies (Figure 2), 3) end of prior growing season residue, 4) spatial variability in prior year precipitation, and 5) understanding of the characteristics of the available ecological sites (Table 1) and the amount of ecological sites in pastures (Table 2). Furthermore, forecasted weather conditions and precipitation (from the National Weather Service Climate Prediction Center (http://www.cpc.ncep.noaa.gov/) could be included.

At the January 10, 2013 meeting, seasonality of grazing was discussed with the following suggestions to consider:

For Days 1-45 (or until end of active cool-season growth) of the grazing season:

- Do not necessarily use previously rested pastures as start pastures
- Use pastures with salt flats early in grazing season
- Use different AGM pastures each year to enhance cool-season grasses

- Could graze blue grama-dominated pastures to defer grazing on pastures where increasing cool-season grasses is a high priority

For Days 75-105 (saltbush growth) of the grazing season:

- Avoid pastures where saltbush increase is desired (Headquarters, Snowfence, Ridgeline and South)

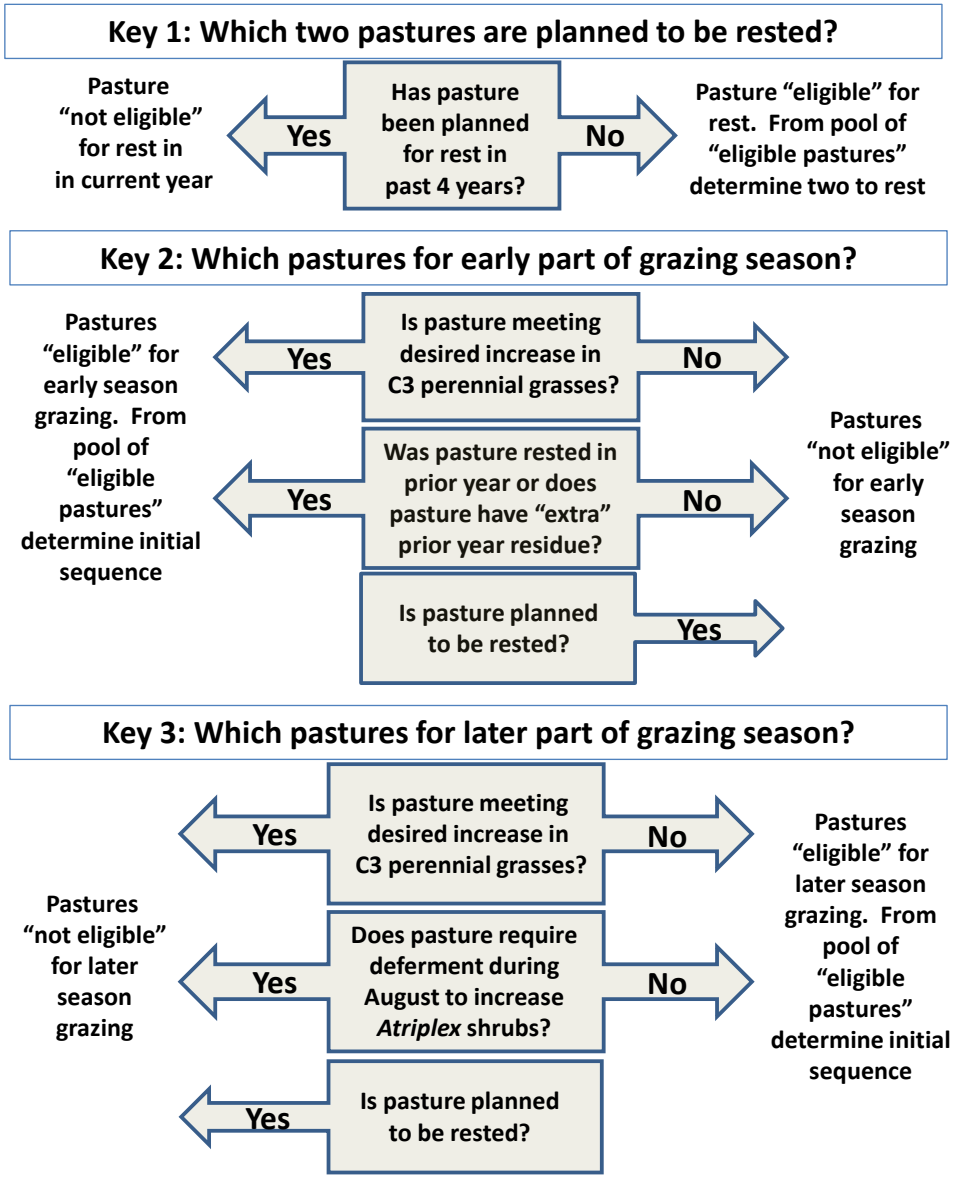
For Days 105-155 (late season) of the grazing season:

- Consider late-grazing impact on next spring's bird habitat
- If growing season is good, rest additional pastures? If so, priority for cactus control with prescribed burning, additional tall structure bird habitat, additional drought mitigation?

A decision tree was developed to assist in determining the initial grazing sequence of AGM pastures. First, a decision is made on the 2 planned pastures for rest. Second, pastures are separated into "eligible" and "not eligible" for both early and later parts of the grazing season.

Figure 4

Decision-tree approach for determining initial grazing sequence of AGM pastures for a given year



At the January 16, 2014 meeting, the Stakeholder Group requested a summary table of key characteristics that would be of utility for developing the grazing sequence. That table was included in previous versions of the AGMP, and then was updated with data collected during the 2014 growing season. ~~Those data were presented to stakeholders at the September, 2014 meeting, and are summarized in Table 3:~~The research team further updated the table based on 2015 monitoring data, which were presented at the October, 2015 meeting and are summarized in Table 3:

Table 3. Summary Table of pasture conditions to assist in developing the 201~~5~~6 grazing sequence.

Pasture	Ecologial Site	Forage Production	Cool-season potential increase	Four wing saltbush	Upland vs Saltflat	VOR in June (cm)	Western Wheat (tillers/m^2)	Needle & Thread (indiv/m^2)	Cactus (cladodes /m^2)
Nighthawk	Loamy	Mod	Low	Low	Upland	7.8	36.0	0.3	8.0
Highway	Loamy	Low	Low	Low	Upland	8.5	28.0	0.8	18.2
Hilltank	Loamy	Low	Low	Low	Upland	6.6	10.0	0.5	5.3
Crossroads	Mixed	Low	High	Low	Upland	6.6	66.6	0.2	3.1
South	Mixed	Low	High	Mod	Upland	7.1	58.4	0.2	11.1
Ridgeline	Mixed	Mod	High	High	Upland	6.4	76.8	0.1	9.6
Headquarters	Mixed	Mod	High	Mod	Upland	12.0	98.8	2.4	10.3
					Saltflat	5.5	34.3	3.4	13.3
Salt Flat	Sandy	High	Low	Low	Upland	13.4	18.3	7.9	16.5
					Saltflat	9.4	118.5	3.3	7.4
Elm	Sandy	High	Low	Low	Upland	5.1	15.6	12.1	3.2
					Saltflat	7.2	107.1	2.4	0.1
Snowfence	Sandy	High	Low	High	Upland	9.0	67.2	17.5	22.3

At the April 14, 2014 Stakeholder meeting, a decision was made regarding grazing in planned rested pastures in the event of a drought:

1) In event of a drought, the pastures that were planned for rest will be made available for grazing
2) Of the two pastures planned for rest, first graze the pasture closes to the last pasture in the planned sequence, to prevent long-distance livestock moves.
3) Then graze the second pasture
4) At this point, stakeholders will need to decide whether to regraze some pastures used early in the grazing sequence or to pull cattle off the study pastures entirely.

Figure 5

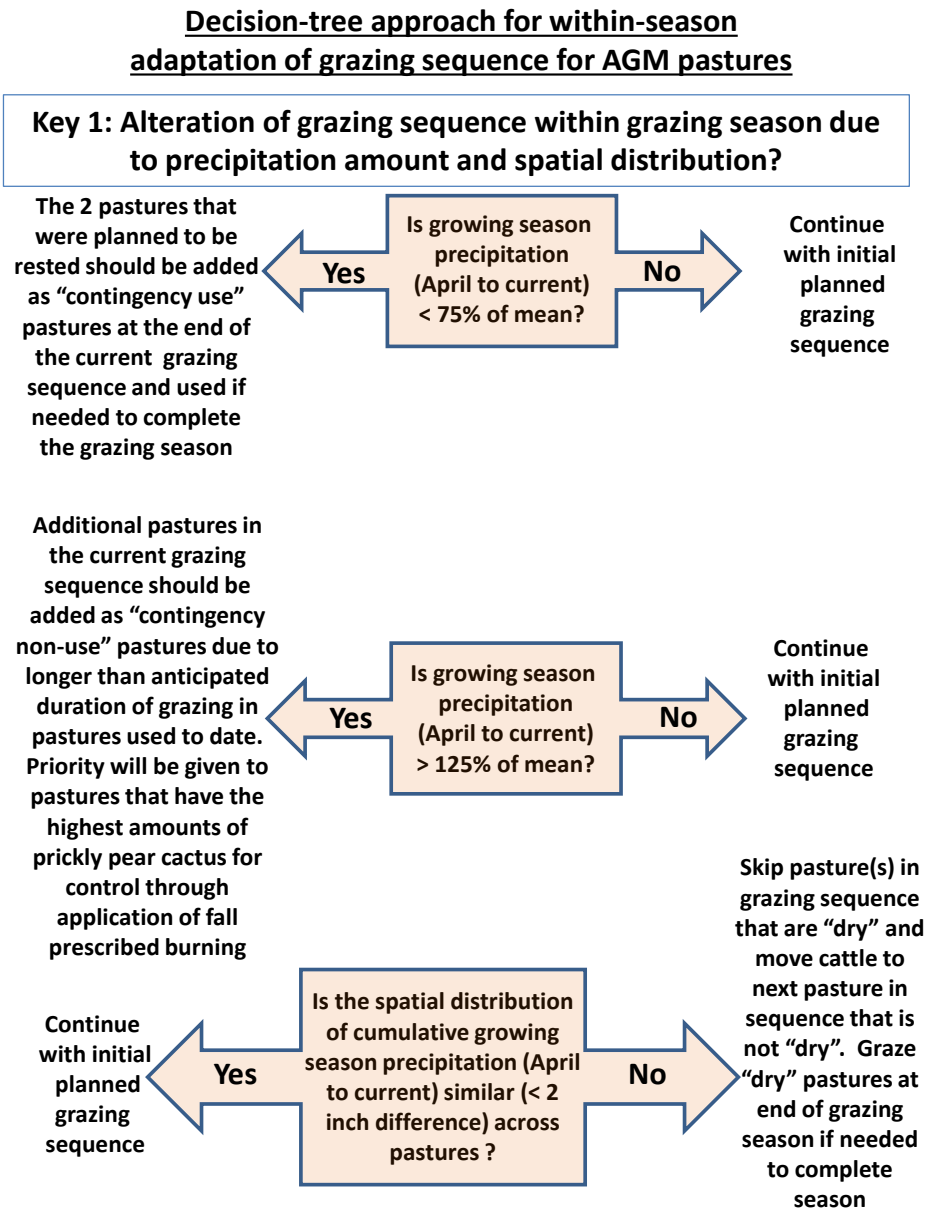


Table 4 presents the grazing sequence as it was implemented during the 2014 grazing season (see also the map on the cover page of this document), as well as the planned grazing sequence as it was

At the January, 2015 meeting, it was decided that the Ridgeline and Hilltank pastures would be planned for rest in 2015. At the April 27, 2015 meeting, the following planned grazing sequence and associated triggers for moving cattle among them were approved by the stakeholders:

Table 4. Planned grazing sequence and associated triggers for 2015 grazing season.

Pasture	Date On	Trigger	Factors Considered
Snowfence	5/15/15	Start here only if biomass on Saltflat patch burn is <350 lbs/ac; move cattle to Saltflat when >350 lbs/ac new growth available on burn.	Highest biomass of cool-season grasses in this pasture, hence grazing here early in season until growth on burn is ready
Saltflat	5/29/15	when biomass on burn transect (N=8) < 200 lbs/ac or mean residual on all uplands (N = 8 on burn and 8 off burn) < 450 lbs/ac or observations of cattle behavior indicate they have stopped using the burn during their primary morning graze period	Enter this pasture when forage on burn is optimal for cattle in terms of quantity and quality
Nighthawk	6/24/15	when biomass on burn transect (N=8) < 200 lbs/ac or mean residual on all uplands (N = 8 on burn and 8 off burn) < 300 lbs/ac or observations of cattle behavior indicate they have stopped using the burn during their primary morning graze period	Use this pasture next to get cattle to utilize burn when forage quality is still higher than off-burn forage
Highway	7/5/15	residual on uplands < 300 lbs/ac	Use this pasture in July/Aug due to high abundance of blue grama
South	7/18/15	residual on uplands < 400 lbs/ac	Grazing here in July avoids impacts on saltbush
Crossroads	8/1/15	residual on uplands < 400 lbs/ac, or move out of here by Aug 10 to reduce impact on saltbush	Move here next, due to lack of saltbush, high abundance of cool season grasses, and near to souoth
HQ	8/16/15	residual on uplands < 450 lbs/ac	Grazing here in August is compromise, allowing Elm to be grazed later when there may be less impact on cattle weight gains - good mix of C4 and C3 forage, but not ideal for the saltbush in this pasture; sequence does provide benefits to saltbush in South and Ridgeline.
Elm	9/1/15	residual on uplands < 400 lbs/ac	Best to graze this as late as possible to maintain cattle weight gains (high cool-season abundance here); avoids grazing this pasture earlier in the season (July) when forage quality is low
Snowfence	9/26/15	Plan to go here for at least 7 days (not worth it for very short time), or more if the veg criteria in Elm is met sooner than 9/23	Good for late Sept grazing due to highest abundance of cool-season grasses; will not use at this time if Snowfence was grazed after Saltflat

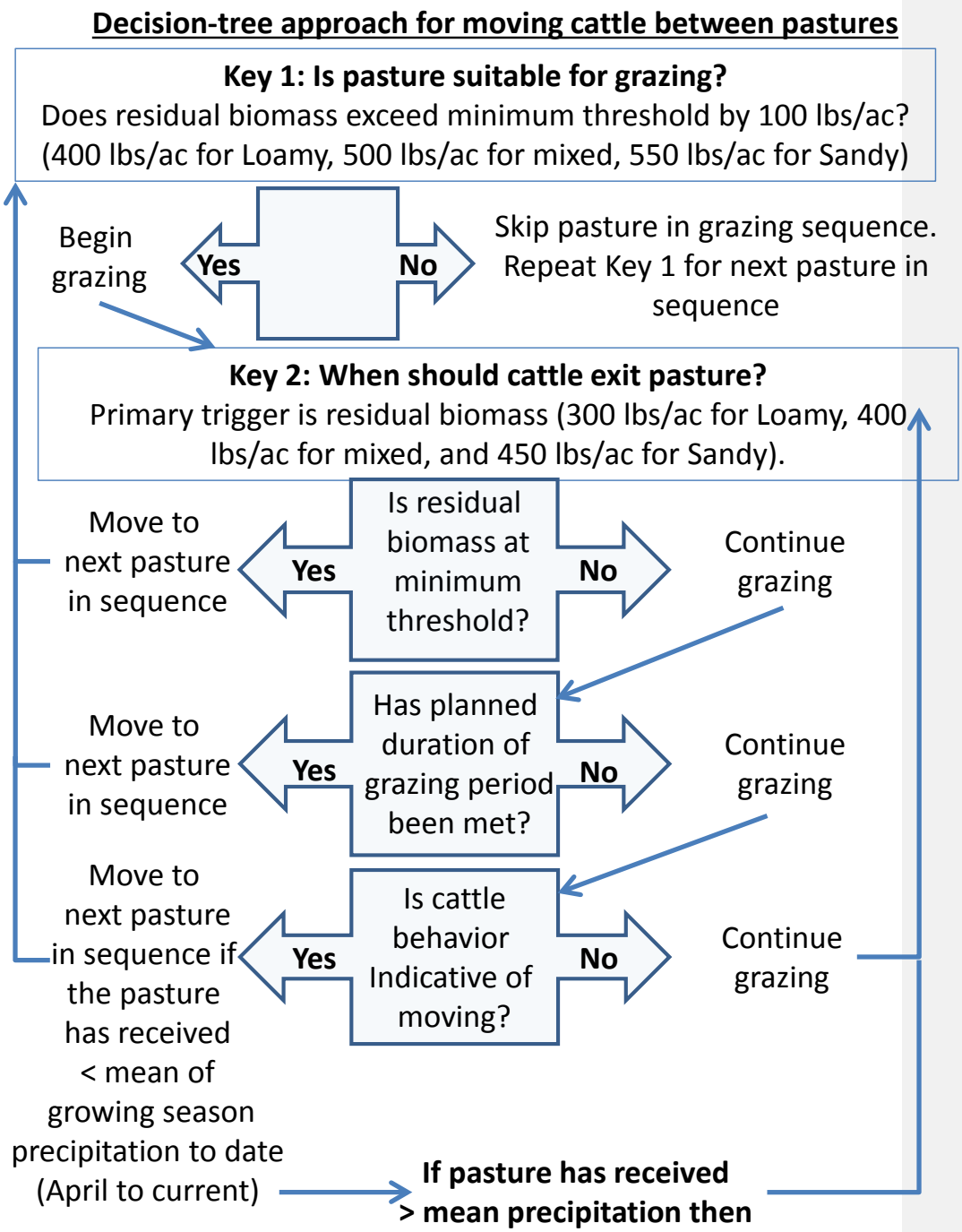
The group also decided that it was acceptable to graze a given pasture more than once during a grazing season if necessary to achieve specific goals with respect to timing of grazing in a given pasture(s).

Triggers to Move Cattle Bewteen Pastures

Triggers to begin and end grazing in a given AGM pasture are outlined in Figure 5. These triggers serve as the decision criteria for movement from one pasture to the next, and

encompass thresholds of 1) residual biomass (determined via regression equations developed from the Robel height-density value (see Table 5), 2) duration of planned use, determined from calculating forage demand (animal intake) and forage availability (standing crop residual, proportion of biomass growth to date, and biomass growth during planned duration of grazing), and 3) soil moisture (determined from Syntek probes, one each in all pastures) and cattle behavior (see animal and forage checklist developed – Table 6 below).

Figure 6


Decision-tree approach for moving cattle between pastures
Key 1: Is pasture suitable for grazing?
Does residual biomass exceed minimum threshold by 100 lbs/ac?
(400 lbs/ac for Loamy, 500 lbs/ac for mixed, 550 lbs/ac for Sandy)
Begin grazing
Yes
No
Skip pasture in grazing sequence. Repeat Key 1 for next pasture in sequence
Key 2: When should cattle exit pasture?
Primary trigger is residual biomass (300 lbs/ac for Loamy, 400 lbs/ac for mixed, and 450 lbs/ac for Sandy).
Is residual biomass at minimum threshold?
Yes
No
Move to next pasture in sequence
Continue grazing
Has planned duration of grazing period been met?
Yes
No
Move to next pasture in sequence
Continue grazing
Is cattle behavior Indicative of moving?
Yes
No
Move to next pasture in sequence if the pasture has received < mean of growing season precipitation to date (April to current)
Continue grazing
If pasture has received > mean precipitation then

The residual biomass threshold will be the primary trigger for both entry and exit determinations. Prior to entry into the next scheduled pasture in the grazing sequence, Robel pole readings (n=100, 4 transects of 25 readings each) will be conducted. If the residual biomass value does not meet the threshold identified (see Table 5), that pasture will be skipped in the grazing sequence (see Figure 6), and these data will be collected in the next pasture in the sequence to determine if cattle will be moved there. Following entry of cattle into a pasture, Robel pole readings (n=100) will be conducted weekly (every 7 days post-entry of cattle) to determine if the threshold is met for movement to the next pasture (see Figure 6).

If neither of the above criteria are met, then cattle behavior will also be considered as a factor indicating that cattle should be moved to the next pasture in the sequence. Cattle behavior data (along with other cattle and forage observation data) will be taken each time cattle are checked (usually Monday, Wednesday and Friday) in the AGM pasture as well as the paired TGM pasture. Scores of 1 in the body condition, hair coat, eyes, activity, or forage consumed categories will serve as indicators of a need to move. In addition, cattle foraging distribution on the burns (see Table 4) will be used as a potential indicator of the need to move cattle from the patch-burned pastures.

For 2015, it was decided that no maximum duration of grazing would be set for the pastures as a criteria for moving cattle; movements would only be based on vegetation criteria (Table 4), and cattle behavior criteria.

Table 5. Threshold triggers for entry and exit of cattle on AGM pastures

Dominant Ecological Site	Entry threshold (pounds/acre)	Exit threshold (pounds/acre)
Loamy	400	300
Mixed	500	400
Sandy	550	450

Other Vegetation Treatments

At the September, 2014 meeting, stakeholders discussed potential burning and herbicide treatments in light of (1) the above-average precipitation experience during the 2014 growing season, and (2) the fact that 3 pastures were rested during the 2014 growing season. Based on this discussion, it was decided that:

1) The use of prescribed burning during the 2014-2015 dormant season is acceptable to the stakeholder group (consensus).
2) Through a ranking of preferences for burning, the plan is to conduct patch burns in the fall of 2014 in the Hilltank and Saltflat pastures; however, the Nighthawk pasture will be held as a backup site in the event that residual biomass in Hilltank is too low for burning (given that Hilltank was grazed last in the 2014 sequence). Measurements of residual biomass in October will determine whether to burn in Hilltank or Nighthawk.

At the October, 2015 meeting, stakeholders discussed potential burning and herbicide treatments in light of the above-average forage production during 2015 and the fact that 6 of the 10 pastures were rested during the 2015 grazing season. Based on this discussion, it

was decided that no prescribed burning or herbicide treatments would be implemented during the 2015-2016 dormant season.

Achieving Desired Objectives

The profitable ranching operations objective of maintaing or increasing livestock weight gains is posited to occur due to a better matching of forage quality on offer and nutritional demands by the livestock across the grazing season. For the TGM (or control) pastures, livestock remain in the same pasture for the entire grazing season each year despite nutritional status of plants changing within the grazing season. In contrast, for the AGM treatment, the movement of the one large herd among pastures provides flexibility to match forage demand and plant nutritional status, as well as preventing (in theory at least) negative effects of multiple defoliations on key forage species.

The vegetation objective of enhanced abundance and production of cool-season perennial grasses is posited to occur through the combination of rest (1 in 5 years) and pulsed grazing outside of the critical growth windows for these desired cool-season grasses (primarily for pastures dominated by Sandy Plains ecological sites). The vegetation objective of increased vegetation heterogeneity across the landscape, will be accomplished through rest (planned 2 of the 10 AGM pastures) to facilitate taller vegetation structure. Increased vegetation heterogeneity (within and among pastures) facilitates more variation in grassland bird habitat (from short-structure to taller-structure vegetation).

The grassland bird community encompasses a broad gradient of habitat associations, from species associated with sparse, prostrate grassland (Mountain Plover, Horned Lark, McCown's Longspur), to species associated with tall, dense grassland (Lark Bunting, Grasshopper Sparrow). If AGM successfully increases heterogeneity in vegetation structure, it is hypothesized to provide the habitats necessary to increase the abundance of species associated with more dense grassland, and thereby increase species evenness of the bird communities

The intent of resting 2 pastures each year (i.e., grassbanking) in the AGM treatment is to increase drought management flexibility. Although it is likely that during an extremely dry year cattle would move more quickly among pastures not rested the year before (due to reaching the triggers faster), the strategy should be to maintain stocking rate at the moderate level with AGM and only reduce the length of the grazing season as a last option. TGM pastures would have to maintain the same moderate stocking rate and also have cattle removed at the same time as AGM, if that decision is made.

The intent of conducting patch burns in the fall of 2014 is to (1) create habitat for mountain plover, (2) increase forage quality early in the growing season (May and June) in a portion of the pastures that cattle are grazing at that time, and (3) reduce cactus density in the burned areas.

Management Monitoring Data

At the January 10, 2013 meeting, there was consensus agreement that photopoints were quite valuable and should be taken throughout the grazing season. These photos would provide an excellent archive throughout the length of this experiment. Photos should be taken at permantent locations in each pasture (likely at each transect) at the beginning (mid-May) and end (early October) of each grazing season as well as periodic times throughout the season. These times should, at the minimum, coincide with cattle entering and exiting each AGM pasture. Photos would also need to be taken at the same times in the corresponding TGM pasture pair for comparative purposes.

Economics of the labor, maitenance, time for monitoring, gasoline, equipment, checking cattle, fencing, providing water, doctoring cattle, etc. will be addressed by addition of Marshall Frasier (Colorado State University, Department of Agricultural and Resource Economics).

Scientific Monitoring Data for Management Decisions

Response Variables

Response measures will include soil, vegetation, livestock, and wildlife parameters that have either been selected to (1) examine specific mechanisms by which adaptive grazing management is hypothesized to achieve desired objectives, or (2) quantify the degree to which desired objectives are being achieved. Although response measures will be measured each year, we anticipate the most robust comparisons will be made comparing year 5 (2018) to year 1 (2014). Pre-treatment data was taken in 2013 on all pastures.

Suggested response variables measured in each pasture pair prior to/during/following each AGM grazing period to quantify effects of the AGM treatment over the entire grazing season include: 1) height density using Robel pole, 2) livestock distribution and foraging behavior (via GPS collars and pedometers), 3) diet quality through fecal Near Infrared Spectroscopy, and 4) soil water (via Sentek probes).

Response variables that will be quantified annually in all pastures include those taken in June (species composition, basal and foliar cover, vegetation structure, bare ground, litter, grassland birds), August (aboveground net primary productivity), and October (end of grazing season residue). Additionally, soil stability, soil C and soil N will be taken in year 1 (2014) and year 5 (2018).

Livestock distribution and foraging behavior; dung distribution and livestock diet quality

Distribution of yearling steers and foraging behavior will be evaluated during 2014-2018 using GPS units mounted on collars (Lotek LR3300, Lotek Engineering, Newmarket, Ontario) placed on 2 steers each in 5 randomly chosen TGM pastures, and 10 steers in the AGM treatment. Collars will be deployed for the full 5-month grazing season with batteries replaced at 4-week intervals. Steer locations will be recorded at 5-min intervals. A previously-developed regression tree model based on 2009-2011 deployments (Augustine and Derner, 2013), will be used to predict when steers are grazing versus walking, standing or resting. These data will quantify the location and proportion of time spent grazing by steers in the 2 different treatments. Livestock energetics will be assessed using pedometers.

Diet quality of cattle will be monitored weekly using fecal Near Infrared Spectroscopy (NIRS) by sampling 10 fecal pats from each pasture in pasture pair which has steers grazing in the AGM pasture (e.g., if steers are grazing in the AGM pasture Nighthawk, then fecal pats sampled in that pasture and the corresponding TGM pasture 15E for pasture pair 1). Fecal NIRS has been shown to be robust and may help explain difference in steer gain among pastures (e.g., Walker 2010).

Vegetation and soil responses

Variables include 1) vegetation species composition, 2) basal and foliar cover of species, 3) bare ground exposure, 4) litter cover, 5) vegetation structure (Robel pole), 6) aboveground net primary production (ANPP), 7) soil water, 8) end of season residue, and in year 1 and year 5 only 9) soil stability, 10) soil carbon, and 11) soil nitrogen. These data will be jointly obtained with the Stakeholder Group (pending schedules and travel ability) and data will be provided to the Stakeholder Group for feedback input for possible modifications in their adaptive management plans. Soil stability will be assessed using soil stability kits (Herrick et al. 2001) by collecting 2 samples at each of the 4 transects in each plot. Triplicate soil cores

(1 inch diameter x 12 inches deep, incremented into 0-2 inch, 2-6 inch, and 6-12 inch depths) will be collected in 2014 and 2018 at the 2 transects in each plot where cages have been located for aboveground production. Soil and root fragments will be ground to a fine powder and analyzed for total organic carbon and total nitrogen using a Carlo–Erba NA 1500 elemental analyzer. Soil water will be automatically measured hourly in each pasture from a Syntek probe installed to a depth of 1 yard at the center of one of the plots in each pasture. Soil water readings will be taken at 4 inch increments.

Grassland bird responses

Densities of 6 grassland bird species [Horned Lark (*Eremophila alpestris*), Mountain Plover (*Charadrius montanus*), McCown's Longspur (*Rhynchophanes mccownii*), Western Meadowlark (*Sturnella neglecta*), Lark Bunting (*Calamospiza melanocorys*), and Grasshopper Sparrow (*Ammodramus savannarum*)] will be measured in a grid of 4 survey points per pasture each year in June. This community encompasses a broad gradient of habitat associations, from species associated with sparse, prostrate grassland (Mountain Plover, Horned Lark), to species associated with tall, dense grassland (Lark Bunting, Grasshopper Sparrow). Breeding bird abundance will be estimated in each grid using standard 5-min point counts (Ralph et al. 1993). Counts will be conducted between sunrise and 10:30am, with counts repeated at each point on 3 different mornings. Observers will record the distance to each bird (measured with a rangefinder), plus means of detection (visual vs. aural), microhabitat type, and bird behavior and sex. Densities of each species will be estimated using Program Distance (v6) to model detection rates of each species and sex as a function of distance from the survey point (Buckland et al. 2001). Field and analytical methods follow protocols used for past studies at CPER and at the western Great Plains (Augustine 2011; Augustine and Baker 2014).

Livestock weight gains

Yearling steers (initial weights of approximately 650 pounds) will be randomly allocated to the two grazing treatments. Steers will be weighed at the beginning (in mid-May) and end (early October) of the summer grazing season. Seasonal livestock gains (pounds/head) will be calculated as the difference between these two weights, average daily gains (pounds/head/day) will be determined by dividing the seasonal gains by the actual number of days grazed, and beef production (pounds/acre) will be determined by summing seasonal gains for all animals in each treatment and dividing by the number of hectares (3,200 acres).

Monitoring Schedule

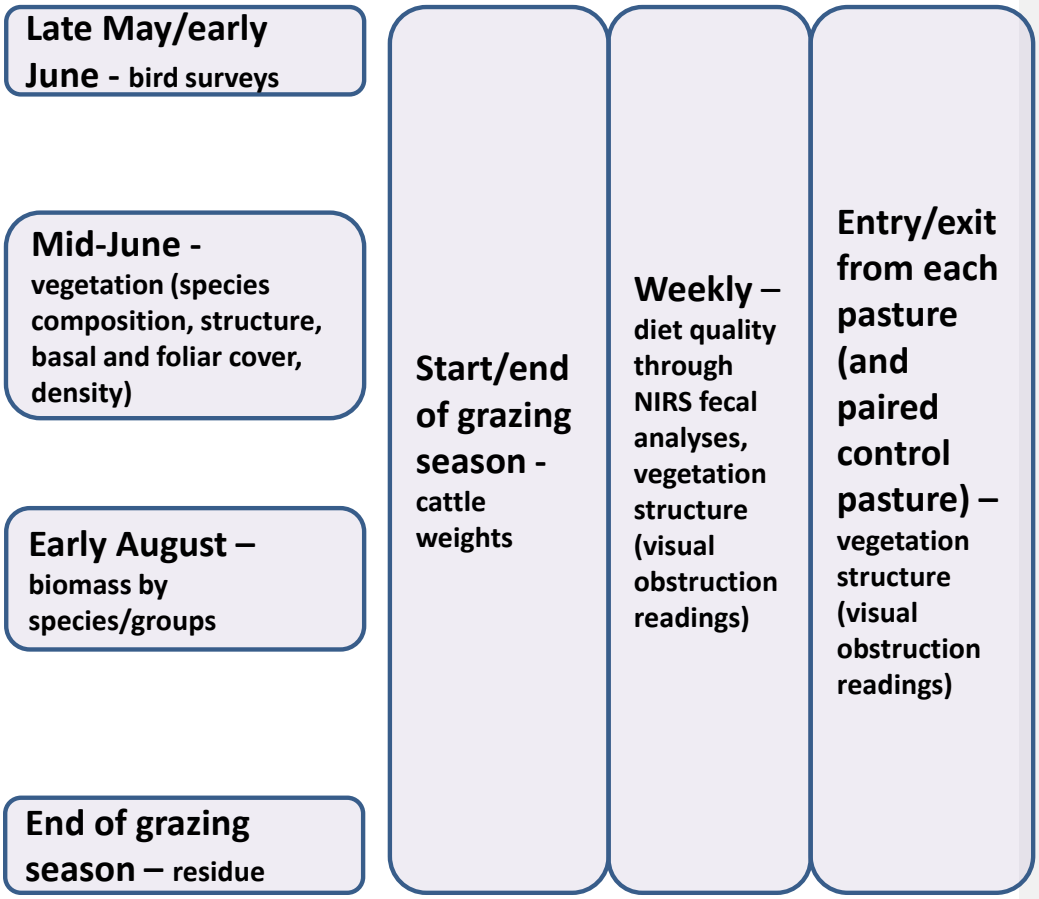


Figure 7. Schedule of monitoring activities.