Evaluation of Ecological Site Classes and Community Classes for Regional Scale Modeling of Conservation Effects on Grazing Lands: MLRA 67B

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Report date: March 21, 2017

INTRODUCTION

The Grazing Lands Component of the Conservation Effects Assessment Project is evaluating the development and use of Ecological Site Classes and Community Classes within Major Land Resource Areas for regional and national scale modeling of conservation effects. National Resources Inventory (NRI) data is correlated to proposed Ecological Site Classes to provide data for the Agricultural Policy/Environmental eXtender (APEX) model and other models. The Rangeland Hydrology and Erosion Model (RHEM) is used to assess runoff and erosion differences between Community Classes, and is appropriate for inclusion in ecological site descriptions and this broader ecological site class work.

CLASSIFICATION HIERARCHY AND DEFINITIONS

Ecological Site Class

Ecological Site Classes are proposed subdivisions of a Major Land Resource Area (MLRA) or Land Resource Unit (LRU). They are similar in concept to a general soil survey map unit – a general grouping of ecological sites by major landforms and vegetation types. An Ecological Site Class differs from other kinds of land in the kinds and amounts of vegetation produced, in the responses to disturbances, in recovery mechanisms, and management responses.

Plant Functional Groups

The Plant Functional/Structural Group indicator is defined in Interpreting Indicators of Rangeland Health (version 4) as, "*A suite or group of species that because of similar shoot or root structure, photosynthetic pathways, nitrogen fixing ability, life cycle, etc., are grouped together on an ecological site basis.*"

The presence, dominance and relative proportions of plant functional groups affect soil, hydrologic and biotic variables including:

- the kinds and amounts of canopy and foliar cover
- amount and arrangement of bare ground and litter cover
- plant spacing and basal cover
- runoff and erosion rates
- structure and arrangement of vegetation which then influences the potential to carry fire and regulate fire intensity
- grazing preferences and distribution
- wildlife habitat values

The change in presence, dominance and/or proportion of plant functional groups is the primary attribute used to characterize States and Community Phases within an Ecological Site Description. Standardized plant functional groups were developed based on growth forms and flowering period. All plant species found in the MLRA were assigned to a plant functional groups. Non-native species were assigned to functional groups designated with (I) - indicating the functional group represents introduced species. Production by functional group was then calculated for each NRI Primary Sampling Unit (PSU) community in the MLRA.

Community Class

A Community Class is a proposed plant community classification for an Ecological Site Class. The name of the Community Class is derived using the seven (7) dominant plant functional groups, listed in descending order by annual aboveground production on a dry weight basis. A Community Class is differentiated from other Community Classes by the presence and relative dominance of plant functional groups, and/or by significant differences in annual production. Refer to Appendix D for a list of common species and their assigned functional groups used for this project.

Plant Community

An actual plant community found at a given location, at a point in time.

Figure 1. MLRA 67B, Sandy Plains Ecological Site.

MAJOR LAND RESOURCE AREA 67B CENTRAL HIGH PLAINS, SOUTHERN PART

Major Land Resource Area (MLRA) 67B is part of the Western Great Plains Range and Irrigation Region (Region G) shown in yellow (Figure 2). MLRA 67B, shown in orange, occurs on the eastern slope of the Rocky Mountains in Colorado. The MLRA is just over 12.7 million acres in size. The South Platte and Arkansas Rivers flow east from here into Nebraska and Kansas. This Major Land Resource Area is characterized by smooth to irregular sloping plains created by Cretaceous and Quaternary sediment deposits from rivers that drained the young Rocky Mountains. There are now several areas capped with lava. Sandy dunes and plains are also present. Elevations range from 3000 feet to 7800 feet above mean sea level.

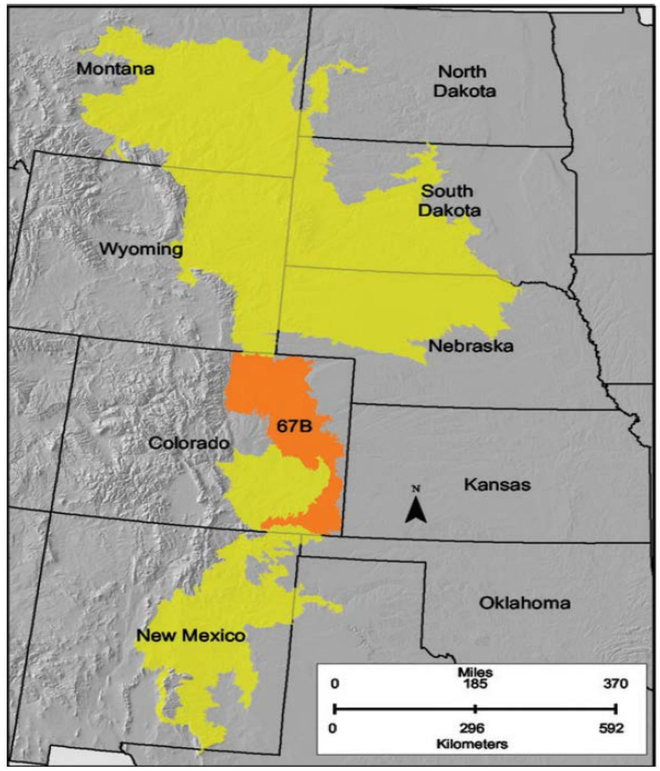

Figure 2. LRR G and MLRA 67B map. Source: Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296 (2006).

Plant communities in this Major Land Resource Area are dominated by shortgrass prairie species such as blue grama, buffalograss, and ring muhly, with midgrasses such as needleandthread, purple threeawn, and alkali sacaton. Shrubs include sand sagebrush, broom snakeweed, and cane cholla. Trees include oneseed juniper, and eastern cottonwood.

Climate

The following climate information is from the MLRA 67B Loamy Plains Ecological Site Description and characterizes MLRA 67B.

The mean average annual precipitation varies from 12 to 16 inches per year depending on location and ranges from less than 8 inches to over 20 inches per year. Approximately 75 percent of the annual precipitation occurs during the growing season from mid-April to late September. Snowfall can vary greatly from year to year but averages 35 to 45 inches per year. Winds are estimated to average about 9 miles per hour annually, ranging from 10 miles per hour during the spring to 9 miles per hour during late summer. Daytime winds are generally stronger than nighttime and occasional strong storms may bring periods of high winds with gusts to more than 90 miles per hour.

The average length of the growing season is 142 days, but varies from 129 to 154 days. The average date of first frost in the fall is September 28, and the last frost in the spring is about May 9. July is the hottest month and December and January are the coldest. It is not uncommon for the temperature to exceed 100 degrees F during the summer. Summer humidity is low and evaporation is high. The winters are characterized with frequent northerly winds, producing severe cold with temperatures dropping to -35 degrees F or lower. Growth of native cool season plants begins about March 15 and continues to about June 15. Native warm season plants begin growth about May 15 and continue to about August 15. Regrowth of cool season plants occurs in September and October of most years, depending on moisture. For local climate stations that may be more representative, refer to the Western Regional Climate Center website at http://www.wrcc.dri.edu/.

Averages

Frost-free period, below 32°F (days): 144
Freeze-free period, below 28°F (days): 166
Mean annual precipitation (inches): 16.00

Table 1. Monthly Precipitation (Inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	0.36	0.38	0.82	1.28	2.46	2.61	2.31	2.37	1.37	1.05	0.52	0.33
Low	0.32	0.26	0.87	1.38	2.32	1.93	1.42	1.07	1.02	0.89	0.53	0.37

Table 2. Monthly Temperature (°F)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	45.2	50.7	58.8	69.2	78.1	88.5	93.9	91.9	83.8	72.7	57.1	47.0
Low	12.5	15.7	22.5	30.6	40.3	49.2	55.3	53.7	49.3	32.5	20.8	12.2

The soil temperature regime is thermic and the soil moisture regime is ustic.

Representative Climate Stations

(1) CO0945, Briggsdale. Period of record 1948-2005
(2) CO4076 Holly. Period of Record 1918-2005
(3) CO9147 Windsor. Period of Record 1948-1990
Note: Station CO415183 - Fort Morgan was used for the Rangeland Hydrology and Erosion Model (RHEM) evaluations for this project.

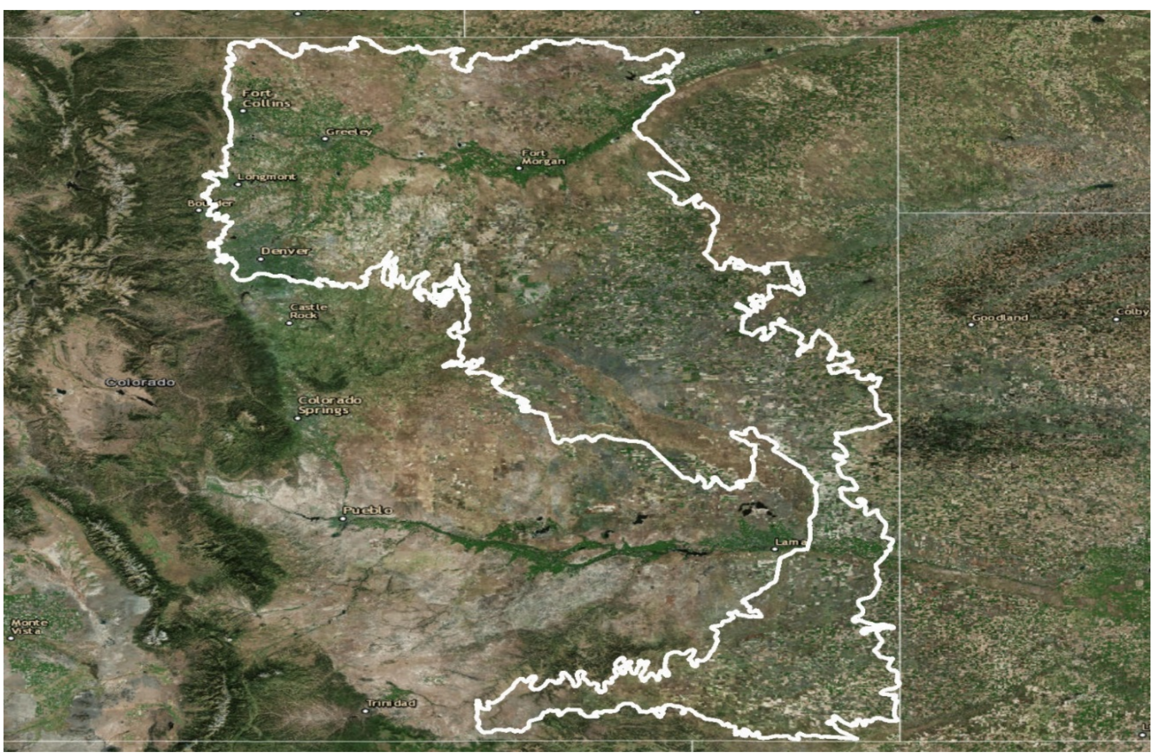

Figure 3. MLRA 67B Satellite View.
Source: ArcGIS World Imagery, Earthstar Geographics, Esri, HERE, DeLorme.

AGRICULTURAL OPERATIONS

About one third of the livestock producers in MLRA 67B also raise crops. Most producers primarily engaged in farming also run a few cows. The vast majority of this Major Land Resource Area is grazed shortgrass prairie. The kinds and sizes of operations are highly variable because of the 8 to 20-inch rainfall change from east to west. Operation sizes and irrigation needs increase from west to east as precipitation decreases. The major crops grown include wheat, corn, grain sorghum, soybeans, and sugar beets. Grain corn is typically planted in June and harvested in October - November. Winter wheat is planted mostly in September, and then harvested from May to mid-July. USDA Agricultural Statistics 2014 average yields for this part of the state are as follows - winter wheat (25 bushels/ac), grain sorghum (25 bushels/ac), corn (130 bushels/ac) dry beans (2200 lbs/ac), sugar beets (33 tons/ac).

The average size of a livestock operation ranges from about 600 acres in the western portion of the MLRA to about 4000 acres on the eastern side. Livestock are grazed on the native rangelands during the growing season, and then typically graze on some combination of rangeland, wheat fields, crop residues or they may be fed on dry lots from December through February. Common cattle breeds are black and red Angus, Hereford and Charolaise. Weaning weights average 450 lbs for heifers and 550 lbs for steers.

RESOURCE MANAGEMENT SYSTEMS

Conservation Practices Applied

Table 3 shows the kinds and amounts of conservation practices that the landowners are implementing with NRCS assistance on grazed rangelands in MLRA 67B.

Table 3. MLRA 67B, Conservation practices applied from 2006-2011 (NRCS)

Practice Code	Practice Name (units)	Practice Count	Amount Applied	Acres Benefited
528	Prescribed Grazing (ac)	4,007	2,405,352	2,086,691
614	Watering Facility (no)	1,173	1,523	1,338,950
382	Fence (ft)	1,144	4,695,927	740,001
516	Pipeline (ft)	777	2,708,321	838,328
645	Upland Wildlife Habitat Management (ac)	604	221,803	240,488
595	Herbaceous Weed Control (ac)	468	245,796	271,188
642	Water Well (no)	308	1,705	192,634
533	Pumping Plant (no)	294	301	283,698
ANM18	Retrofit watering facility for wildlife escape (no)	169	192	106,463
PLT02	Monitor key grazing areas to improve grazing management (ac)	159	95,832	96,032
WQL03	Rotation of supplement and feeding areas (ac)	137	54,586	54,786
ANM17	Monitoring nutritional status of livestock using the NUTBAL PRO System (ac)	114	44,780	44,779
314	Brush Management (ac)	111	14,091	96,773
ANM09	Grazing management to improve wildlife habitat (ac)	61	359,743	39,765
550	Range Planting (ac)	56	2,547	9,484
574	Spring Development (no)	16	18	60,495
378	Pond (no)	10	11	3,354

Prescribed Grazing

Prescribed grazing is the most common conservation practices applied to address resource concerns on grazed rangelands in this MLRA. High intensity, short duration grazing systems have been successful in addressing common resource concerns. This kind of grazing strategy limits grazing duration to only a few days a year on any given area. Providing 90-120 days of rest during the hot part of the growing season has been effective in maintaining species vigor and composition. In areas with Lesser Prairie Chicken, grazing is deferred from March 15 to July 15 to provide nesting cover. Conservative stocking rates range from 4-5 acres per animal unit yearlong in the western portion of the MLRA, to 15-20 acres per animal unit yearlong in the eastern portion of the MLRA where rainfall is lower. The ecological site descriptions provide initial stocking guidelines (AUMs/ac) for community phases using 25% harvest efficiency and 912.5 lbs. of ingestible air-dry vegetation per animal unit month.

Watering Facilities

Most livestock water is provided by wells. Livestock pipelines, storage tanks and troughs are used to distribute grazing and provide water to wildlife. Ponds generally do not provide a reliable water source, except in carefully placed locations with appropriate engineering designs.

Brush Management

The invasive woody species targeted for brush management in this MLRA are typically saltcedar, Russian olive and occasionally sand sagebrush. Most brush management is done using chemicals.

- Saltcedar and Russian olive are normally treated with imazapyr. Multiple treatments are required. The Colorado Cooperative Extension Service does not have any online recommendations for treatment. Normally saltcedar is sprayed in late summer to early fall before the leaves start turning yellow.
- Sand sagebrush is controlled occasionally with 2, 4-D following label directions.

Range Planting

Range planting is used to help stabilize smaller areas that need improvement in MLRA 67B. The average area seeded from 2006 through 2011 was about 45 acres. There is typically a sufficient seed source for the desirable species to become re-established with good grazing management. With normal rainfall, reestablishment can occur in one year. The Colorado NRCS Plant Materials Technical Note 59 recommends seeding cool season plants from November 1 to April 30, and warm season plants from November 1 to May 15. Species adapted for seeding in this MLRA include sideoats grama, blue grama, little bluestem, wheatgrasses, prairie sandreed, buffalograss, and western wheatgrass.

Prescribed Burning

Prescribed Burning is not commonly used in this MLRA, but it is an important part of the ecology of the shortgrass prairie. Lack of burning may be due to social and economic concerns about the use of fire. Prescribed burning is used for maintaining early successional habitat for mountain plover.

Fencing

Typical fencing installations are either electric or standard barbed wire. Two-wire electric fencing is typically used for interior pasture fencing in the high intensity grazing systems. Three- and four-strand barbed wire fences are used in other areas.

Herbaceous Weed Control

Canada thistle is being successfully treated with biological control methods using a rust fungus. For musk thistle, the Colorado Cooperative Extension recommends application of a variety of chemicals to the rosette stage in the spring or fall. Cheatgrass occurs in this Major Land Resource Area as an episodic species that does not seem to have any significant impacts on the function of the native plant communities.

Upland Wildlife Habitat Management

Wildlife in MLRA 67B includes a wide variety of grassland birds, deer, pronghorn antelope, badger, coyote, swift fox, jackrabbit, ground squirrel, and a variety of reptiles and amphibians. Species of concern include the lesser prairie chicken and mountain plover. Prescribed grazing and watering facilities provide the most common habitat improvements for wildlife species.

Figure 4. Colorado NRCS Soil and Rangeland Management Scientists discuss ecological site class concepts for Wet Bottomland in MLRA 67B.

ECOLOGICAL SITE CLASSES AND COMMUNITY CLASSES

In January 2016, there were twenty-four (24) Ecological Sites developed in MLRA 67B. These were grouped into eight (8) Ecological Site Classes by working with the State and local NRCS soil and rangeland management scientists in Colorado. Grouping was based on landscape position, soil characteristics, plant community composition, plant production, and the response to climate, disturbance, use, and management. The groupings are as follows:

Bottom Ecological Site Class

- Sandy Bottomland R067BY031CO

Breaks Ecological Site Class

- Shale Breaks R067BY044CO
- Loess Breaks R067BY052CO
- Sandstone Breaks R067BY056CO
- Limestone Breaks R067BY060CO
- Gravel Breaks R067BY063CO

Loamy Upland Ecological Site Class

- Loamy Plains R067BY002CO
- Loamy Slopes R067BY008CO
- Siltstone Plains R067BY009CO
- Sandy Plains R067BY02CO
- Shallow Siltstone R067BY039CO
- Clayey Plains R067BY042CO
- Shaly Plains R067BY045CO
- Alkaline Plains R067BY047CO

Playa Ecological Site Class

- Plains Swale R067BY010CO

Saline Upland Ecological Site Class

- Sandy Salt Flat R067BY032CO
- Salt Flat R067BY033CO

Sandy Upland Ecological Site Class

- Deep Sand R067BY015CO
- Choppy Sands R067BY022CO

Stream Terrace Ecological Site Class

- Overflow R067BY036CO
- Saline Overflow R067BY037CO

Wet Bottomland Ecological Site Class

- Sandy Meadow R067BY029CO
- Salt Meadow R067BY035CO
- Wet Meadow R067BY038CO

Each NRI Primary Sampling Unit (PSU) in the MLRA was correlated to a plant Community Class where possible. PSU data were not used when the species present or vegetative production was questionable. Additional Community Classes that are not currently represented in the ecological site descriptions were added when present in the NRI data (these most commonly were non-native dominated communities). Community Class names are derived using the top seven (7) plant functional groups, listed in descending order of annual aboveground air-dry production. The production for the plant functional groups is calculated from the NRI PSUs that are correlated to the Community Class. Refer to Appendix E for plant taxonomy.

All species and plant community production shown as pounds per acre (lbs/ac) in the following ecological site class descriptions refers to annual aboveground production, air-dried.

BOTTOM ECOLOGICAL SITE CLASS

FIGURE 5. MLRA 67B, Bottom ecological site class.

General Description

The Bottom ecological site class occurs on floodplains which receive occasional to frequent flooding and run-on moisture from adjacent uplands. Surface water and/or subsurface flows may be present from several hours to several weeks following rainfall events or snowmelt. This ecological site class does not have access to seasonal or yearlong shallow water tables. Flooding is the dominant erosion/deposition process for this ecological site class. Potential plant community production is higher than that of adjacent uplands, and the response to management may be more rapid because of the availability of additional water. This ecological site class is high in wildlife diversity.

Geomorphic Features

Landscape Position: Floodplains
Slope (percent): 0-3

Representative Soil Features

Soil Depth: Deep to Very Deep
Parent Material Kind: Alluvium
Parent Material Origin: Mixed
Surface Texture: Fine Sandy Loam to Loamy Sand
Surface Texture Modifier: None to Gravelly

Subsurface Texture Group: Sandy
Permeability Class: Moderately Rapid to Rapid
Chemistry: None
Available Water Capacity: 6-8 inches
Drainage Class: Well Drained to Somewhat Excessively Well Drained

State and Transition Model

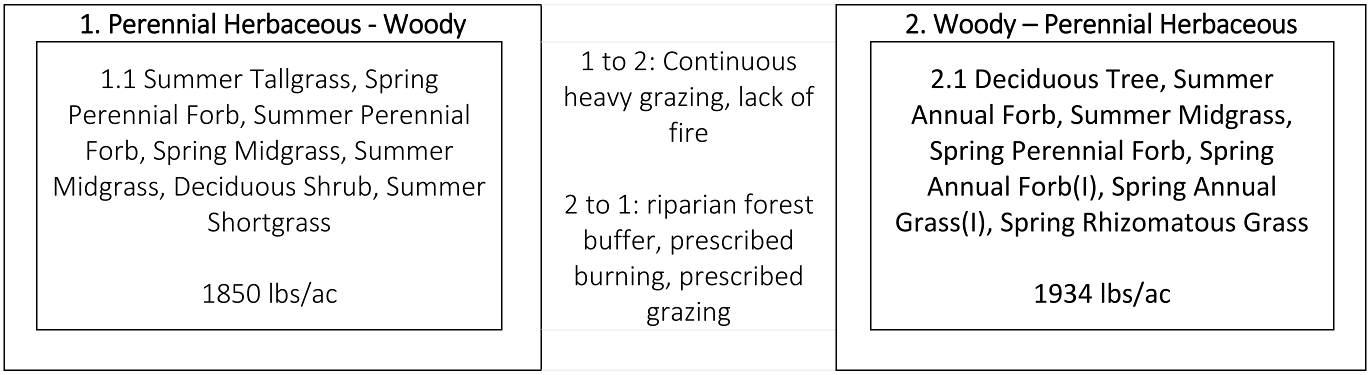

Figure 6. State and Transition Model MLRA 67B Bottom ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 6) was derived from the reference communities in the ecological sites correlated to the Bottom ecological site class. The reference state for this ecological site class has an average air-dry annual production of 1850 lbs/ac. This is comprised of sand bluestem, switchgrass, prairie sandreed, Indiangrass, needleandthread, sand dropseed, western wheatgrass, little bluestem, western sandcherry, sand sagebrush, and eastern cottonwood. To maintain these conditions, grazing management that allows for recovery after each grazing event is required. With continuous heavy grazing the tallgrasses are removed from the plant community and midgrasses, shortgrasses and forbs increase. With Prescribed Grazing and Prescribed Burning, the reference plant community can be restored. With lack of fire and continuous heavy grazing, woody species will dominate the production on the site. Riparian Forest Buffer is the conservation practice applied to restore riparian area plant communities.

NRI Primary Sampling Units (PSUs) were correlated to these community classes where possible. The number of PSUs correlated to each Community Class, and the dominant functional groups, dominant species, and average production for those PSUs is shown in Table 4. Ground and canopy cover from the NRI PSUs was used to estimate soil loss and percent runoff under rainfall conditions using the Rangeland Hydrology and Erosion Model (RHEM). The RHEM results displayed in Table 4 show that very little of the runoff and erosion on this site class is from precipitation. Flooding is the principle driver of erosion on this ecological site class. Additional data is provided in the Appendices.

Table 4. NRI Community Class Data and RHEM Results - MLRA 67B Bottom Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
067B.2.1.1	Summer Midgrass, Summer Shortgrass, Spring Perennial Forb, Summer Annual Forb, Spring Rhizomatous Grass, Spring Annual Forb(I), Evergreen Shrub	sand dropseed (SPCR)(366), blue grama (BOGR2)(194), western wheatgrass (PASM)(89), common sunflower (HEAN3)(69), bractless blazingstar (MENU)(61), sand sagebrush (ARFI2)(58), Buffalograss (BODA2)(50)	1151	0.03	3.09	7
067B.2.2.1	Deciduous Tree, Summer Annual Forb, Summer Midgrass, Spring Perennial Forb, Spring Annual Forb(I), Spring Annual Grass(I), Spring Rhizomatous Grass	eastern cottonwood (PODE3)(793), common sunflower (HEAN3)(508), sand dropseed (SPCR)(327), dwarf bur ragweed (AMPU4)(126), Russian thistle (SAKA)(61), lemon scurfpea (PSLA3)(48), cheatgrass (BRTE)(47)	1934	0.00	1.31	1

Supporting Information

No literature was found that dealt with the Bottom ecological site class.

BREAKS ECOLOGICAL SITE CLASS

FIGURE 7. MLRA 67B, Breaks ecological site class.

General Description

This ecological site class occurs in an upland position where there is an abrupt change in elevation between two relatively flat plains or plateaus. It is not associated with floodplain terraces. It does not receive run-on moisture from adjacent sites. The site class is characterized as escarpments of calcareous sandstone, limestone, shale, gravel and loess in MLRA 67B. It includes areas of rock outcrop and shallow soils at the summits and the associated steep colluvial slopes. Soils are typically very shallow to shallow at the summit, and moderately deep to very deep on the colluvial slopes. The soils are gravelly to extremely gravelly stony loams and sandy loams. Site stability is bedrock controlled. As wind and water erosion occur, the coarse fragments in the soil profile are exposed at the surface, helping to armor and protect the surface from wind and water erosion. As wind and water erosion occur, the coarse fragments in the soil profile become exposed at the surface, helping to armor and protect the surface from further wind and water erosion. This ecological site class is a minor component of the MLRA which is part of the reason all of the break sites were grouped together.

Geomorphic Features

Landscape Position: Ridges, Escarpments, Hills
Slope (percent): 2-60

Representative Soil Features

Soil Depth: Very Shallow to Very Deep
Parent Material Kind: Alluvium, Colluvium
Parent Material Origin: Limestone, Sandstone, Shale
Surface Texture: Loamy Fine Sand to Clay
Surface Texture Modifier: Gravelly to Extremely Gravelly, Bouldery

Subsurface Texture Group: Loamy to Clayey
Drainage Class: Very Poorly to Excessively Well
Permeability Class: Moderate to Impermeable
Chemistry: None to Calcareous
Available Water Capacity: 2-9 inches

State and Transition Model

1. Perennial Herbaceous		2. Perennial Herbaceous - Woody
1.1 Summer Midgrass, Summer Tallgrass, Summer Perennial Forb, Spring Midgrass, Spring Perennial Forb, Spring Rhizomatous Grass, Summer Shortgrass 900 lbs/ac	1 to 2: Continuous heavy grazing, drought, lack of fire 2 to 1: brush management, prescribed burning, prescribed grazing	2.1 Summer Shortgrass, Spring Perennial Forb, Evergreen Subshrub, Summer Rhizomatous Grass, Summer Midgrass, Spring Midgrass, Summer Perennial Forb 865 lbs/ac

Figure 8. State and Transition Model MLRA 67B Breaks ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 8) was derived from the reference communities in the Ecological Sites correlated to this ecological site class. The reference plant community for this ecological site class have an average air-dry annual production of 900 lbs/ac. This will be comprised of mid/tall/short grass including sideoats grama, little bluestem, western wheatgrass, and blue grama. To maintain this community, grazing management that provides for recovery after each grazing period will be required. Shortgrasses such as blue grama will become dominant with continuous grazing use. With continuous heavy grazing and without fire on a regular basis, this site will transition to a Perennial Herbaceous – Woody state (community class 2.1). Prescribed Burning, Brush Management and Prescribed Grazing will allow it to return to the reference community (1.1).

Three NRI Primary Sampling Units (PSUs) are correlated to this ecological site class, and all are located on the Gravel Breaks ecological site. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 5. Ground and canopy cover from the NRI PSUs was then used to estimate erosion and percent runoff using RHEM.

Table 5. NRI Community Class Data and RHEM Results - MLRA 67B Breaks Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
067B.12.1.1	Summer Shortgrass, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Midgrass, Summer Midgrass, Evergreen Subshrub	blue grama (BOGR2)(350), Buffalograss (BODA2)(219), bractless blazingstar (MENU)(192), squirreltail (ELEL5)(79), Rocky Mountain zinnia (ZIGR)(62), Nailwort (PARON)(54), purple threeawn (ARPU9)(48)	1165	0.06	2.72	1
067B.12.2.1	Summer Shortgrass, Evergreen Subshrub, Spring Perennial Forb, Spring Rhizomatous Grass, Summer Midgrass, Spring Midgrass, Summer Perennial Forb	blue grama (BOGR2)(247), prairie sagewort (ARFR4)(159), hairy false goldenaster (HEVI4)(130), hairy grama (BOHI2)(93), western wheatgrass (PASM)(70), needlegrass (HESPE11)(34), purple threeawn (ARPU9)(28)	865	0.02	2.06	2

Supporting Information

No literature was found that dealt with this ecological site class.

LOAMY UPLAND ECOLOGICAL SITE CLASS

Figure 9. MLRA 67B, Loamy Upland ecological site class.

General Description

This ecological site class in an upland position on gently sloping plains. The site does not benefit from run-on moisture from adjacent sites. The soils are deep and loamy textured. Sheet and rill erosion are the dominant erosional process on this ecological site class. The level terrain allows easy travel for grazing animals.

Geomorphic Features:

Landscape Position	Plains, Flat Ridges
Slope (percent)	1-25

Representative Soil Features

Soil Depth:	Moderately Deep to Deep
Parent Material Kind:	Mixed
Parent Material Origin:	Mixed
Surface Texture:	Clay Loam to sandy Loam
Surface Texture Modifier	None to gravelly
Subsurface Texture Group:	Clayey to Loamy
Drainage Class:	Well Drained
Permeability Class:	Slow to Moderately Rapid
Chemistry	None to Calcareous
Available Water Capacity:	3-12 inches

State and Transition Model

1. Perennial Herbaceous 1.1 Summer Shortgrass, Spring Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Tallgrass, Summer Midgrass, Spring Rhizomatous Grass 1250 lbs/ac	1 to 5: continuous heavy grazing 5 to 1: herbaceous weed control, prescribed grazing	**5. Annual – Perennial Herbaceous** 5.1 Spring Annual Forb(I), Spring Annual Forb, Summer Shortgrass, Summer Annual Grass(I), Spring Midgrass(I), Summer Midgrass, Summer Rhizomatous Grass 1350 lbs/ac
1 to 2: plow, disk, plant	5 to 2: plow, disk, plant	
2. Cultivated Cropland **Average County Yields** winter wheat 25 bu/ac grain sorghum 25 bu/ac corn 130 bu/ac dry beans 2200 lbs/ac sugar beets 33 tons/ac		
2 to 3: abandonment 3 to 2: plow, disk, plant	2 to 4: range planting, critical area planting, prescribed grazing 4 to 2: plow, disk, plant	
3. Abandoned Cropland 3.1 Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Midgrass, Cacti 270 lbs/ac	3 to 4: range planting, prescribed grazing 4 to 3: Continuous heavy grazing, lack of fire	**4. Seeded Rangeland** 4.1 Spring Rhizomatous Grass(I), Spring Midgrass(I), Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Perennial Forb 1765 lbs/ac

Figure 10. State and Transition Model, MLRA 67B, Loamy Upland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 10) was derived from the reference communities in the Ecological Sites correlated to this ecological site class. The reference plant community (1.1) on this ecological site class produces approximately 1250 lbs/ac/yr. It consists of midgrasses and shortgrasses including western wheatgrass, blue grama, green needlegrass, sideoats grama, and winterfat. With continuous heavy grazing the site will transition to a mix of annual and perennial grasses and forbs, dominated by Russian thistle, and kochia (community class 5.1). With herbaceous weed control and several years of prescribed grazing the site can transition back to the Perennial Herbaceous state (1.1). With plowing and tillage, the site will transition to the Cultivated Cropland state (community 2). From this state, with abandonment the site can decrease its vegetation production to approximately 271 lbs/acre of broom snakeweed, blue grama, purple threeawn, and sand dropseed (community 3.1). The site may be seeded to return vegetation to species in the Seeded Rangeland state (community 4.1). With continuous heavy grazing and a lack of regular fire intervals, the Seeded Rangeland state can be invaded by Russian thistle, broom snakeweed and other invasive annual grasses and forbs, and production will decrease. This transitions the site back to the Abandoned Cropland state (community 3.1).

NRI PSUs were correlated to these community classes where possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 6. Ground and canopy cover from the PSUs was then used to estimate erosion and runoff using RHEM.

Table 6. NRI Community Class Data and RHEM Results - MLRA 67B Loamy Upland Ecological Site Class

Comm Class ID	Community Class Name	Dominant Species (Symbol, Lbs/Ac)	Production Lbs/Ac	Soil Loss T/Ac/Yr	% Runoff	# PSUs
067B.6.1.1	Summer Shortgrass, Summer Rhizomatous Grass, Summer Midgrass, Spring Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb(I), Summer Annual Forb	blue grama (BOGR2)(432), Buffalograss (BODA2)(139), western wheatgrass (PASM)(83), sand dropseed (SPCR)(55), purple threeawn (ARPU9)(37), Russian thistle (SAKA)(17), scarlet globemallow (SPCO)(12)	982	0.07	4.59	63
067B.6.3.1	Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Midgrass, Cacti	broom snakeweed (GUSA2)(140), blue grama (BOGR2)(91), rush skeletonplant (LYJU)(28), sand dropseed (SPCR)(4), tumblegrass (SCPA)(4), plains pricklypear (OPPO)(2)	271	0.08	5.27	1
067B.6.4.1	Spring Rhizomatous Grass(I), Spring Midgrass(I), Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Perennial Forb	smooth brome (BRIN2)(836), crested wheatgrass (AGCR)(368), blue grama (BOGR2)(107), purple threeawn (ARPU9)(106), red lovegrass (ERSE)(86), western wheatgrass (PASM)(53), saltgrass (DISP)(47)	1767	0.03	2.66	3
067B.6.5.1	Spring Annual Forb(I), Spring Annual Forb, Summer Shortgrass, Summer Annual Grass(I), Spring Midgrass(I), Summer Midgrass, Summer Rhizomatous Grass	Russian thistle (SAKA)(308), kochia (BASC5)(270), lambsquarters (CHAL7)(184), blue grama (BOGR2)(110), yellow foxtail (SEPU8)(101), crested wheatgrass (AGCR)(96), sand dropseed (SPCR)(76)	1349	0.08	5.44	6

Supporting Information

The following publications support the STM. The first publication involves the study of vegetation parameters in relation to runoff with various grazing intensities. The study found similar vegetation characteristics to that of the STM, with comparable changes in aboveground annual production amounts to various plant species, as a result of different grazing intensities. The second publication, though conducted in a greenhouse, evaluates the competition between western wheatgrass and blue grama. The third publication examines the interaction of blue grama and western wheatgrass and their response to varying degrees and conditions of grazing.

Hart, R.H. and G.W. Frasier. 2003. Bareground and litter estimators of runoff on short- and mixed-grass prairie. Arid Land Research and Management 17: 485-490.

This study took place at Nunn, Colorado on the Central Plains Experimental Range, and the High Plains Grassland Research Station northwest of Cheyenne, Wyoming. To better understand the correlation between vegetation parameters to runoff, a rotating boom rainfall simulator was used to quantify runoff from a shortgrass prairie that had been grazed for 56 years with controlled intensities, and a mixed-grass prairie following 13 years of controlled grazing.

The vegetation biomass on the shortgrass prairie consisted of mainly blue grama and buffalograss, with forbs and cool-season grasses comprising approximately 13%. Additionally, plains pricklypear was ubiquitous and provided nearly 30% of total aboveground biomass under heavy grazing. On the mixed-grass prairie, the vegetation cover was dominated by blue grama, but western wheatgrass and needleandthread could provide up to 50% cover under light grazing. Forb biomass averaged approximately 30%, but increased under heavy grazing. The grazing study began in 1982, and included three grazing strategies (season-long, 4-pasture rotationally deferred, and 8-paddock time-controlled rotational grazing). Each strategy included three stocking rates of light, moderate, and heavy.

The cover and runoff was measured on all three stocking rate pastures in 1992, 1993, and 1994. Cover was measured on sixty 1.5m x 1.5m permanent plots at the Central Plains Experimental Range (CPER). At the High Plains Grassland Research Station (HPGRS) with the 8-paddock rotational grazing, cover was measured along two 50m transects in each of the pastures. The measurements included basal plant cover, litter cover, and bare ground. Runoff was measured on two pairs of 3m x 10m rainfall simulator plots per pasture. Depth of water flowing through the flumes was measured and recorded with bubble flowmeters at 1-minute intervals with three phases of time length and application rate.

Results found that after 56 years of grazing at the CPER, bare ground increased from 21.9% to 23.1%. The mean equilibrium runoff during the rainfall simulator increased over the three years of the study from 10% to 46% as grazing intensity increased from light to moderate. After 13 years of grazing on the HPGRS, runoff was 38% with light grazing and 48% with heavy grazing. This was positively correlated with bare ground, which increased with stocking rates.

Samuel, M.J. and R.H. Hart. 1992. Survival and growth of blue grama seedlings in competition with western wheatgrass. Journal of Range Management 45(5): 444-448.

The purpose of this study was to measure the effects of intensities of competition by western wheatgrass on the survival and growth of germinated blue grama seedlings. The site was located on a dryland area of the High Plains Grassland Research Station (HPGRS) northwest of Cheyenne, Wyoming. Blue grama seed had been germinated on filter paper in 1985 and singly transplanted into deep cells in Wheatridge loam in a greenhouse. Several weeks later, the seedlings were transplanted into western wheatgrass sod or fallow soil which had been planted five years earlier. Sod was removed from cores 4, 8, or 16cm in diameter to create gaps of various degrees of reduced competition for the transplanted blue grama seedlings. The experimental design included four replicate blocks in sod and in fallow. Seedling survival was recorded approximately weekly during the growing season with number of seed heads and plant height recorded. By the end of the third growing season, above- and below-ground phytomass of both species was evaluated. The plants were also clipped to the ground, oven-dried, and weighed.

The results found blue grama survival was 100% at all intensities of competition in fallow after the first growing season. Western wheatgrass competition reduced survival of blue grama seedling in 0- and 4-cm openings below the fallow. There was a significant drop in the survival of blue grama within 15 days of transplanting in the 0-cm opening and 37 days in the 4-cm opening. During the three-year study, the lowest blue grama survival was in the 0-

cm opening. Of the 96 plants, only 13 survived the first winter in the fallow background. However, in the first growing season the plants averaged 13 seed heads per plant. These numbers were reduced with the intensity of competition of western wheatgrass. In sod, blue grama height increased with decrease in competition. In regards to phytomass, both above- and below-ground were positively related to opening size; below-ground was more closely related. Fewer western wheatgrass roots and rhizomes were able to re-establish in larger openings.

The conclusions of this study were that the impact of western wheatgrass competition on survival of blue grama seedlings was detectable throughout the experiment. The likelihood of survival is dependent on opening size and degree of western wheatgrass competition. Blue grama establishment is more favorable with the following conditions: 1) an adequate seed bank; 2) sufficient soil water for germination and establishment of adventitious roots; 3) levels of competition and protection allow survival and growth of seedlings.

R.H. Hart, S. Clapp, and P.S. Test. 1993. Grazing strategies, stocking rates, and frequency and intensity of grazing on western wheatgrass and blue grama. Journal of Range Management 46(2): 122-126.

This study used long-interval time-lapse photography to test the theory that grazing frequency and intensity on western wheatgrass and blue grama would alter plant composition compared to continuous season-long grazing by steers at 2 different stocking rates. The experiment was conducted as a part of another study in 1983, in which a pair of 25-m transects were placed in each continuously grazed pasture under heavy and moderate stocking. Additionally, they were placed in one paddock each of short-duration rotationally grazed with heavy and moderately stocking in 1 of the 2 replications. The western wheatgrass tiller that was closest to the 1m mark was encircled with a poultry leg band and wired to a spike. These tillers were photographed against a gridded background with date and pasture identification. At the end of each year, photographs were placed in chronological order and tillers that had been grazed were estimated for percent removed by reductions in tiller height and leaf size/number. Additionally, if the tiller had grown, this was recorded as well.

The results of the study found that grazing strategies had no effect on peak standing crop or utilization. It also had no effect on percent of western wheatgrass tillers grazed once, twice, three times, or not at all. With continuous grazing, the only effect of stocking rate occurred in 1990 when more tillers were grazed twice under heavy stocking in both grazing strategies. This was viewed as atypical, as few tillers were grazed twice in either treatment. Percent aboveground biomass removed from blue grama tillers was unaffected by grazing strategy or stocking rate in the first year. At the second grazing, there was an increase in removal under heavy versus moderate stocking. Western wheatgrass tillers had more herbage removed in the second grazing as compared to the first. No significant difference was found in blue grama herbage removal between the first and second grazing. Frequency and sometimes intensity of grazing of western wheatgrass and blue grama tillers increased with stocking rate. Because severe defoliation is usually less damaging to blue grama as compared to western wheatgrass, blue grama often increases with stocking rate while western wheatgrass decreases.

Porensky, L.M, K.E. Mueller, D.J. Augustine, and J.D. Derner. 2016. Thresholds and gradients in a semi-arid grassland: long-term grazing treatments induce slow, continuous, and reversible vegetation change. Journal of Applied Ecology.

This article empirically evaluated several of the thresholds and rates of change between alternative states and community phases within an STM that studied plant community responses to grazing treatments in a northern mixed-grass prairie. The study observed whether long-term grazing treatments (33 years) caused alternative stable states. This would include: 1) plant communities that were different and stable over time during the third decade of the experiment; 2) evidence that after reducing stocking rate from heavy (1982-2006) to light or no grazing (2007-2014), the plant community did not shift back toward expected community composition for a lightly grazed or ungrazed state. Additionally, the study used long-term experimental data to examine specific elements of the existing STM. Specifically, the study quantified the magnitude and temporal dynamics of vegetation change in relation to the varying grazing strategies and determined whether long-term heavy grazing affected the loss of C3 perennial grasses.

The study was initiated in 1982 on the northern mixed-grass prairie at the High Plains Grassland Research Station near Cheyenne, WY. Vegetation was primarily grass including western wheatgrass, needleandthread, needleleaf sedge, and blue grama. Season-long, continuous grazing treatments began in 1982 on two replicate pastures (one north-facing, one south-facing) per treatment and continued annually. The treatments were light (15.7 ± 2.8 animal unit days/ ha; or 4 steers/20 ha), moderate (32.6 ± 5.5 AUD or 4 steers/12 ha), and heavy (43.4 ± 7.3 AUD or 4 steers/ 9 ha). These stocking rates were determined from NRCS data to be ~35% below, equal to, or ~33% above recommended stocking rates. Two 0.5 ha fenced exclosures were constructed to remained un-grazed throughout the experiment. The original experiment also included eight pastures assigned to rotational grazing. In 2007, four pastures that were heavily stocked were switched to continuous light or no grazing. Prior to this switch, there was no evidence of significantly differing plant composition or aboveground production regardless of grazing system. Therefore, the study was based on two pasture-scale replications of six grazing treatments. These included: 1) no grazing; 2) light grazing; 3) moderate grazing; 4) heavy grazing; 5) heavy to light grazing; 6) heavy to no grazing. Vegetation sampling was done to quantify changes in species composition by foliar cover and was done by annually sampling 25 permanent quadrats randomly located along each of two 50-m permanent transects per pasture. The statistical analysis was done by partial redundancy analysis (RDA) with the year included as the co-variable.

The results found significant variation among grazing treatments and years. Long-term stocking rate treatments caused continued, directional shifts in plant community composition from 2003-2014. Higher stocking rates were associated with lower RDA scores, which indicated that an increased cover of blue grama would be associated with a decreased cover of western wheatgrass and needleandthread. Additionally, communities with varying treatments tended to diverge from one another in years 22-33 of the experiment. Further, long-term data found that RDA scores decreased for exclosures with an increase in western wheatgrass, while the scores for the lightly grazed increased with more cover of needleandthread. Moderately and heavily grazed pastures had low and stable scores on the RDA axis, portraying a low relative cover of grasses.

In reference to specific plant species, it was found that the combined cover of western wheatgrass and needleandthread increased sharply in exclosures, remained stable in lightly stocked pastures, and decreased in moderately and heavily stocked pastures. Blue grama comprised 99% of C4 perennial grass cover. In 2003, blue grama was 314% higher in cover in the heavily grazed pastures, and 105% higher in lightly grazed than in the exclosures. Throughout the study, blue grama showed a trend of increasing under heavily and moderately stocked pastures and remained stable in lightly stocked and exclosures. Grazing reversal treatments did not differ from the long-term heavy stocking treatment and all of these treatments had significantly lower RDA scores than long-term light stocking and exclosure treatments. Following reversal to light stocking or no grazing, the three dominant plant species varied in response. The combined cover of western wheatgrass and needleandthread increased in the grazing reversal and long-term exclosure treatments, while it decreased slightly in the moderate and heavy stocking treatments. By 2014, the cover was similar to that of the long-term lightly grazed pastures. Basal cover of blue grama did not have a strong response to the grazing reversal.

The conclusions of this study found that although it could not eliminate the possibility of alternative stable states in the ecosystem, the results are most consistent with a temporal gradient model in which grazing instigates slow, constant and revocable changes in plant species abundance. At the end of the experiment, the vegetation had not reached apparent, stable equilibria as a result of the different grazing intensities, but were steadily diverging. It is a theory that a state shift had occurred, but was not clearly marked by sudden changes or subsequent stabilization. It was found that pastures that were converted from heavy stocking to light or no grazing, had strong evidence of reversibility and rates of change for the two most dominant C3 grasses. Discontinuing heavy grazing did not induce significant changes in basal cover of the dominant C4 grass. Future monitoring is required to determine whether vegetation dynamics shift in grazing reversals. Overall, the study results found that STM's might misrepresent an ecosystems resilience to grazing by overemphasizing nonreversible transitions. It may be relevant to understand the time scales and compositional gradients of crucial phase shifts rather than to emphasize the probability of threshold shifts between alterative stable states.

Augustine, D.J., J.D. Derner, and J.K. Detling. 2014. Testing for thresholds in a semiarid grassland: The influence of prairie dogs and plague. Rangeland Ecology & Management 67(6): 701-709.

This article sought to examine how the recent history of prairie dog occupancy influenced the effects on vegetation composition of a shortgrass steppe in Colorado. Additionally, it sought to determine how that occupancy history affected vegetation dynamics over a 5-year period following extirpation of the prairie dogs. To do this, the study focused on how the plant community foliar cover composition changed in relation to the years the prairie dogs had occupied the site. Additionally, the study quantified the temporal dynamics in the abundance of four plant functional groups (C4 perennial grasses, C3 perennial graminoids, annual forbs, and perennial forbs) and alterations in the spatial pattern of plant cover over time post-extirpation.

The study took place in native shortgrass steppe at the Central Plains Experimental Range northeast of Nunn, Colorado. Soils consisted of very deep, well-drained, fine sandy loams to loamy sands on convex alluvial flats and upland plains. Two C4 grasses, blue grama and buffalograss dominate the vegetation. Plains pricklypear and scarlet globemallow were also dominant on the site. The site had no history of cultivation, but was being moderately grazed by cattle each year from May to October.

The study design was a natural experiment involving the observation of four prairie dog colonies. These colonies declined by >95% following extirpation by epizootic plague caused by bacteria. Following the extirpation, scientists used annual maps of colony boundaries to identify five prairie dog occupancy history categories in each pasture. These included: 1) areas occupied by prairie dogs prior to 2000; 2) areas colonized between 2000 and 2002; 3) areas colonized between 2002 and 2004; 4) areas colonized between 2004 and 2006, and; 5) areas with no recent history of prairie dog occupancy. Within these five occupancy categories, portions of each category were identified in each pasture with similar soils and randomly selected the location for a 40m x 40m plot. At each plot, a nested grid of quadrats was created to visually measure vegetation foliar cover of each species and to estimate bare soil. The grid consisted of 17 sampling locations. At each of these locations, vegetation cover was measured in three 50cm x 20cm quadrats placed 20cm apart. To statistically analyze the data, a nonmetric multidimensional scaling ordination was conducted of the species X site matrix. The vegetation was divided into functional groups of C4 perennial grasses (blue grama, buffalograss, sand dropseed, purple threeawn, and ring muhly), C3 perennial grasses and sedges (western wheatgrass, needleandthread, needleleaf sedge, and squirreltail), perennial forbs (scarlet globemallow), and annual forbs (little crypthantha and tansyaster).

Results found that there was a clear gradient in plant species composition and cover of plant functional groups in relationship to the length of the prior occupancy of prairie dogs. Following prairie dog extirpation, there were significant differences in cover among occupancy history categories and among years, but no significant year X occupancy interactions across all four functional groups. Generally, cover of all functional groups on sites occupied 1-4 years prior to the plague were comparable to sites with no history of prairie dogs. C4 grasses increased significantly and at equal rate as all five categories over time. When prairie dogs occupied the site for 7-10 years prior to the plague, C4 grass cover still had not recovered to the same level as unoccupied sites by 2011. C3 perennial graminoid cover was stable during 2007-2009, then increased substantially during the following wet years. Further trends indicated that C3 graminoids were not stifled by long-term prairie dog occupancy and did not have an increase with prairie dog removal. Throughout the study, perennial forb cover decreased from 2007 to 2011 and remained significantly greater on sites occupied 7-10 years relative to unoccupied sites. Annual forb cover varied widely among years, but was significantly higher on sites occupied for 7-10 years compared to <6 years as well as unoccupied. Trends for bare soil exposure were mostly inverse of results of the C4 perennial grasses. Bare ground was significantly higher on sites occupied for 7-10 years compared to all other sites.

The conclusions of this study found that prairie dogs do not create irreversible change on shortgrass steppe vegetation composition. The findings suggest that changes should be made to traditional STM's that include a transition from a state dominated by a mixture of C4 shortgrasses and C3 graminoids to a state of high bare soil abundance and an increase in purple threeawn and annual forbs. Additionally, current models suggest that recovery may only be possible through prescriptive grazing that allows for rest for a portion of the growing season. In contrast, the study found that changes included an increase in bare soil, reduced cover of perennial C4 grasses, and increased cover of C3 graminoids and forbs.

Figure 11. MLRA 67B, Loamy Upland ecological site class, Cultivated Cropland State.

PLAYA ECOLOGICAL SITE CLASS

Figure 12. MLRA 67B, Playa ecological site class.

General Description

The Playa ecological site class occurs in lower positions on the landscape as closed basin depressions that receive run-on and/or subsurface water flows from adjacent uplands. Surface water may be present all or part of the year. These are depositional sites for water erosion, so wind is the primary erosion driver. Wetland soils and obligate wetland vegetation may be present on sites that hold water seasonally or yearlong. Ponding occurs occasionally to frequently. Salts and other soluble chemicals in the watershed above this site are transported to this site where they accumulate as the water evaporates. This ecological site class is high in wildlife value but very minor extent in the MLRA.

Geomorphic Features

Landscape Position:	Plains
Slope (percent):	0-1 percent

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Mixed
Parent Material Origin:	Mixed
Surface Texture:	Silt Loam to Clay
Surface Texture Modifier:	None
Subsurface Texture Group:	Clayey
Drainage Class:	Poorly to moderately well drained
Permeability Class:	Slow
Chemistry:	None
Available Water Capacity:	7-12 inches

State and Transition Model

1. Perennial - Annual Herbaceous 1.1 Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Spring Perennial Grasslike, Summer Stoloniferous Grass, Evergreen Shrub, Summer Midgrass 1300 lbs/ac		**4. Seeded Rangeland** 4.1 Summer Shortgrass, Summer Midgrass, Annual Grass, Annual Forb 1000 lbs/ac
1 to 2: plow, disk, plant	2 to 4: range planting 4 to 2: plow, disk, plant	3 to 4: range planting, prescribed grazing
2. Cultivated Cropland **Average County Yields** winter wheat 25 bu/ac grain sorghum 25 bu/ac corn 130 bu/ac dry beans 2200 lbs/ac sugar beets 33 tons/ac	2 to 3: abandonment 3 to 2: plow, disk, plant	**3. Abandoned Cropland** 3.1 Summer Shortgrass, Summer Midgrass, Forbs 150 lbs/ac

Figure 13. State and Transition Model, MLRA 67B, Playa ecological site class.

Vegetation Dynamics

Reference state (1.1) conditions in the Playa ecological site class state and transition model (Figure 13) are characterized by western wheatgrass, blue grama, buffalograss, green needlegrass, sideoats grama, and winterfat with average air-dry annual production of 1300 lbs/acre. With plowing and tillage, the site will transition to a cultivated crop state (state 2). If the Cultivated Cropland state is abandoned, annual production will decrease to 150 lbs/acre consisting of blue grama, purple threeawn, and sand dropseed (state 3). The site may be reseeded to transition to a seeded state with a representative value of approximately 1000 lbs/ac (state 4). The seeded site will likely have similar species composition to that of the reference state, but in varying amounts.

There are no NRI Primary Sampling Units (PSUs) located on this ecological site class. This state and transition information and the plant community information in Table 7 is from the Plains Swale Ecological Site Description and the local soil and range specialists. Crop yields are county averages from USDA National Agricultural Statistics 2014. This site class should not be evaluated with water erosion models, such as RHEM, since it is a depositional site for water erosion.

Table 7. ESD Community Class Data - MLRA 67B Playa Ecological Site Class

Comm Class ID	ESD Community Class	ESD Dominant Species (Symbol, Lbs/Ac)	Production Lbs/Ac	Soil Loss T/Ac/Yr	% Runoff	# PSUs
067B.1.1.1	Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Spring Perennial Grasslike, Summer Stoloniferous Grass, Evergreen Shrub, Summer Midgrass	western wheatgrass (PASM)(850-900), blue grama (BOGR2)(50-100), Buffalograss (BODA2)(25-100), green needlegrass (NAVI4)(25-50), sideoats grama (BOCU)(50-150) , fourwing saltbush (ATCA2)(25-50), winterfat (KRLA2)(20 – 70)	1300	N/A	N/A	0
067B.1.3.1	Summer Shortgrass, Summer Midgrass, Annual Grass, Annual Forb	Blue grama (BOGR2), purple threeawn (ARPU9), sand dropseed (SPCR), annual grass (AAGG), annual forb (AAFF)	150	N/A	N/A	0
067B.1.4.1	Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Evergreen Shrub	western wheatgrass (PASM)(300-450), blue grama (BOGR2)(200 – 325), green needlegrass (NAVI4)(150-250), sideoats grama (BOCU)(50-150), fourwing saltbush (ATCA2)(50-100), winterfat (KRLA2)(20-75)	1000	N/A	N/A	0

Supporting Information

The following publications support the state and transition model. The first publication examines varying soil types and associated vegetation characteristics. The pastures were also under various grazing prescriptions and had similar vegetation reactions to that of the STM. The second publication examines steer diets on replanted pastures. Although the STM does not indicate grazing, the study does illustrate similar vegetation characteristics to that of the STM within the steer's diets on the seeded pastures.

Rauzi, F. and F.M. Smith. 1973. Infiltration rates: Three soils with three grazing levels in Northeastern Colorado. Journal of Range Management 26(2): 126-129.

This study took place at the Central Plains Experimental Range near Nunn, Colorado. It was developed to evaluate how grazing affected infiltration rates on three predominant soil types. The soil types included Ascalon sandy loam, Shingle sandy loam, and Nunn loam. Vegetation was comprised of blue grama, buffalograss, and red threeawn.

Cattle stocking rates were averaged to 4.14, 3.13, and 1.79 acres per yearling heifer per month for the lightly, moderately, and heavily grazed pastures, respectively. Simulated rainfall was applied with a mobile infiltrometer to a circular area of approximately 13 ft^2 for one hour at a rate of 2.5 and 3.5 inches/hr. The test plot was 2 ft^2 and was positioned at the midpoint of the circular area. The infiltration rates were measured as the difference between application rate and measured runoff rates. Three tests were conducted on each soil type for each grazing prescription for a total of 27 plots. All standing vegetation was clipped at ground level a few days after the simulated rainfall. It was separated by species and was oven-dried and weighed.

The results found that infiltration rates, standing crop, litter, and total plant material varied by soil type and grazing level. The Ascalon sandy loam site showed blue grama and buffalograss as the dominant vegetation. These two grasses made up slightly over 50% of the total herbage by weight on the lightly and moderately grazed pastures and accounted for nearly all of the herbage on the heavily grazed. There were scattered plants of red threeawn on the lightly and moderately grazed pastures. Additionally, annual and perennial forbs were present on all grazing treatments. Infiltration rates were significantly higher for the lightly and moderately grazed pastures than on the heavily grazed. On the Shingle sandy loam site, blue grama and buffalograss comprised 90% of the total herbage at all levels of grazing. There were significant differences in amount of litter and plant material between grazing levels. There were no significant differences in infiltration rates between grazing levels. There was a high percentage of bare ground in the plots. The Nunn loam site was comprised of 80% to 85% blue grama and buffalograss. Sun sedge, six-weeks fescue, and a handful of annual and perennial forbs made up the rest. There were no significant differences in amount of litter and total plant material between grazing levels. Total plant material was significantly higher on pastures lightly and moderately grazed than on those that were heavily grazed. There was no significant difference in infiltration rate between the lightly and moderately grazed plots. However, the infiltration rates were significantly higher for the first and second 30-minute and 1-hour periods on the lightly and moderately grazed than on the heavily grazed sites. Additionally, significant correlation was found between infiltration rates and total plant material.

The conclusions of this study found that infiltration data obtained indicates that a stocking rate equivalent to that of the moderate grazing level on Ascalon sandy loam and Nunn loam soils would be a recommended grazing prescription.

Beck, Reldon F. 1975. Steer diets in Southeastern Colorado. Journal of Range Management 28(1): 48-51.

This study was located southwest of Springfield, Colorado in 1967 to 1968. The objective of the study was to determine dietary habits of grazing steers with access to either seeded, native or old field pastures during the growing season. Additionally, the study was implemented to propose a grazing scheme from the attained dietary information that allows for more efficient use of the available forage.

Each of the pastures in this study represented one of the three vegetation types in the area, which included seeded, native, and old field. The three pastures were adjacent to one another and had no fences. To implement light to moderate grazing, eight yearling Hereford steers were free to graze the pastures and were observed. The plant composition was determined by the step-point method and steer diets were found by counting the number of bites of each plant species. The observation periods of steers lasted 75 minutes and were done almost every morning and evening.

The results showed that each pasture had two perennial grasses that comprised at least 65% of available herbage by weight. The two most common on the seeded pasture were sideoats grama and blue grama (seeded with those species in 1961). On the native pasture, it was blue grama and buffalograss. The old field pasture had prominent sand dropseed and buffalograss. Other grasses on the old field pasture included threeawns, western wheatgrass, tumblegrass and a variety of forbs. Steer diets were comprised of nearly all plants present on all of the pastures at varying times in the growing season. Time spent on each pasture was very similar each year. There was a decline on usage of the old field at certain times of the year. Additionally, the animals never grazed the seeded pasture as long as the others.

The results of this study indicate that successful grazing programs should be based on perennial plants. Additionally, it was found that steers given free-choice will be selective and their diets will change in the summer grazing season. Further results indicate that sand dropseed is preferred by steers, while sideoats grama is less preferred. Lastly, forbs are important to steer diet and are fully utilized when available, but they fluctuate with rainfall so grazing plans should not be based off of them.

Additional Literature Pertinent to this STM

Augustine, D.J., D.T. Booth, S.E. Cox, and J.D. Derner. 2012. Grazing Intensity and Spatial Heterogeneity in Bare Soil in a Grazing-Resistant Grassland. Rangeland Ecology & Management 65(1): 39-46.

SALINE UPLAND ECOLOGICAL SITE CLASS

Figure 14. MLRA 67B, Saline Upland ecological site class.

General Description

This site class occurs in an upland position on hills and alluvial fans. It does not receive run-on moisture from adjacent sites. The soils are moderately deep to deep loams and clay loams. The soils are saline to saline-sodic. Salt tolerance species such as alkali sacaton and are common.

Geomorphic Features

Landscape Position:	Alluvial Fans, Terraces
Slope (percent):	0-3

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Alluvium
Parent Material Origin:	Mixed
Surface Texture:	Clay Loam to Sandy Loam
Surface Texture Modifier:	None
Subsurface Texture Group:	Clayey
Drainage Class:	Well Drained
Permeability Class:	Slow to Moderate
Chemistry:	Saline to Saline-Sodic
Available Water Capacity:	1-5 inches

State and Transition Model

1. Perennial Herbaceous 1.1 Summer Midgrass, Summer Tallgrass, Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Evergreen Shrub, Summer Perennial Forb 1249 lbs/ac		**4. Seeded Rangeland** 4.1 Summer Shortgrass, Summer Midgrass, Forbs, Annual Grasses and Forbs 1000 lbs/ac
1 to 2: plow, disk, plant	2 to 4: range planting 4 to 2: plow, disk, plant	3 to 4: range planting, prescribed grazing 4 to 3: continuous heavy grazing
2. Cultivated Cropland **Average County Yields** winter wheat 25 bu/ac grain sorghum 25 bu/ac corn 130 bu/ac dry beans 2200 lbs/ac sugar beets 33 tons/ac	2 to 3: abandonment 3 to 2: plow, disk, plant	**3. Abandoned Cropland** 3.1 Summer Shortgrass, Summer Midgrass, Forbs, shrubs 500 lbs/ac

Figure 15. State and Transition Model, MLRA 67B, Saline Upland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 15) was derived from the reference communities in the Ecological Sites correlated to this ecological site class. The reference plant community on this ecological site class produces approximately 1200 lbs/acre on a dry weight basis. This is comprised of alkali sacaton, western wheatgrass, blue grama, and switchgrass. With plowing and tillage, sites turn to a Cultivated Cropland state (state 2). From here, abandonment will cause it to transition to the Abandoned Cropland state (state 3), with a vegetative community of purple threeawn, ring muhly, and sand dropseed. If the site is instead planted, the reference state vegetation may be maintained, just with a slightly lower production, as seen in the Seeded Rangeland state (state 4).

One NRI Primary Sampling Unit (PSU) was correlated to this ecological site class. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 8. Ground and canopy cover from the PSUs was then used to estimate erosion and runoff using RHEM.

Table 8. NRI Community Class Data and RHEM Results - MLRA 67B Saline Upland Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
067B.24.1.1	Summer Shortgrass, Summer Midgrass, Evergreen Shrub, Cacti, Spring Midgrass, Spring Annual Forb(I), Spring Perennial Forb	blue grama (BOGR2)(558), alkali sacaton (SPAI)(378), green rabbitbrush (ERTE18)(110), plains pricklypear (OPPO)(33), squirreltail (ELEL5)(32), Russian thistle (SAKA)(25), scarlet globemallow (SPCO)(13)	1182	0.01	4.92	1

Supporting Information

The following publications support the STM. The first publication evaluated soil and climatic conditions as integrated and expressed through plant growth dynamics. The study displayed similar vegetation characteristics to that of the STM and found that soil fertility evaluation is necessary in cultivation practices. The second publication examined reseeding practices on saline-sodic soils. Although the study was not long enough to show transition back into previous states, it does give examples of the mechanics of seeding and the implied outcomes.

Bowman, R.A., D.M. Mueller, and W.J. McGinnies. 1985. Soil and vegetation relationships in a central plains saltgrass meadow. Journal of Range Management 38(4): 325-328.

This field study was initiated with the purpose of better understanding the ecology of a saltgrass meadow and to facilitate the use of various planting practices. It evaluated relationships between soil types, salinity, sodicity, soil N, soil sodium bicarbonate-extractable P, vegetation ground cover, nutrient content, and species composition by foliar cover.

The study was located at the Central Plains Experimental Range (CPER), in the shortgrass prairie in close proximity of Fort Collins, Colorado. The dominant grasses at the study site were saltgrass, alkali sacaton, blue grama, and western wheatgrass. Forty-eight soil cores were taken along three east-west transects perpendicular to the main drainage creek. Soil analyses included pH, electrical conductivity (EC), and sodium absorption ratio (SAR). Vegetation sampling consisted of determining the ground cover of four 30cm x 30cm plots at each location. Vegetation that was harvested from the grids was dried, passed through a 40-mesh screen, and wet-digested for elemental analyses.

The results found that A horizons varied from being absent to 30cm thickness. The B horizon varied in thickness as well, was typically of columnar structure, and largely impermeable to water. The C horizon was much lighter in color because of insignificant amounts of organic matter. The soils varied from acidic to alkaline, but were more alkaline the deeper into the profile. The EC had a similar trend, increasing deeper into the horizons. In terms of vegetation data, the ground cover generally reflected that blue grama > alkali sacaton > inland saltgrass > western wheatgrass. Ground cover and species composition changes were a function of available soil water, which was reflected by the rainfall patterns throughout the years. The wetter years produced an increase in ground cover. Forage chemical composition reflected soil chemical properties and species plant genetic capabilities of root growth. Blue grama cover was positively correlated with the thickness of the A horizon, depth to salinity, and depth to C horizon. This is due to its lack of salt tolerance and tendency to have shallow roots that avoid the salt. Therefore, blue grama was growing most abundantly on areas with deeper soil. Where higher salt concentrations occurred, total plant cover was reduced and inland saltgrass became the more dominant species. Western wheatgrass and alkali sacaton were not strongly influenced by salinity, but N concentration in the surface 10cm was correlated to cover and percent composition of western wheatgrass. No western wheatgrass grew on sodic soils.

The conclusions of this study found that soil and climatic conditions are integrated and expressed through plant growth dynamics. Therefore, researchers may be able to make predictions about soil capability based on vegetation. Under cultivation management, inherent soil fertility is sampled in order to predict crop productivity potential. These management practices are crucial to rehabilitate saltgrass meadow soils.

Ludwig, J.R. and W.J. McGinnies. 1978. Revegetation trials on saltgrass meadow. Journal of Range Management 31(4): 308-311.

This field study was conducted on an inland saltgrass meadow on the Central Plains Experimental Range near Nunn, Colorado. Dominant vegetation included inland saltgrass, alkali sacaton, western wheatgrass, blue grama, and threadleaf sedge. The objective of this study was to find palatable grasses adapted to Natrustoll soils to evaluate the effects of N and Ca on seedling establishment.

In 1974, a previously-plowed plot was sprayed with glyphosate to kill inland saltgrass. It was then plowed, disked, and planted to tall wheatgrass, crested wheatgrass, smooth brome, and Russian wildrye. These were seeded with the two methods of level drilled and alternate furrow and two levels of nitrogen in a randomized block design with four replications. Seedling counts were conducted monthly beginning three months post-seeding. Additionally, soil moisture and seedling vigor estimates were made. By the second growing season, aboveground biomass was clipped and oven-dried. In 1976, the site was seeded again with the same four species, but drilled with a cone-type seeder. Calcium chloride and potassium chloride were also applied.

The results found high variability in establishment on the plots of both seeding trials. Due to the variations in thickness of soil horizons, plowing brought different soil horizons to the surface, which ultimately caused locally thinner stands and lower yields. For the 1975 planting, the average number of seedlings in the level plots was significantly higher than in the alternate-furrow plots. However, in the following year the plots did not differ significantly. The 1976 plantings found that the addition of calcium, nitrogen, and mulch created improved seeded stands. The number of seedlings of crested wheatgrass was higher than any of the other three species.

The conclusions of this study found that crested wheatgrass is indicated to be the most adaptable of the four species in this experiment. However, no treatment was completely satisfactory for the revegetation of saline-sodic soils, but use of heavy mulch was helpful. Especially in years of below-average precipitation, salt meadow sites are likely to have poor spots in seeded stands where Natrustoll soils occur.

SANDY UPLAND ECOLOGICAL SITE CLASS

Figure 16. MLRA 67B, Sandy Upland ecological site class.

General Description

This ecological site class occurs on gently sloping plains and rolling dunes. The soils are deep and sandy textured. The soils in this site class can capture most or all of the precipitation that falls, but the water-holding capacity is limited. Wind erosion becomes the primary concern on this site class when vegetation cover is reduced.

Geomorphic Features

Landscape Position:	Dunes, Hills, Plains
Slope (percent):	1-40

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Mixed
Parent Material Origin:	Mixed
Surface Texture:	Loamy sand to Sand
Surface Texture Modifier:	None
Subsurface Texture Group:	Sandy
Drainage Class:	Somewhat Excessively to Excessively Well Drained
Permeability Class:	Moderately Rapid to Very Rapid
Chemistry:	None
Available Water Capacity:	2-6 inches

State and Transition Model

1. Perennial Herbaceous - Woody 1.1 Summer Tallgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Midgrass, Spring Midgrass, Deciduous Shrub, Summer Shortgrass 1724 lbs/ac	1 to 4: continuous heavy grazing 4 to 1: herbaceous weed control, prescribed grazing	**4. Annual – Perennial Herbaceous** 4.1 Spring Annual Forb(I), Spring Annual Forb, Spring Perennial Forb, Summer Shortgrass, Spring Annual Grass(I), Summer Annual Forb, Summer Midgrass 1693 lbs/ac
1 to 2: plow, disk, plant	1 to 3: continuous heavy grazing, lack of fire 3 to 1: brush management, prescribed burning, prescribed grazing 4 to 2: plow, disk, plant	4 to 3: continuous heavy grazing, lack of fire 3 to 4: brush management, prescribed burning without prescribed grazing
2. Cultivated Cropland **Average County Yields** winter wheat 16 bushels/ac grain sorghum 19 bushels/ac corn 178 bushels/ac alfalfa 2-3 tons/ac	3 to 2: plow, disk, plant	**3. Woody – Herbaceous** 3.1 Evergreen Shrub, Deciduous Tree, Summer Annual Forb, Spring Rhizomatous Grass(I), Spring Annual Forb(I), Summer Perennial Forb, Summer Midgrass 1273 lbs/ac
2 to 5: abandonment 5 to 2: plow, disk, plant	2 to 6: critical area planting, prescribed grazing 6 to 2: plow, disk, plant	
5. Abandoned Cropland 5.1 Summer Shortgrass, Summer Midgrass, Spring Perennial Forb, Summer Annual Forb, Monocot Shrubs 300 lbs/ac	5 to 6: critical area planting, prescribed grazing 5 to 6: continuous heavy grazing	**6. Seeded Rangeland** 6.1 Summer Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Perennial Forb, Evergreen Shrub, Deciduous Shrub 800lbs/ac

Figure 17. State and Transition Model, MLRA 67B, Sandy Upland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 17) was derived from the reference communities in the ecological sites correlated to this ecological site class. The reference plant community on this ecological site class produces approximately 1700 lbs/acre on an air-dry weight basis. The vegetation composition likely consists of sand bluestem, switchgrass, needleandthread, and blue grama. With continuous season-long heavy grazing, the site will transition to an Annual – Perennial Herbaceous state (4.1) dominated by Russian thistle, kochia and tall tumblemustard. To return the reference state (1.1), the site will require herbaceous weed control and prescribed grazing with deferral periods long enough to provide regrowth. With continuous heavy grazing and lack of a regular fire interval, woody species including sand sagebrush and black locust will increase on the site, causing it to transition to the Woody – Annual Herbaceous state (3.1). Brush management, prescribed burning, and prescribed grazing can be used to return it to the reference state (1.1). With plowing and tillage, sites turn to a Cultivated Cropland state (2). From here, abandonment will cause it to transition to the Abandoned Cropland state (5.1), with a vegetative community of purple threeawn, sand muhly, and sand dropseed. If the site is instead planted using critical area planting, the Seeded Rangeland state (6.1) may be maintained, just with a slightly lower production.

NRI PSUs were correlated to these community classes where possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 9. Ground and canopy cover from the PSUs was then used to estimate erosion and runoff using RHEM. On this ecological site class, wind erosion is the primary erosion process.

Table 9. NRI Community Class Data and RHEM Results - MLRA 67B Saline Upland Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
067B.7.1.1	Summer Midgrass, Summer Tallgrass, Summer Shortgrass, Spring Midgrass, Summer Annual Forb, Evergreen Shrub, Spring Annual Forb(I)	sand dropseed (SPCR)(255), blue grama (BOGR2)(245), switchgrass (PAVI2)(196), needle and thread (HECO26)(165), sand sagebrush (ARFI2)(85), prairie sandreed (CALO)(67), common sunflower (HEAN3)(50)	1507	0.04	1.88	46
067B.7.3.1	Evergreen Shrub, Deciduous Tree, Summer Annual Forb, Spring Rhizomatous Grass(I), Spring Annual Forb(I), Summer Perennial Forb, Summer Midgrass	sand sagebrush (ARFI2)(2226), black locust (ROPS)(1760), common sunflower (HEAN3)(475), smooth brome (BRIN2)(404), Russian thistle (SAKA)(90), Cuman ragweed (AMPS)(76), sand dropseed (SPCR)(51)	5373	0.01	1.42	4
067B.7.4.1	Spring Annual Forb(I), Spring Annual Forb, Spring Perennial Forb, Summer Shortgrass, Spring Annual Grass(I), Summer Annual Forb, Summer Midgrass	Russian thistle (SAKA)(381), tall tumblemustard (SIAL2)(272), kochia (BASC5)(263), blue grama (BOGR2)(88), cheatgrass (BRTE)(84), common sunflower (HEAN3)(74), sand sagebrush (ARFI2)(69)	1693	0.03	2.17	7

Supporting Information

The following publication supports the STM. It studies the thresholds and rates of change to alternative states and community phases within grazed northern mixed-grass prairie. It found that transitions should not be understood as a hard threshold to alternative states, but did find similar shifts in vegetation dynamics at this STM.

Porensky, L.M, K.E. Mueller, D.J. Augustine, and J.D. Derner. 2016. Thresholds and gradients in a semi-arid grassland: long-term grazing treatments induce slow, continuous, and reversible vegetation change. Journal of Applied Ecology.

This article empirically evaluated several of the thresholds and rates of change between alternative states and community phases within an STM that studied plant community responses to grazing treatments in a northern mixed-grass prairie. The study observed whether long-term grazing treatments (33 years) caused alternative stable states. This would include: 1) plant communities that were different and stable over time during the third decade of the experiment; 2) evidence that after reducing stocking rate from heavy (1982-2006) to light or no grazing (2007-2014), the plant community did not shift back toward expected community composition for a lightly grazed or un-grazed state. Additionally, the study used long-term experimental data to examine specific elements of the existing STM. Specifically, the study quantified the magnitude and temporal dynamics of vegetation change in relation to the varying grazing strategies and determined whether long-term heavy grazing affected the loss of C3 perennial grasses.

The study was initiated in 1982 on the northern mixed-grass prairie at the High Plains Grassland Research Station near Cheyenne, WY. Vegetation was primarily grass including western wheatgrass, needleandthread, needleleaf sedge, and blue grama. Season-long, continuous grazing treatments began in 1982 on two replicate pastures (one north-facing, one south-facing) per treatment and continued annually. The treatments were light (15.7 ± 2.8 animal unit days/ ha; or 4 steers/20 ha), moderate (32.6 ± 5.5 AUD or 4 steers/12 ha), and heavy (43.4 ± 7.3 AUD or 4 steers/ 9 ha). These stocking rates were determined from NRCS data to be ~35% below, equal to, or ~33% above recommended stocking rates. Two 0.5 ha fenced exclosures were constructed to remained un-grazed throughout the experiment. The original experiment also included eight pastures assigned to rotational grazing. In 2007, four pastures that were heavily stocked were switched to continuous light or no grazing. Prior to this switch, there was no evidence of significantly differing plant composition or aboveground production regardless of grazing system. Therefore, the study was based on two pasture-scale replications of six grazing treatments. These included: 1) no grazing; 2) light grazing; 3) moderate grazing; 4) heavy grazing; 5) heavy to light grazing; 6) heavy to no grazing. Vegetation sampling was done to quantify changes in species composition by foliar cover and was done by annually sampling 25 permanent quadrats randomly located along each of two 50m permanent transects per pasture. The statistical analysis was done by partial redundancy analysis (RDA) with the year included as the co-variable.

The results found significant variation among grazing treatments and years. Long-term stocking rate treatments caused continued, directional shifts in plant community composition from 2003-2014. Higher stocking rates were associated with lower RDA scores, which indicated that an increased cover of blue grama would be associated with a decreased cover of western wheatgrass and needleandthread. Additionally, communities with varying treatments tended to diverge from one another in years 22-33 of the experiment. Further, long-term data found that RDA scores decreased for exclosures with an increase in western wheatgrass, while the scores for the lightly grazed increased with more cover of needleandthread. Moderately and heavily grazed pastures had low and stable scores on the RDA axis, portraying a low relative cover of grasses.

In reference to specific plant species, it was found that the combined cover of western wheatgrass and needleandthread increased sharply in exclosures, remained stable in lightly stocked pastures, and decreased in moderately and heavily stocked pastures. Blue grama comprised 99% of C4 perennial grass cover. In 2003, blue grama was 314% higher in cover in the heavily grazed pastures, and 105% higher in lightly grazed than in the exclosures. Throughout the study, blue grama showed a trend of increasing under heavily and moderately stocked pastures and remained stable in lightly stocked and exclosures. Grazing reversal treatments did not differ from the long-term heavy stocking treatment and all of these treatments had significantly lower RDA scores than long-term light stocking and exclosure treatments. Following reversal to light stocking or no grazing, the three dominant plant species varied in response. The combined cover of western wheatgrass and needleandthread increased in the grazing reversal and long-term exclosure treatments, while it decreased slightly in the moderate and heavy stocking treatments. By 2014, the cover was similar to that of the long-term lightly grazed pastures. Basal cover of blue grama did not have a strong response to the grazing reversal.

The conclusions of this study found that although it could not eliminate the possibility of alternative stable states in the ecosystem, the results are most consistent with a temporal gradient model in which grazing instigates slow, constant and revocable changes in plant species abundance. At the end of the experiment, the vegetation had not reached apparent, stable equilibria as a result of the different grazing intensities, but were steadily diverging. It is a theory that a state shift had occurred, but was not clearly marked by sudden changes or subsequent stabilization. It was found that pastures that were converted from heavy stocking to light or no grazing, had strong evidence of reversibility and rates of change for the two most dominant C3 grasses. Discontinuing heavy grazing did not induce significant changes in basal cover of the dominant C4 grass. Future monitoring is required to determine whether vegetation dynamics shift in grazing reversals. Overall, the study results found that STM's might misrepresent an ecosystems resilience to grazing by overemphasizing nonreversible transitions. It may be relevant to understand the time-scales and compositional gradients of crucial phase shifts rather than to emphasize the probability of threshold shifts between alterative stable states.

Additional Literature Pertinent to the STM

Reppert, Jack N. 1960. Forage preference and grazing habits of cattle at the Eastern Colorado Range Station. Journal of Range Management 13(2): 58-65.

Dahl, B.E. 1963. Soil moisture as a predictive index to forage yield for the sandhills range type. Journal of Range Management 16(3): 128-132.

Sparks, Donnie R. 1968. Diet of Black-Tailed Jackrabbits on sandhill rangeland in Colorado. Journal of Range Management 21(4): 203-208.

STREAM TERRACE ECOLOGICAL SITE CLASS

Figure 18. MLRA 67B, Stream Terrace ecological site class.

General Description

The Stream Terrace ecological site class occurs on active and abandoned floodplain steps, terraces and in draws. The site benefits from run-on moisture from adjacent uplands and/or rare to occasional flooding. Deposition and erosion from flow events results in variable surface and subsurface textures across the site.

Geomorphic Features

Landscape Position:	Floodplains, Floodplain steps, Draws
Slope (percent):	0-3

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Alluvium
Parent Material Origin:	Mixed
Surface Texture:	Clay Loam to Loam
Surface Texture Modifier:	None
Subsurface Texture Group:	Loamy to Clayey
Drainage Class:	Well Drained
Permeability Class:	Slow to Well Drained
Chemistry:	None to Saline-Sodic
Available Water Capacity:	6-8 inches

State and Transition Model

1. Perennial Herbaceous 1.1 Summer Midgrass, Spring Rhizomatous Grass, Summer Tallgrass, Spring Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb 1850 lbs/ac		**4. Seeded Rangeland** 4.1 Summer Shortgrass, Summer Midgrass, Evergreen Shrubs, Forb 1000 lbs/ac
1 to 2: plow, disk, plant	2 to 4: range planting, prescribed grazing 4 to 2: plow, disk, plant	3 to 4: range planting, prescribed grazing
2. Cultivated Cropland **Average County Yields** winter wheat 25 bu/ac grain sorghum 25 bu/ac corn 130 bu/ac dry beans 2200 lbs/ac sugar beets 33 tons/ac	2 to 3: abandonment 3 to 2: plow, disk, plant	**3. Abandoned Cropland** 3.1 Summer Midgrass, Spring Rhizomatous Grass, Summer Tallgrass, Spring Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb 924 lbs/ac

Figure 19. State and Transition Model, MLRA 67B, Stream Terrace ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 19) was derived from the reference communities in the ecological sites correlated to this ecological site class. The reference plant community on this ecological site class produces approximately 1500 lbs/acre air-dry weight. This is comprised of alkali sacaton, western wheatgrass, blue grama, and vine mesquite. With plowing and tillage, sites turn to the Cultivated Cropland state (2). From here, abandonment will cause it to transition to a vegetative community of purple threeawn, ring muhly, and sand dropseed, characterized by the Abandoned Cropland state (3.1). If the site is instead planted, the reference state vegetation composition may be maintained, just with a lower representative value of 1000 lbs/acre, as shown in the Seeded Rangeland state (4.1).

Three NRI PSUs were correlated to these community classes where possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 10. Ground and canopy cover from the PSUs was then used to estimate erosion and runoff using RHEM.

Table 10. NRI Community Class Data and RHEM Results - MLRA 67B Stream Terrace Ecological Site Class

Comm Class ID	Community Class Name	Dominant Species (Symbol, Lbs/Ac)	Production Lbs/Ac	Soil Loss T/Ac/Yr	% Runoff	# PSUs
067B.3.1.1	Summer Shortgrass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Midgrass, Summer Rhizomatous Grass	blue grama (BOGR2)(349), western wheatgrass (PASM)(227), Buffalograss (BODA2)(35), kochia (BASC5)(27), sand dropseed (SPCR)(27), Russian thistle (SAKA)(23), tumblegrass (SCPA)(10)	702	0.05	3.70	2
067B.3.3.1	Spring Annual Forb(I), Summer Midgrass, Summer Annual Forb, Spring Rhizomatous Grass, Summer Shortgrass, Spring Perennial Forb(I), Spring Perennial Forb	sand dropseed (SPCR)(237), kochia (BASC5)(200), western wheatgrass (PASM)(134), pigweed (AMARA)(122), Russian thistle (SAKA)(64), blue grama (BOGR2)(46), curly dock (RUCR)(37)	924	0.04	7.57	1

Supporting Information

The following publications support the STM. The first publication evaluates vegetation characteristics in relation to soils and grazing. The study correlates to the STM with similar findings in vegetation increasers and decreasers with disturbance and soil-vegetation characteristics. The second publication evaluates vegetation characteristics in relation to soil. The findings indicate similar dominant vegetation to that of the STM and discusses the likely variability of revegetation.

Hyder, D.N., R.E. Bement, E.E. Remmenga, and C. Terwilliger Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. Journal of Range Management 19(1): 11-17.

This study took place at the Central Plains Experimental Range in Nunn, Colorado. It reports on vegetation-soils and vegetation-grazing relationships on blue grama range. Further, it compares these results with previous classifications of range sites and conditions. The study employed frequency sampling techniques where each sample is restricted to a macroplot 100 by 75 feet and includes 250 quadrat placements. The sampling frame includes a nested pair of quadrats. Sixty-seven stands were sampled in 1962 and 1963. Two or more macroplots were situated on each of the soil series found in range units that were in exclosures, as well as those that were lightly, moderately, and heavily grazed. The soils that were present in the study included Vona sandy loam, Greeley sandy loam, Ascalon sandy loam, Renohill loam and fine sandy loam, Midway-Renohill complex, Havre loam and very fine sandy loam, Fort Collins loam, Nunn clay loam, undifferentiated loam, unnamed saline-alkaline loam and clay loam. The frequency percentages of 46 species in each soil-series group were correlated with grazing intensities. Positive correlation coefficients indicate increasers and negative indicate decreasers.

The results found that individual species frequencies are uniformly most significantly correlated to soil texture and subsoil permeability. The soil groups were classified into range sites. These included Sandy Plains, Loamy Plains, Overflow, Clayey Swale, and Salt Meadow. Sandy Plains vegetation included (in decreasing order by weight) blue grama, threeawn, western wheatgrass, broad-leafed sedge, plains pricklypear, scarlet globemallow, and other smaller percentages of vegetation. Loamy Plains had high percentages of blue grama, plains pricklypear, scarlet globemallow, sixweeks fescue, buckwheat, broad-leafed sedge, threeawn, and wooly plantain. Overflow was comprised of high percentages of blue grama, western wheatgrass, broad-leafed sedge, buffalograss, plains pricklypear, and winterfat. Clayey Swale vegetation included high percentages of buffalograss, broad-leafed sedge, western wheatgrass, povertyweed, blue grama, skeletonleaf bur-sage, and sixweeks fescue. Salt Meadow vegetation included inland saltgrass, western wheatgrass, sixweeks fescue, alkali sacaton, blue grama, talinum, scarlet globemallow, wooly plantain, and povertyweed. Midgrasses and shrubs decrease with soil permeability, but shortgrasses, plains pricklypear, and scarlet globemallow increase. Blue grama was dominant on all upland soils, as was buffalograss. Western wheatgrass, fourwing saltbush, and blue grama are replaced by buffalograss on saline-alkaline soils as soil permeability and flooding frequency increase. In regards to vegetation-grazing relations, needleandthread is a decreaser on sandy loams, while western wheatgrass is a decreaser. Scarlet globemallow is an increaser on saline-alkaline soils. Conclusions of the study found that regarding frequency data: 1) vegetation-soil relations have been clarified very well; 2) summer-long grazing at different intensities for 23 years has not affected species frequency to a high degree; 3) frequency percentages of species are stable enough to permit study of vegetation-soils relations at all grazing intensities, and; 4) the most important effect of heavy grazing has been a reduction in herbage yields.

McGinnies, W.J., L.W. Osborn, and W.A. Berg. 1976. Plant-Soil-Microsite relationships on a saltgrass meadow. Journal of Range Management 29(5): 395-400.

This saltgrass meadow study took place on the Central Plains Experimental Range on the Eastman Creek Drainage. The objective of the study was to determine relationships between existing vegetation and soil characteristics. The meadow soil had been identified as an alkali-saline complex, but had not been named. The study design delineated the saltgrass meadow boundaries on the basis of presence or absence of saltgrass, and the soils and vegetation in those areas were sampled. Forty-seven meter square plots were permanently marked and the vegetation sampled during July and August. After completion of the vegetation sampling, a soil pit was dug in the center of each plot with three horizons included in the data. In addition to field observations of depth, color, structure, consistency, and presence/absence of calcium carbonate, the samples were evaluated for electrical conductivity, pH, and Ca/Mg levels. The results found that in descending order, the dominant perennial vegetation by weight was saltgrass, alkali sacaton, blue grama, threadleaf sedge, and western wheatgrass. The average total cover of the 47 plots was 33.5%. None of the specific plants were found to be an indicator species of soil physical or chemical characteristics. The percent composition of saltgrass was negatively correlated to total basal area of the other dominant species. This is likely due to its low palatability and ability to use moisture from greater soil depths, and thus it outcompetes other species. The soil evaluation found no salinization stage had occurred, but some solodization had. The pH averaged from 7.0 to 8.8 in the varying horizons and had an electrical conductivity (EC) that indicated salt increased in the profile from top to bottom. Overall, the saltgrass meadow was extremely variable from plot to plot in both vegetation and soil properties. Microsites were determined to be “slickspot”, “level”, “mound”, and “swale”. The slickspot and mound were similar, but the mound was moderately raised with dense vegetation. The level microsite was intermediate between the slickspot and moderate, and had a relatively thin A horizon with dense vegetation. The swale microsite often had indistinct surface drainage patterns and finer-textured soils with dense vegetation of western wheatgrass and threadleaf sedge.

When viewing the microsites, rather than the meadow as a whole, vegetation-soil relationships were generally higher. The slickspot microsite was most unfavorable for plant growth and had sparse basal cover. The vegetation was mainly saltgrass and EC levels were highest in this microsite. The level microsite had a dominant vegetation of saltgrass, but also had subdominants of blue grama and alkali sacaton. There was a negative correlation between saltgrass and alkali sacaton, meaning that as alkali sacaton decreased, saltgrass increased. This is especially evident in its varying resistance to grazing. The mound microsite produced the densest vegetation cover of the four microsites. In decreasing order by weight, the vegetation consisted of alkali sacaton, saltgrass, threadleaf sedge, blue grama, and western wheatgrass. On this site, alkali sacaton was able to persist on mounds that the saltgrass did not invade. This microsite also had a very thick A horizon with greater water storage capacity and lower sodium absorption ratio (SAR) and EC levels. The swale microsites had the highest clay content which resulted in their higher moisture holding capacity. The vegetation in decreasing order by weight was saltgrass, western wheatgrass, threadleaf sedge, blue grama, and alkali sacaton. Together, threadleaf sedge and western wheatgrass provided 50% of the cover. The conclusions of this study found that saltgrass was most consistent with soils that were solonetzic. Blue grama was highly sensitive to salt content. Total blue grama basal area and plant height increased significantly with an increase in the A horizon thickness. With higher pH values, alkali sacaton was more likely to persist. Because the saltgrass meadow is so highly variable, attempts to revegetate will likely be highly variable as well.

Additional Literature Pertinent to the STM

Shoop, M.C., R.C. Clark, W.A. Laycock, and R.M. Hansen. 1985. Cattle Diets on Shortgrass Ranges with Different Amounts of Fourwing Saltbush. Journal of Range Management 38(5): 443-449.

WET BOTTOMLAND ECOLOGICAL SITE CLASS

Figure 20. MLRA 67B, Wet Bottomland ecological site class.

General Description

The Wet Bottomland ecological site class occurs in the lowest portions of the landscape. This site receives occasional flooding and/or subsurface water flows from adjacent uplands. It has a shallow water table available for plant growth seasonally or yearlong in most years. Surface water may be present all or part of the year. Wetland soils and obligate wetland vegetation may be present. Flooding and/or ponding occur occasionally to frequently. Potential plant community production is significantly higher than that of adjacent uplands, and the response to management is more rapid because of the availability of water. This ecological site class is high in wildlife value.

Geomorphic Features

Landscape Position:	Floodplains, Stream Terraces
Slope (percent):	0-3 percent

Representative Soil Features

Soil Depth:	Deep to Very Deep
Parent Material Kind:	Mixed
Parent Material Origin:	Mixed
Surface Texture:	Clay Loam to Sandy Loam
Surface Texture Modifier:	None to Very Gravelly
Subsurface Texture Group:	Loamy to Sandy
Drainage Class:	Poorly to Somewhat Poorly Drained
Permeability Class:	Slow to Rapid
Chemistry:	None to Saline-Sodic
Available Water Capacity:	2-6.5 inches

State and Transition Model

1. Perennial Herbaceous - Woody		2 Annual – Perennial Herbaceous
1.1 Summer Tallgrass, Summer Midgrass, Spring Rhizomatous Grass, Spring Perennial Grasslike, Summer Perennial Grasslike, Summer Perennial Forb, Spring Midgrass 3500 lbs/ac	1 to 2: continuous heavy grazing 2 to 1: herbaceous weed control, range planting, prescribed grazing	2.1 Summer Annual Forb(I), Spring Annual Forb, Spring Annual Forb(I), Spring Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Cacti 3416 lbs/ac
1 to 3: continuous heavy grazing, lack of fire 3 to 1: brush management, prescribed burning, prescribed grazing	2 to 3: continuous heavy grazing, lack of fire 3 to 2: brush management, prescribed burning	
3. Woody – Herbaceous		
Deciduous shrub(I), Evergreen Tree(I), Spring Rhizomatous Grass(I), Spring Annual Forb(I), Annual Grass 700 lbs/ac		

Figure 21. State and Transition Model, MLRA 67B, Wet Bottomland ecological site class.

Vegetation Dynamics

Community Class 1.1 in the State and Transition Model (Figure 21) was derived from the reference communities in the ecological sites correlated to this ecological site class. The reference plant community on this ecological site class produces approximately 4000 lbs/ac/yr air-dry weight. Big bluestem, switchgrass, prairie sandreed, Indiangrass, prairie cordgrass, western wheatgrass, and Nebraska sedge are common vegetation. Prescribed Grazing with 90 to 120 days of growing season deferment at least once every 2-3 years will keep the plant community in this State. With heavy continuous grazing, the site will transition to an Annual – Perennial Herbaceous state (2.1). Annual production is more variable in this Community Class because the production of annuals is more variable. The plant community may be returned to within reference conditions using range planting, herbaceous weed control, and long term prescribed grazing. However, if this does not occur and there is also a lack of fire and proper grazing management, the site will likely transition to a woody invasive state. The Woody - Herbaceous state (3) may also occur straight from reference conditions if there is no fire or proper grazing management. Within this state invasive trees include tamarisk and Russian olive. It will take mechanical and chemical treatment with long term prescribed grazing allowing for growing season deferment to return the site to reference conditions.

Two NRI PSUs were correlated to these community classes where possible. Community Class production, functional group dominance, and dominant species based on available NRI data are shown in Table 11. Ground and canopy cover from the PSUs was then used to estimate erosion and runoff using RHEM. However, flooding is the major driver of erosion and deposition in this ecological site class.

Table 11. NRI Community Class Data and RHEM Results - MLRA 67B Wet Bottomland Ecological Site Class

Comm Class ID	**Community Class Name**	**Dominant Species** (Symbol, Lbs/Ac)	**Production** Lbs/Ac	**Soil Loss** T/Ac/Yr	**% Runoff**	**# PSUs**
067B.22.1.1	Summer Midgrass, Spring Annual Forb(I), Summer Rhizomatous Grass, Spring Annual Forb, Summer Perennial Forb, Spring Annual Grass, Spring Perennial Forb	alkali sacaton (SPAI)(1009), Russian thistle (SAKA)(422), saltgrass (DISP)(127), Buffalograss (BODA2)(108), upright prairie coneflower (RACO3)(80), herb sophia (DESO2)(67), sixweeks fescue (VUOC)(35)	1936	0.01	3.78	1
067B.22.2.1	Summer Annual Forb(I), Spring Annual Forb, Spring Annual Forb(I), Spring Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Cacti	fivehorn smotherweed (BAHY)(2792), goosefoots (CHENO)(511), Russian thistle (SAKA)(48), scarlet globemallow (SPCO)(25), sand dropseed (SPCR)(18), saltgrass (DISTI)(10), plains pricklypear (OPPO)(7)	3416	0.03	3.06	1
067B.22.3.1	Deciduous shrub(I), Evergreen Tree(I), Spring Rhizomatous Grass(I), Spring Annual Forb(I), Annual Grass	saltcedar (TAMAR2) (200 - 400), Russian olive (ELAN)(200-400) foxtail barley (HOJU), Kentucky bluegrass (POPR) annual grasses (AAGG), annual forbs (AAFF)	700	--		0

Supporting Information

The following publications support the STM. The first publication studies the changes in vegetation structure after 30 years of decreased grazing pressure. It found similar conclusions to that of the STM, with herbage production matching that of the varying transitions with different grazing intensities or exclusion. The second study examined moderate grazing on a riparian area. It found no significant decrease in the herbage production as grazing was at a prescribed level.

Schulz, T.T. and W.C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management 43(4): 295-299.

The objective of this study was to evaluate the changes in vegetation structure in a montane riparian area in north-central Colorado after 30 years of decreased grazing pressure and livestock exclusion. The study was conducted within a riparian area of Sheep Creek northwest of Fort Collins, CO. Previous history of the site was said to have had extremely heavy cattle grazing from the turn of the century until the 1950's. By the late 1940's historical records indicated that the area had been damaged to the point that there was very little herbaceous plant cover and only a few remnant willows. In 1956, the U.S. Forest Service constructed exclosures to protect the riparian area, fencing a total of 40 ha with very little grazing in limited areas. The study methods included comparing riparian vegetation density and cover between grazed areas and exclosures in July-August 1985 and 1986. Each year, 60 10-m transect lines were established perpendicular to the stream. Density of woody species, canopy cover of all plant species, litter, bare ground, and rock coverage were all recorded using 300 20- by 50-cm cover plots. Data was evaluated with analysis of variance using a randomized split-plot design, with grazing as main plots, exposure and years as subplots, and sites as replications. Additionally, 60 0.25m^2 plots were created to measure peak standing crop in grazed areas and exclosures. Utilization cages, covering the 30 plots in the grazed areas were used to estimate standing crop of riparian vegetation in the grazed area. The results found that 29 years after fencing, riparian vegetation within the exclosures had become so abundant that it obscured the view of the stream channel. By 1985, herbaceous vegetation had increased over the entire allotment. Additionally, the rested sections of Sheep Creek exhibited abundant shrubby vegetation. This was evident as willow and other individual woody species densities within the transect belt were similar between the exclosures and grazed areas, but higher within exclosures. Total vascular vegetation cover was greater in the exclosures than the grazed areas. Additionally, litter cover in the protected areas was nearly 2 times that of the grazed. The grazed had nearly 5 times more bare ground than the exclosures. The grazed area had higher amounts of clover and dandelion than the exclosures. Kentucky bluegrass cover was greater in the grazed areas, while fowl bluegrass was greater in the exclosures. Nebraska sedge and beaked sedge cover were no different between grazed and excluded riparian areas.

Conclusions of this study found that vegetation differences at Sheep Creek could be attributed to 30 years of reduced stocking rates and rest from grazing. The grazed area showed increased herbaceous vegetation with reduced stocking rates, while the exclosures showed an increase in woody and herbaceous vegetation and biomass. It was clear from the study that woody plant species do increase rapidly when riparian areas are protected from livestock grazing. It was also found that Kentucky bluegrass appears to be favored by cattle grazing, whereas fowl bluegrass may be enhanced by protection. Additionally, Nebraska sedge was approximately equal in both grazed and rested areas. Overall, the study found that some rest may be required to reestablish healthy stands of shrubs in degraded riparian areas.

Sedgewick, J.A. and F.L. Knopf. 1991. Prescribed grazing as a secondary impact in a western riparian floodplain. Journal of Range Management 44(4): 369-373.

The purpose of this study was to evaluate the effects of grazing on above-ground biomass of a shrub-herbaceous vegetation layer. The vegetation of this northeastern Colorado floodplain included prairie cordgrass, common reed, witchgrass panicum, sedges, and knotweeds. Higher elevations had cheatgrass, western wheatgrass, Canada wildrye, sand dropseed, burning bush, white sweetclover, and sunflower. Along with other herbaceous species, common shrubs included western snowberry, coyote willow, sandbar willow. Ten 16-ha pastures were established in the floodplain and five of these were randomly selected to be un-grazed controls while the other five were moderately grazed. Vegetation data was collected prior to grazing and 1, 2 and 3 seasons post-grazing. Sampling points were determined off of 14 stakes that were spaced 100m apart in each pasture. Standing biomass of grasses, forbs, and shrubs was calculated, clipped, then dried. Standing biomass was compared between treatments and among years using a 2-way, repeated measures analysis of variance.

The results found that of the 3 major plant groups sampled, grasses made up the majority of the standing biomass, followed by forbs. The change in standing biomass was similar for the two treatments. The study also examined grazing effects on specific species, but it was only significant on prairie cordgrass which responded positively and willows which responded negatively. Most studies found decreases in herbaceous biomass due to grazing. However, under prescribed, late season grazing, the herbaceous and shrub communities of this study appeared to be resilient to grazing. This is likely attributed to grazing at a proper level and grazing late in the year during the dormant season.

Additional Literature Pertinent to the STM

Evans, S.G., A.J. Pelster, W.C. Leininger, and M.J. Trlica. 2004. Seasonal Diet Selection of Cattle Grazing a Montane Riparian Community. Journal of Range Management 57(5): 539-545.

McEldowney, R.R., M. Flenniken, G.W. Frasier, M.J. Trlica, and W.C. Leininger. 2002. Sediment movement and filtration in a riparian meadow following cattle use. Journal of Range Management 55(4): 367-373.

APPENDIX A. MLRA 67B, ECOLOGICAL SITE CLASSES SHOWING THE ECOLOGICAL SITES, ECOLOGICAL SITE IDS, AND PLANT COMMUNITY CLASSES THAT WERE CORRELATED TO EACH SITE CLASS.

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Bottom**	Sandy Bottomland	R067BY031CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Midgrass, Summer Shortgrass, Spring Perennial Forb, Summer Annual Forb, Spring Rhizomatous Grass, Spring Annual Forb(I), Evergreen Shrub	067B.2.1.1
		Deciduous Tree, Summer Annual Forb, Summer Midgrass, Spring Perennial Forb, Spring Annual Forb(I), Spring Annual Grass(I), Spring Rhizomatous Grass	067B.2.2.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Breaks**	Shale Breaks	R067BY044CO
		Loess Breaks	R067BY052CO
		Sandstone Breaks	R067BY056CO
		Limestone Breaks	R067BY060CO
		Gravel Breaks	R067BY063CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Midgrass, Summer Midgrass, Evergreen Subshrub	067B.12.1.1
		Summer Shortgrass, Evergreen Subshrub, Spring Perennial Forb, Spring Rhizomatous Grass, Summer Midgrass, Spring Midgrass, Summer Perennial Forb	067B.12.2.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Loamy Upland**	Loamy Plains	R067BY002CO
		Loamy Slopes	R067BY008CO
		Siltstone Plains	R067BY009CO
		Sandy Plains	R067BY042CO
		Shallow Siltstone	R067BY039CO
		Clayey Plains	R067BY042CO
		Shaly Plains	R067BY045CO
		Alkaline Plains	R067BY047CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Summer Rhizomatous Grass, Summer Midgrass, Spring Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb(I), Summer Annual Forb	067B.6.1.1
		Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Midgrass, Cacti	067B.6.3.1
		Spring Rhizomatous Grass(I), Spring Midgrass(I), Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Perennial Forb	067B.6.4.1
		Spring Annual Forb(I), Spring Annual Forb, Summer Shortgrass, Summer Annual Grass(I), Spring Midgrass(I), Summer Midgrass, Summer Rhizomatous Grass	067B.6.5.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Playa**	Plains Swale	R067BY010CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Spring Perennial Grasslike, Summer Stoloniferous Grass, Evergreen Shrub, Summer Midgrass	067B.1.1.1
		Summer Shortgrass, Summer Midgrass, Annual Grass, Annual Forb	067B.1.3.1
		Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Evergreen Shrub	067B.1.4.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Saline Upland**	Sandy Salt Flat	R067BY032CO
		Salt Flat	R067BY033CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Summer Midgrass, Evergreen Shrub, Cacti, Spring Midgrass, Spring Annual Forb(I), Spring Perennial Forb	067B.24.1.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Sandy Upland**	Deep Sand	R067BY015CO
		Choppy Sands	R067BY022CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Midgrass, Summer Tall Grass, Summer Shortgrass, Spring Midgrass, Summer Annual Forb, Evergreen Shrub, Spring Annual Forb(I)	067B.7.1.1
		Evergreen Shrub, Deciduous Tree, Summer Annual Forb, Spring Rhizomatous Grass(I), Spring Annual Forb(I), Summer Perennial Forb, Summer Midgrass	067B.7.3.1
		Spring Annual Forb(I), Spring Annual Forb, Spring Perennial Forb, Summer Shortgrass, Spring Annual Grass(I), Summer Annual Forb, Summer Midgrass	067B.7.4.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Stream Terrace**	Overflow	R067BY036CO
		Saline Overflow	R067BY037CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Shortgrass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Midgrass, Summer Rhizomatous Grass	067B.3.1.1
		Spring Annual Forb(I), Summer Midgrass, Summer Annual Forb, Spring Rhizomatous Grass, Summer Shortgrass, Spring Perennial Forb(I), Spring Perennial Forb	067B.3.3.1

MLRA	Ecological Site Class Name	Ecological Site Names	Ecological Site ID
67B	**Wet Bottomland**	Sandy Meadow	R067BY029CO
		Salt Meadow	R067BY035CO
		Wet Meadow	R067BY038CO
		Plant Community Class Names, from NRI data	**Plant Community Class ID**
		Summer Midgrass, Spring Annual Forb(I), Summer Rhizomatous Grass, Spring Annual Forb, Summer Perennial Forb, Spring Annual Grass, Spring Perennial Forb	067B.22.1.1
		Summer Annual Forb(I), Spring Annual Forb, Spring Annual Forb(I), Spring Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Cacti	067B.22.2.1
		Deciduous shrub(I), Evergreen Tree(I), Spring Rhizomatous Grass(I), Spring Annual Forb(I), Annual Grass	067B.22.3.1

APPENDIX B. MLRA 67B, ECOLOGICAL SITE CLASS AND COMMUNITY CLASS SUMMARY

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD Lbs/Ac	NRI Community Class	NRI Dominant Species (Symbol, Lbs/Ac)	NRI Lbs/ Ac	# PSUs
Bottom	Perennial Herbaceous - Woody	067B.2.1.1	Summer Tallgrass, Spring Perennial Forb, Summer Perennial Forb, Spring Midgrass, Summer Midgrass, Deciduous Shrub, Summer Shortgrass	1850	Summer Midgrass, Summer Shortgrass, Spring Perennial Forb, Summer Annual Forb, Spring Rhizomatous Grass, Spring Annual Forb(I), Evergreen Shrub	sand dropseed (SPCR)(567), blue grama (BOGR2)(154), common sunflower (HEAN3)(122), bractless blazingstar (MENU)(108), sand sagebrush (ARFI2)(103), Buffalograss (BODA2)(71), white sagebrush (ARLU)(51)	1432	4
Bottom	Woody - Perennial Herbaceous	067B.2.2.1			Deciduous Tree, Summer Annual Forb, Summer Midgrass, Spring Perennial Forb, Spring Annual Forb(I), Spring Annual Grass(I), Spring Rhizomatous Grass	eastern cottonwood (PODE3)(793), common sunflower (HEAN3)(508), sand dropseed (SPCR)(327), dwarf bur ragweed (AMPU4)(126), Russian thistle (SAKA)(61), lemon scurfpea (PSLA3)(48), cheatgrass (BRTE)(47)	1934	1
Breaks	Perennial Herbaceous	067B.12.1.1	Summer Midgrass, Summer Tallgrass, Summer Perennial Forb, Spring Midgrass, Spring Perennial Forb, Spring Rhizomatous Grass, Summer Shortgrass	909	Summer Shortgrass, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Midgrass, Summer Midgrass, Evergreen Subshrub	blue grama (BOGR2)(350), Buffalograss (BODA2)(219), bractless blazingstar (MENU)(192), squirreltail (ELEL5)(79), Rocky Mountain zinnia (ZIGR)(62), Nailwort (PARON)(54), purple threeawn (ARPU9)(48)	1165	1
Breaks		067B.12.2.1			Summer Shortgrass, Evergreen Subshrub, Spring Perennial Forb, Spring Rhizomatous Grass, Summer Midgrass, Spring Midgrass, Summer Perennial Forb	blue grama (BOGR2)(247), prairie sagewort (ARFR4)(159), hairy false goldenaster (HEVI4)(130), hairy grama (BOHI2)(93), western wheatgrass (PASM)(70), needlegrass (HESPE11)(34), purple threeawn (ARPU9)(28)	865	2
Loamy Upland	Perennial Herbaceous	067B.6.1.1	Summer Shortgrass, Spring Midgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Tallgrass, Summer Midgrass, Spring Rhizomatous Grass	1127	Summer Shortgrass, Summer Rhizomatous Grass, Summer Midgrass, Spring Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb(I), Summer Annual Forb	blue grama (BOGR2)(432), Buffalograss (BODA2)(139), western wheatgrass (PASM)(83), sand dropseed (SPCR)(55), purple threeawn (ARPU9)(37), Russian thistle (SAKA)(17), scarlet globemallow (SPCO)(12)	982	63
Loamy Upland	Cultivated Cropland	067B.6.2.1				winter wheat 25 bu/ac, grain sorghum 25 bu/ac, corn 130 bu/ac, dry beans 2200 lbs/ac, sugar beets 33 tons/ac		
Loamy Upland	Abandoned Cropland	067B.6.3.1			Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Midgrass, Cacti	broom snakeweed (GUSA2)(140), blue grama (BOGR2)(91), rush skeletonplant (LYJU)(28), sand dropseed (SPCR)(4), tumblegrass (SCPA)(4), plains pricklypear (OPPO)(2)	271	1

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD Lbs/Ac	NRI Community Class	NRI Dominant Species (Symbol, Lbs/Ac)	NRI Lbs/ Ac	# PSUs
Loamy Upland	Seeded Rangeland	067B.6.4.1			Spring Rhizomatous Grass(I), Spring Midgrass(I), Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Perennial Forb	smooth brome (BRIN2)(836), crested wheatgrass (AGCR)(368), blue grama (BOGR2)(107), purple threeawn (ARPU9)(106), red lovegrass (ERSE)(86), western wheatgrass (PASM)(53), saltgrass (DISP)(47)	1767	3
Loamy Upland	Annual - Perennial Herbaceous	067B.6.5.1			Spring Annual Forb(I), Spring Annual Forb, Summer Shortgrass, Summer Annual Grass(I), Spring Midgrass(I), Summer Midgrass, Summer Rhizomatous Grass	Russian thistle (SAKA)(308), kochia (BASC5)(270), lambsquarters (CHAL7)(184), blue grama (BOGR2)(110), yellow foxtail (SEPU8)(101), crested wheatgrass (AGCR)(96), sand dropseed (SPCR)(76)	1349	6
Playa	Perennial – Annual Herbaceous	067B.1.1.1	Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Spring Perennial Grasslike, Summer Stoloniferous Grass, Evergreen Shrub, Summer Midgrass	1300		western wheatgrass (PASM)(850-900), blue grama (BOGR2)(50-100), Buffalograss (BODA2)(25-100), green needlegrass (NAVI4)(25-50), sideoats grama (BOCU)(50-150) , fourwing saltbush (ATCA2)(25-50), winterfat (KRLA2)(20 – 70)		
Playa	Cultivated Cropland	067B.1.2.1				winter wheat 25 bu/ac, grain sorghum 25 bu/ac, corn 130 bu/ac, dry beans 2200 lbs/ac, sugar beets 33 tons/ac		
Playa	Abandoned Cropland	067B.1.3.1	Summer Shortgrass, Summer Midgrass, Annual Grass, Annual Forb	150		Blue grama (BOGR2), purple threeawn (ARPU9), sand dropseed (SPCR), annual grass (AAGG), annual forb (AAFF)		
Playa	Seeded Rangeland	067B.1.4.1	Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Spring Perennial Forb, Evergreen Shrub	1000		western wheatgrass (PASM)(300-450), blue grama (BOGR2)(200 – 325), green needlegrass (NAVI4)(150-250), sideoats grama (BOCU)(50-150), fourwing saltbush (ATCA2)(50-100), winterfat (KRLA2)(20-75)		
Saline Upland	Perennial Herbaceous	067B.24.1.1	Summer Midgrass, Summer Tallgrass, Spring Rhizomatous Grass, Summer Shortgrass, Spring Midgrass, Evergreen Shrub, Summer Perennial Forb	1249	Summer Shortgrass, Summer Midgrass, Evergreen Shrub, Cacti, Spring Midgrass, Spring Annual Forb(I), Spring Perennial Forb	blue grama (BOGR2)(558), alkali sacaton (SPAI)(378), green rabbitbrush (ERTE18)(110), plains pricklypear (OPPO)(33), squirreltail (ELEL5)(32), Russian thistle (SAKA)(25), scarlet globemallow (SPCO)(13)	1182	1
Saline Upland	Cultivated Cropland	067B.24.2.1				winter wheat 25 bu/ac, grain sorghum 25 bu/ac, corn 130 bu/ac, dry beans 2200 lbs/ac, sugar beets 33 tons/ac		
Saline Upland	Abandoned Cropland	067B.24.3.1	Summer Shortgrass, Summer Midgrass, Forbs, shrubs	1000		purple threeawn (ARPU9), ring muhly (MUTO2). sand dropseed (SPCR), annual		

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD Lbs/Ac	NRI Community Class	NRI Dominant Species (Symbol, Lbs/Ac)	NRI Lbs/ Ac	# PSUs
						forbs (AAFF). annual grass (AAGG)		
Saline Upland	Seeded Rangeland	067B.24.4.1	Summer Shortgrass, Summer Midgrass, Forbs, Annual Grasses and Forbs	1000		Alkali sacaton (SPAI)(250-500), western wheatgrass (PASM)(150-300), blue grama (BOGR2)(150-300), switchgrass (PAVI2)(100-350), shrubs (SSSS) 50-200)		
Sandy Upland	Perennial Herbaceous - Woody	067B.7.1.1	Summer Tallgrass, Summer Perennial Forb, Spring Perennial Forb, Summer Midgrass, Spring Midgrass, Deciduous Shrub, Summer Shortgrass	1724	Summer Midgrass, Summer Tallgrass, Summer Shortgrass, Spring Midgrass, Summer Annual Forb, Evergreen Shrub, Spring Annual Forb(I)	sand dropseed (SPCR)(255), blue grama (BOGR2)(245), switchgrass (PAVI2)(196), needle and thread (HECO26)(165), sand sagebrush (ARFI2)(85), prairie sandreed (CALO)(67), common sunflower (HEAN3)(50)	1506	46
Sandy Upland	Cultivated Cropland	067B.7.2.1				winter wheat 25 bu/ac, grain sorghum 25 bu/ac, corn 130 bu/ac, dry beans 2200 lbs/ac, sugar beets 33 tons/ac		
Sandy Upland	Woody - Herbaceous	067B.7.3.1			Evergreen Shrub, Deciduous Tree, Summer Annual Forb, Spring Rhizomatous Grass(I), Spring Annual Forb(I), Summer Perennial Forb, Summer Midgrass	sand sagebrush (ARFI2)(2226), black locust (ROPS)(1760), common sunflower (HEAN3)(475), smooth brome (BRIN2)(404), Russian thistle (SAKA)(90), Cuman ragweed (AMPS)(76), sand dropseed (SPCR)(51)	5373	4
Sandy Upland	Annual – Perennial Herbaceous	067B.7.4.1			Spring Annual Forb(I), Spring Annual Forb, Spring Perennial Forb, Summer Shortgrass, Spring Annual Grass(I), Summer Annual Forb, Summer Midgrass	Russian thistle (SAKA)(381), tall tumblemustard (SIAL2)(272), kochia (BASC5)(263), blue grama (BOGR2)(88), cheatgrass (BRTE)(84), common sunflower (HEAN3)(74), sand sagebrush (ARFI2)(69)	1693	7
Sandy Upland	Abandoned Cropland	067B.7.5.1	Summer Shortgrass, Summer Midgrass, Spring Perennial Forb, Summer Annual Forb, Monocot Shrubs	300		Blue grama (BOGR2)(50-100), ring muhly (MUPU2)(50-100), purple threeawn (ARPU9)(50-100), soapweed yucca (YUGL)(50-100)		
Sandy Upland	Seeded Rangeland	067B.7.6.1	Summer Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Perennial Forb, Evergreen Shrub, Deciduous Shrub	800		sand dropseed (SPCR)(200), blue grama (BOGR2)(200), switchgrass (PAVI2)(100), needle and thread (HECO26)(50), sand sagebrush (ARFI2)(50), prairie sandreed (CALO)(50)		
Stream Terrace		067B.3.1.1	Summer Midgrass, Spring Rhizomatous Grass, Summer Tallgrass, Spring	1850		blue grama (BOGR2)(349), western wheatgrass (PASM)(227), Buffalograss (BODA2)(35), kochia	702	2

Site Class Name	State	Comm Class ID	ESD Comm Class	ESD Lbs/Ac	NRI Community Class	NRI Dominant Species (Symbol, Lbs/Ac)	NRI Lbs/ Ac	# PSUs
			Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb			(BASC5)(27), sand dropseed (SPCR)(27), Russian thistle (SAKA)(23), tumblegrass (SCPA)(10)		
Stream Terrace	Cultivated Cropland	067B.3.2.1				winter wheat 25 bu/ac, grain sorghum 25 bu/ac, corn 130 bu/ac, dry beans 2200 lbs/ac, sugar beets 33 tons/ac		
Stream Terrace	Abandoned Cropland	067B.3.3.1			Summer Midgrass, Spring Rhizomatous Grass, Summer Tallgrass, Spring Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb	sand dropseed (SPCR)(237), kochia (BASC5)(200), western wheatgrass (PASM)(134), pigweed (AMARA)(122), Russian thistle (SAKA)(64), blue grama (BOGR2)(46), curly dock (RUCR)(37)	924	1
Stream Terrace	Seeded Rangeland	067B.3.4.1	Summer Shortgrass, Summer Midgrass, Evergreen Shrubs, Forb	1000		Alkali sacaton(SPAI)(250-500), western wheatgrass (PASM)(150-300), blue grama (BOGR2)(150-300), fourwing saltbush (ATCA2)(50-200)		
Wet Bottomland	Perennial Herbaceous - Woody	067B.22.1.1	Summer Tallgrass, Summer Midgrass, Spring Rhizomatous Grass, Spring Perennial Grasslike, Summer Perennial Grasslike, Summer Perennial Forb, Spring Midgrass	3500	Summer Midgrass, Spring Annual Forb(I), Summer Rhizomatous Grass, Spring Annual Forb, Summer Perennial Forb, Spring Annual Grass, Spring Perennial Forb	alkali sacaton (SPAI)(1009), Russian thistle (SAKA)(422), saltgrass (DISP)(127), Buffalograss (BODA2)(108), upright prairie coneflower (RACO3)(80), herb sophia (DESO2)(67), sixweeks fescue (VUOC)(35)	1936	1
Wet Bottomland	Annual - Perennial Herbaceous	067B.22.2.1			Summer Annual Forb(I), Spring Annual Forb, Spring Annual Forb(I), Spring Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Cacti	fivehorn smotherweed (BAHY)(2792), goosefoots (CHENO)(511), Russian thistle (SAKA)(48), scarlet globemallow (SPCO)(25), sand dropseed (SPCR)(18), saltgrass (DISTI)(10), plains pricklypear (OPPO)(7)	3416	1
Wet Bottomland	Woody - Perennial Herbaceous	067B.22.3.1	Deciduous shrub(I), Evergreen Tree(I), Spring Rhizomatous Grass(I), Spring Annual Forb(I), Annual Grass			saltcedar (TAMAR2) (200 - 400), Russian olive (ELAN)(200-400) foxtail barley (HOJU), Kentucky bluegrass (POPR) annual grasses (AAGG), annual forbs (AAFF)	700	0

Appendix C. MLRA 67B, NRI Cover Data by Community Class

Site Class Name	Comm Class ID	Bunch-grass	Sodgrass	Shrub	Forb + AnnGrass	Lichen	BareGrnd	Rock	Litter	Basal	Avg Plant Ht (ft)	Avg % Slope
		|---- Percent Cover Values ----								|		
Bottom	**067B.2.1.1**	21	3	24	22	2	35	2	58	6	2.3	2
	Summer Midgrass, Summer Shortgrass, Spring Perennial Forb, Summer Annual Forb, Spring Rhizomatous Grass, Spring Annual Forb(I), Evergreen Shrub											
Bottom	**067B.2.2.1**	2	2	0	32	0	49	0	48	3	1.67	0
	Deciduous Tree, Summer Annual Forb, Summer Midgrass, Spring Perennial Forb, Spring Annual Forb(I), Spring Annual Grass(I), Spring Rhizomatous Grass											
Breaks	**067B.12.1.1**	6	11	8	6	1	24	5	34	36	0	16
	Summer Shortgrass, Spring Perennial Forb, Summer Rhizomatous Grass, Summer Perennial Forb, Spring Midgrass, Summer Midgrass, Evergreen Subshrub											
Breaks	**067B.12.2.1**	19	8	10	14	5	14	8	37	39	0	12
	Summer Shortgrass, Evergreen Subshrub, Spring Perennial Forb, Spring Rhizomatous Grass, Summer Midgrass, Spring Midgrass, Summer Perennial Forb											
Loamy Upland	**067B.6.1.1**	14	19	4	6	6	24	5	41	33	0.86	3
	Summer Shortgrass, Summer Rhizomatous Grass, Summer Midgrass, Spring Rhizomatous Grass, Spring Perennial Forb, Spring Annual Forb(I), Summer Annual Forb											
Loamy Upland	**067B.6.3.1**	4	0	12	1	0	29	0	50	16	0	2
	Evergreen Subshrub, Summer Shortgrass, Spring Perennial Forb, Summer Midgrass, Cacti											
Loamy Upland	**067B.6.4.1**	28	22	7	5	0	25	4	55	19	1.42	4
	Spring Rhizomatous Grass(I), Spring Midgrass(I), Summer Shortgrass, Summer Midgrass, Summer Rhizomatous Grass, Spring Rhizomatous Grass, Spring Perennial Forb											
Loamy Upland	**067B.6.5.1**	12	9	10	24	0	35	0	56	9	1.05	2
	Spring Annual Forb(I), Spring Annual Forb, Summer Shortgrass, Summer Annual Grass(I), Spring Midgrass(I), Summer Midgrass, Summer Rhizomatous Grass											
Saline Upland	**067B.24.1.1**	26	2	5	5	0	20	0	46	34	0	1
	Summer Shortgrass, Summer Midgrass, Evergreen Shrub, Cacti, Spring Midgrass, Spring Annual Forb(I), Spring Perennial Forb											
Sandy Upland	**067B.7.1.1**	26	12	9	11	9	24	6	54	21	1.12	4
	Summer Midgrass, Summer Tallgrass, Summer Shortgrass, Spring Midgrass, Summer Annual Forb, Evergreen Shrub, Spring Annual Forb(I)											
Sandy Upland	**067B.7.3.1**	5	14	35	24	1	38	0	59	4	1.92	4
	Evergreen Shrub, Deciduous Tree, Summer Annual Forb, Spring Rhizomatous Grass(I), Spring Annual Forb(I), Summer Perennial Forb, Summer Midgrass											
Sandy Upland	**067B.7.4.1**	11	3	20	40	0	33	1	63	6	1.12	3
	Spring Annual Forb(I), Spring Annual Forb, Spring Perennial Forb, Summer Shortgrass, Spring Annual Grass(I), Summer Annual Forb, Summer Midgrass											
Stream Terrace	**067B.3.1.1**	6	37	1	8	0	12	0	82	7	0	2
	Summer Shortgrass, Spring Rhizomatous Grass, Spring Annual Forb(I), Summer Midgrass, Summer Rhizomatous Grass											
Stream Terrace	**067B.3.3.1**	12	11	4	30	0	52	0	42	6	1.34	1
	Summer Midgrass, Spring Rhizomatous Grass, Summer Tallgrass, Spring Midgrass, Summer Shortgrass, Summer Rhizomatous Grass, Summer Perennial Forb											

Site Class Name	Comm Class ID	|---------- Percent Cover Values ----------| Bunch-grass	Sodgrass	Shrub	Forb + AnnGrass	Lichen	BareGrnd	Rock	Litter	Basal	Avg Plant Ht (ft)	Avg % Slope
Wet Bottomland	**067B.22.1.1**	47	14	0	24	0	9	0	44	48	0	1
	Summer Midgrass, Spring Annual Forb(I), Summer Rhizomatous Grass, Spring Annual Forb, Summer Perennial Forb, Spring Annual Grass, Spring Perennial Forb											
Wet Bottomland	**067B.22.2.1**	6	3	0	51	0	37	0	50	13	0	2
	Summer Annual Forb(I), Spring Annual Forb, Spring Annual Forb(I), Spring Perennial Forb, Summer Midgrass, Summer Rhizomatous Grass, Cacti											

APPENDIX D. MLRA 67B, REPRESENTATIVE SOIL MAP UNIT COMPONENTS

Bottom Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO009	Baca County, Colorado	Bk	Bankard	25914
CO618	Weld County, Colorado, Southern Part	10	Bankard	15041
CO099	Prowers County, Colorado	Lv	Lincoln	13623
CO017	Cheyenne County, Colorado	15	Bankard	13093
CO009	Baca County, Colorado	Gb	Glenberg	11917

Breaks Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO628	Las Animas County Area, Colorado, Parts of Huerfano and Las Animas Counties	DaE	Dalerose	77672
CO121	Washington County, Colorado	86	Colby	30902
CO009	Baca County, Colorado	Gr	Gravelly land	22004
CO009	Baca County, Colorado	Ro	Rough stony land	21011
CO617	Weld County, Colorado, Northern Part	51	Peetz	20292
CO009	Baca County, Colorado	Po	Potter	19900

Loamy Upland Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO009	Baca County, Colorado	BaA	Baca	262841
CO121	Washington County, Colorado	78	Weld	245876
CO617	Weld County, Colorado, Northern Part	4	Ascalon	168517
CO099	Prowers County, Colorado	WaB	Wiley	161397
CO121	Washington County, Colorado	55	Platner	149141
CO009	Baca County, Colorado	Ca	Campo	124362

Playa Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO617	Weld County, Colorado, Northern Part	86	Playas	2273
CO624	Elbert County, Colorado, Eastern Part	PLY	Playas	1751
CO009	Baca County, Colorado	PLY	Playas	1571
CO628	Las Animas County Area, Colorado, Parts of Huerfano and Las Animas Counties	Dv	Feterita	995
CO099	Prowers County, Colorado	PLY	Playas	806

Saline Upland Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO628	Las Animas County Area, Colorado, Parts of Huerfano and Las Animas Counties	AV	Aguilar	5230
CO087	Morgan County, Colorado	WoA	Koen	407
CO063	Kit Carson County, Colorado	11	Beckton	126

Sandy Upland Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO125	Yuma County, Colorado	43	Valent	198259
CO125	Yuma County, Colorado	44	Valent	194166
CO618	Weld County, Colorado, Southern Part	70	Valent	141972
CO087	Morgan County, Colorado	VcD	Valent	120036
NE057	Dundy County, Nebraska	1899	Valent	113677
CO121	Washington County, Colorado	70	Valent	111743

Stream Terrace Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO617	Weld County, Colorado, Northern Part	29	Haverson	31269
CO001	Adams County Area, Parts of Adams and Denver Counties, Colorado	Lu	Loamy alluvial land	25384
CO017	Cheyenne County, Colorado	30	Manzanst	21593
CO017	Cheyenne County, Colorado	37	Sampson	14733
CO063	Kit Carson County, Colorado	75	Sampson	14701
CO121	Washington County, Colorado	68	Table Mountain	13982

Wet Bottomland Ecological Site Class

Area symbol	Soil Survey	Map Unit	Component	Component Acres
CO618	Weld County, Colorado, Southern Part	3	Aquolls	18009
CO618	Weld County, Colorado, Southern Part	4	Aquolls	11530
CO075	Logan County, Colorado	82	Nunn	9879
CO618	Weld County, Colorado, Southern Part	3	Aquents	9823
CO099	Prowers County, Colorado	Lc	Las	7471
CO087	Morgan County, Colorado	Wf	Wann	6023

APPENDIX E. MLRA 67B, COMMON PLANTS AND FUNCTIONAL GROUPS

Common Name	Accepted Symbol	Scientific Name	Functional Group Name
alkali sacaton	SPAI	Sporobolus airoides	Summer Midgrass
American vetch	VIAM	Vicia americana	Herbaceous Vine
annual buckwheat	ERAN4	Eriogonum annuum	Summer Annual Forb
aster	ASTER	Aster	Spring Perennial Forb
bastard toadflax	COMAN	Comandra	Spring Perennial Forb
beaked sedge	CARO6	Carex rostrata	Spring Perennial Grasslike
big bluestem	ANGE	Andropogon gerardii	Summer Tallgrass
black locust	ROPS	Robinia pseudoacacia	Deciduous Tree
blue grama	BOGR2	Bouteloua gracilis	Summer Shortgrass
bractless blazingstar	MENU	Mentzelia nuda	Spring Perennial Forb
broadleafed sedge	CAPL5	Carex platyphylla	Spring Perennial Grasslike
Brome grass	BROMU	Bromus	Spring Annual Grass
broom snakeweed	GUSA2	Gutierrezia sarothrae	Evergreen Subshrub
buckwheat	ERIOG	Eriogonum	Spring Perennial Forb
Buffalograss	BODA2	Buchloe dactyloides	Summer Rhizomatous Grass
burning bush	EUAL13	Euonymus alatus	Deciduous Shrub
camphorweed	HESU3	Heterotheca subaxillaris	Spring Midgrass
Canada thistle	CIAR4	Cirsium arvense	Summer Perennial Forb(I)
Canada wildrye	ELCA4	Elymus canadensis	Spring Midgrass
cane cholla	CYIMI	Opuntia imbricata	Cacti
cheatgrass	BRTE	Bromus tectorum	Spring Annual Grass(I)
common pepperweed	LEDE	Lepidium densiflorum	Spring Annual Forb
common reed	PHAU7	Phragmites australis	Summer Tallgrass
common sunflower	HEAN3	Helianthus annuus	Summer Annual Forb
common wheat	TRAE	Triticum aestivum	Spring Annual Grass(I)
corn	ZEMA	Zea mays	Crop
coyote willow	SAEX	Salix exigua	Deciduous Shrub
crested wheatgrass	AGCR	Agropyron cristatum	Spring Midgrass(I)
cryptantha	CRYPT	Cryptantha	Spring Annual Forb
curly dock	RUCR	Rumex crispus	Spring Perennial Forb(I)
curlycup gumweed	GRSQ	Grindelia squarrosa	Summer Annual Forb
devil's claw	PRLO	Proboscidea louisianica	Summer Annual Forb
dwarf bur ragweed	AMPU4	Ambrosia pumila	Spring Perennial Forb
eastern cottonwood	PODE3	Populus deltoides	Deciduous Tree
Engelmann's daisy	ENPE4	Engelmannia peristenia	Spring Perennial Forb
field bindweed	COAR4	Convolvulus arvensis	Summer Perennial Forb(I)
fivehorn smotherweed	BAHY	Bassia hyssopifolia	Summer Annual Forb(I)
fourwing saltbush	ATCA2	Atriplex canescens	Evergreen Shrub
foxtail barley	HOJU	Hordeum jubatum	Spring Shortgrass
Gaura	GAURA	Gaura	Summer Perennial Forb
golden currant	RIAU	Ribes aureum	Deciduous Shrub

Common Name	Accepted Symbol	Scientific Name	Functional Group Name
goosefoots	CHENO	Chenopodium	Spring Annual Forb
great ragweed	AMTR	Ambrosia trifida	Summer Annual Forb
green needlegrass	NAVI4	Nassella viridula	Spring Midgrass
green rabbitbrush	ERTE18	Ericameria teretifolia	Evergreen Shrub
hairy false goldenaster	HEVI4	Heterotheca villosa	Spring Perennial Forb
hairy grama	BOHI2	Bouteloua hirsuta	Summer Shortgrass
herb sophia	DESO2	Descurainia sophia	Spring Annual Forb
hoary false goldenaster	HECA8	Heterotheca canescens	Summer Annual Forb
Indian ricegrass	ACHY	Achnatherum hymenoides	Spring Midgrass
Indiangrass	SONU2	Sorghastrum nutans	Summer Tallgrass
inland saltgrass	DISP	Distichlis spicata	Summer Rhizomatous Grass
intermediate wheatgrass	THIN6	Thinopyrum intermedium	Spring Rhizomatous Grass(I)
Japanese brome	BRAR5	Bromus japonicus	Spring Annual Grass(I)
Kentucky bluegrass	POPR	Poa pratensis	Spring Rhizomatous Grass(I)
knotweed	POLYG4	Polygonum	Summer Perennial Forb
kochia	BASC5	Kochia scoparia	Spring Annual Forb(I)
lacy tansyaster	MAPI	Machaeranthera pinnatifida	Spring Perennial Forb
lambsquarters	CHAL7	Chenopodium album	Spring Annual Forb
lemon scurfpea	PSLA3	Psoralidium lanceolatum	Spring Perennial Forb
little barley	HOPU	Hordeum pusillum	Spring Annual Grass
little bluestem	SCSC	Schizachyrium scoparium	Summer Midgrass
long-stolon sedge	CAIN9	Carex inops	Spring Perennial Grasslike
milkvetch	ASTRA	Astragalus	Spring Perennial Forb
musk thistle	CANU4	Carduus nutans	Spring Perennial Forb(I)
Nailwort	PARON	Paronychia	Summer Perennial Forb
narrowleaf goosefoot	CHLE4	Chenopodium leptophyllum	Summer Annual Forb
Nebraska sedge	CANE2	Carex nebrascensis	Spring Perennial Grasslike
needleandthread	HECO26	Hesperostipa comata	Spring Midgrass
needlegrass	HESPE11	Hesperostipa	Spring Midgrass
needleleaf sedge	CADU6	Carex duriuscula	Summer Perennial Grasslike
oneseed juniper	JUMO	Juniperus monosperma	Coniferous Tree
pigweed	AMARA	Amaranthus	Summer Annual Forb
plains pricklypear	OPPO	Opuntia polyacantha	Cacti
povertyweed	IVAX	Iva axillaris	Spring Perennial Forb
prairie cordgrass	SPPE	Spartina pectinata	Summer Tallgrass
prairie sagewort	ARFR4	Artemisia frigida	Evergreen Subshrub
prairie sandreed	CALO	Calamovilfa longifolia	Summer Tallgrass
prairie sunflower	HEPE	Helianthus petiolaris	Summer Annual Forb
prairie threeawn	AROL	Aristida oligantha	Summer Midgrass
prostrate sandmat	CHPR6	Chamaesyce prostrata	Spring Annual Forb
purple threeawn	ARPU9	Aristida purpurea	Summer Midgrass
red lovegrass	ERSE	Eragrostis secundiflora	Summer Shortgrass
red threeawn	ARPUL	Aristida purpurea var. longiseta	Summer Shortgrass
redroot amaranth	AMRE	Amaranthus retroflexus	Summer Annual Forb

Common Name	Accepted Symbol	Scientific Name	Functional Group Name
ring muhly	MUTO2	Muhlenbergia torreyi	Spring Rhizomatous Grass
Rocky Mountain zinnia	ZIGR	Zinnia grandiflora	Evergreen Subshrub
rush skeletonplant	LYJU	Lygodesmia juncea	Spring Perennial Forb
Russian olive	ELAN	Elaeagnus angustifolia	Evergreen Tree(I)
Russian thistle	SAKA	Salsola kali	Spring Annual Forb(I)
Russian wildrye	PSJU3	Psathyrostachys juncea	Spring Midgrass(I)
saltcedar	TARA	Tamarix ramosissima	Deciduous Tree(I)
sand bluestem	ANHA	Andropogon hallii	Summer Tallgrass
sand dropseed	SPCR	Sporobolus cryptandrus	Summer Midgrass
sand muhly	MUAR2	Muhlenbergia arenicola	Summer Midgrass
sand sagebrush	ARFI2	Artemisia filifolia	Evergreen Shrub
sandbar willow	SAIN3	Salix interior	Deciduous Shrub
scarlet globemallow	SPCOE	Sphaeralcea coccinea ssp. elata	Spring Perennial Forb
Schweinitz's flatsedge	CYSC3	Cyperus schweinitzii	Summer Perennial Grasslike
sedge	CYPER	Cyperus	Summer Perennial Grasslike
showy milkweed	ASSP	Asclepias speciosa	Summer Perennial Forb
sideoats grama	BOCU	Bouteloua curtipendula	Summer Midgrass
sixweeks fescue	VUOCO	Vulpia octoflora var. octoflora	Spring Annual Grass
skeletonleaf bursage	AMTO3	Ambrosia tomentosa	Summer Perennial Forb
slimflower scurfpea	PSTE5	Psoralidium tenuiflorum	Summer Perennial Forb
smooth brome	BRIN2	Bromus inermis	Spring Rhizomatous Grass(I)
soapweed yucca	YUGL	Yucca glauca	Monocot Shrub
sorghum	SOBI2	Sorghum bicolor	Crop
soybeans	GLMA4	Glycine max	Crop
squirreltail	ELEL5	Elymus elymoides	Spring Midgrass
stickseeds	LAPPU	Lappula	Spring Annual Forb
stinging nettle	URDI	Urtica dioica	Summer Perennial Forb
sugar beets	BEVU2	Beta vulgaris	Crop
sun sedge	CAINH2	Carex inops ssp. heliophila	Spring Perennial Grasslike
sunflower	HELIA3	Helianthus	Summer Annual Forb
sweetclover	MEOF	Melilotus officinalis	Spring Annual Forb(I)
switchgrass	PAVI2	Panicum virgatum	Summer Tallgrass
talinum	TALIN2	Talinum	Spring Perennial Forb
tall tumblemustard	SIAL2	Sisymbrium altissimum	Spring Annual Forb(I)
tall wheatgrass	THPO7	Thinopyrum ponticum	Spring Rhizomatous Grass(I)
tansyleaf aster	MATA2	Machaeranthera tanacetifolia	tanseyleaf tansyaster
tarragon	ARDR4	Artemisia dracunculus	Summer Perennial Forb
threadleaf sedge	CAFI	Carex filifolia	Spring Perennial Grasslike
Threeawn	ARIST	Aristida	Summer Midgrass
tumblegrass	SCPA	Schedonnardus paniculatus	Summer Midgrass
upright prairie coneflower	RACO3	Ratibida columnifera	Summer Perennial Forb
vine mesquite	PAOB	Panicum obtusum	Summer Rhizomatous Grass
wavyleaf thistle	CIUN	Cirsium undulatum	Summer Perennial Forb
wedgeleaf	PHCU3	Phyla cuneifolia	Summer Perennial Forb

Common Name	Accepted Symbol	Scientific Name	Functional Group Name
western ragweed	AMPS	Ambrosia psilostachya	Summer Perennial Forb
western sandcherry	PRPUB	Prunus pumila var. besseyi	Deciduous Shrub
western snowberry	SYOC	Symphoricarpos occidentalis	Deciduous Shrub
western wheatgrass	PASM	Pascopyrum smithii	Spring Rhizomatous Grass
wheat	TRITI	Triticum	Crop
wheatgrass	AGROP2	Agropyron	Spring Perennial Grass
white fowl bluegrass	POPA2	Poa palustris	Spring Midgrass
white sagebrush	ARLU	Artemisia ludoviciana	Summer Perennial Forb
white sweetclover	MEOF	Melilotus alba	Spring Annual Forb(I)
willow	SALIX	Salix	Deciduous Tree
windmill grass	CHLOR	Chloris	Summer Annual Grass
winterfat	KRLA2	Krascheninnikovia lanata	Evergreen Subshrub
witchgrass panicum	PACA6	Panicum capillare	Summar Annual Grass
woolly plantain	PLPA2	Plantago patagonica	Spring Annual Forb
yellow foxtail	SEPU8	Setaria pumila	Summer Annual Grass(I)
yellow salsify	TRDU	Tragopogon dubius	Spring Annual Forb(I)

REFERENCES

Augustine, D.J., D.T. Booth, S.E. Cox, and J.D. Derner. 2012. Grazing Intensity and Spatial Heterogeneity in Bare Soil in a Grazing-Resistant Grassland. Rangeland Ecology & Management 65(1): 39-46.

Augustine, D.J., J.D. Derner, and J.K. Detling. 2014. Testing for thresholds in a semiarid grassland: The influence of prairie dogs and plague. Rangeland Ecology & Management 67(6): 701-709.

Beck, Reldon F. 1975. Steer diets in Southeastern Colorado. Journal of Range Management 28(1): 48-51.

Bowman, R.A., D.M. Mueller, and W.J. McGinnies. 1985. Soil and vegetation relationships in a central plains saltgrass meadow. Journal of Range Management 38(4): 325-328.

Dahl, B.E. 1963. Soil moisture as a predictive index to forage yield for the sandhills range type. Journal of Range Management 16(3): 128-132.

Evans, S.G., A.J. Pelster, W.C. Leininger, and M.J. Trlica. 2004. Seasonal Diet Selection of Cattle Grazing a Montane Riparian Community. Journal of Range Management 57(5): 539-545.

Hart, R.H. and G.W. Frasier. 2003. Bareground and litter estimators of runoff on short- and mixed-grass prairie. Arid Land Research and Management 17: 485-490.

Hyder, D.N., R.E. Bement, E.E. Remmenga, and C. Terwilliger Jr. 1966. Vegetation-soils and vegetation-grazing relations from frequency data. Journal of Range Management 19(1): 11-17.

Ludwig, J.R. and W.J. McGinnies. 1978. Revegetation trials on saltgrass meadow. Journal of Range Management 31(4): 308-311

McEldowney, R.R., M. Flenniken, G.W. Frasier, M.J. Trlica, and W.C. Leininger. 2002. Sediment movement and filtration in a riparian meadow following cattle use. Journal of Range Management 55(4): 367-373.

McGinnies, W.J., L.W. Osborn, and W.A. Berg. 1976. Plant-Soil-Microsite relationships on a saltgrass meadow. Journal of Range Management 29(5): 395-400.

Nearing, M. A. et. al. 2011. A Rangeland Hydrology and Erosion Model. American Society of Agricultural and Biological Engineers, vol. 54(3).

Pellant, M., P. Shaver, D.A. Pyke, and J.E. Herrick. 2005. Interpreting indicators of rangeland health, version 4. Technical Reference 1734-6. U.S. Department of Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. BLM/WO/ST-00/001+1734/REV05. 122 pp.

Porensky, L.M, K.E. Mueller, D.J. Augustine, and J.D. Derner. 2016. Thresholds and gradients in a semi-arid grassland: long-term grazing treatments induce slow, continuous, and reversible vegetation change. Journal of Applied Ecology.

Porensky, L.M, K.E. Mueller, D.J. Augustine, and J.D. Derner. 2016. Thresholds and gradients in a semi-arid grassland: long-term grazing treatments induce slow, continuous, and reversible vegetation change. Journal of Applied Ecology.

R.H. Hart, S. Clapp, and P.S. Test. 1993. Grazing strategies, stocking rates, and frequency and intensity of grazing on western wheatgrass and blue grama. Journal of Range Management 46(2): 122-126.

Rauzi, F. and F.M. Smith. 1973. Infiltration rates: Three soils with three grazing levels in Northeastern Colorado. Journal of Range Management 26(2): 126-129.

Reppert, Jack N. 1960. Forage preference and grazing habits of cattle at the Eastern Colorado Range Station. Journal of Range Management 13(2): 58-65.

Samuel, M.J. and R.H. Hart. 1992. Survival and growth of blue grama seedlings in competition with western wheatgrass. Journal of Range Management 45(5): 444-448.

Schulz, T.T. and W.C. Leininger. 1990. Differences in riparian vegetation structure between grazed areas and exclosures. Journal of Range Management 43(4): 295-299.

Sedgewick, J.A. and F.L. Knopf. 1991. Prescribed grazing as a secondary impact in a western riparian floodplain. Journal of Range Management 44(4): 369-373.

Shoop, M.C., R.C. Clark, W.A. Laycock, and R.M. Hansen. 1985. Cattle Diets on Shortgrass Ranges with Different Amounts of Fourwing Saltbush. Journal of Range Management 38(5): 443-449.

Sparks, Donnie R. 1968. Diet of Black-Tailed Jackrabbits on sandhill rangeland in Colorado. Journal of Range Management 21(4): 203-208.

USDA National Ag Statistics Service, Colorado Field Office. 2014. Colorado Agricultural Statistics 2014. 55pp.

USDA Natural Resources Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.

USDA Natural Resources Conservation Service. 2016. Ecological Site Description (ESD) System - Ecological Site Description reports for ecological sites in MLRA 67B.

USDA Natural Resources Conservation Service. 2016. Field Office Technical Guide for Colorado.

USDA Natural Resources Conservation Service. 2016. National PLANTS Database (http://plants.usda.gov/java/).

ACKNOWLEDGEMENTS

This material is based upon work supported by the Conservation Effects Assessment Project (CEAP)-Grazing Lands, Natural Resources Conservation Service, U.S. Department of Agriculture, under agreement number 67-3A75-15-152.

It was developed in Calendar Year 2016 using NRI Rangeland On-Site Data from 2004-2011, and ecological site and soil survey data available in that year.

Many highly dedicated and talented individuals helped with this project. At the risk of leaving out some of the individuals who contributed, Loretta Metz, Steve Barker, and Pat Shaver would like to thank the following people for their input and support.

Clinton Evans, NRCS State Conservationist, CO
Joel Brown, NRCS NEST, Las Cruces NM
Brandon Bestelmeyer, ARS, Las Cruces NM
Dana Larson, NRCS, Fort Worth TX
Ken Spaeth, NRCS, Fort Worth TX
Phil Heilman, ARS, Tucson AZ
Mark Nearing, ARS, Tucson AZ
Mariano Hernandez, ARS, Tucson AZ
Rachel Murph, NRCS, Denver CO
Kimberly Diller, NRCS, Pueblo CO
Kiesha Yazzie, NRCS, Springfield CO
Andy Steinert, NRCS, Fort Morgan CO
Jonas Feinstein, NRCS, Denver CO
John Fusaro, NRCS, Fort Collins CO
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