USDA Natural Resources Conservation Service

Ecological site R067BY015CO
Deep Sand

Last updated: 9/08/2023
Accessed: 05/18/2024

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

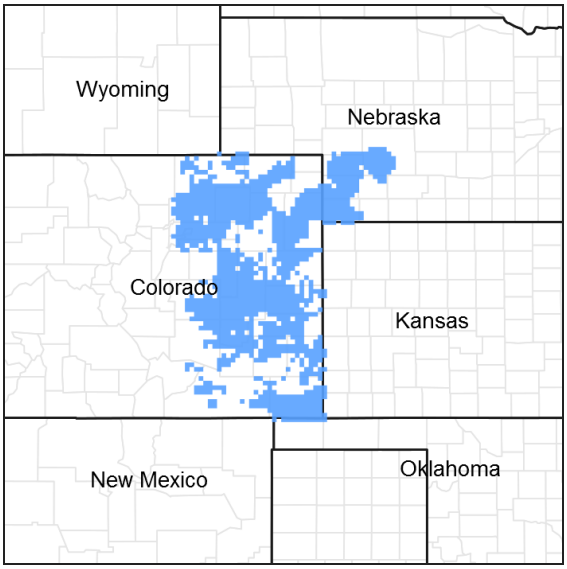


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 067B–Central High Plains, Southern Part

MLRA 67B occurs in eastern Colorado and consists of rolling plains and river valleys. Some canyonlands occur in the southeast portion. The major rivers are the South Platte and Arkansas which flow from the Rocky Mountains to Nebraska and Kansas. Other rivers in the MLRA include the Cache la Poudre and Republican and associated tributaries. This MLRA is traversed by Interstate 25, 70 and 76; and U.S. Highways 50 and 287. Major land uses include 54 percent rangeland, 35 percent cropland, and 2 percent pasture and hayland. Urban, developed open space, and miscellaneous land occupy approximately 9 percent. Major Cities in this area include Fort Collins, Greeley, Sterling, and Denver. Other cities include Limon, Cheyenne Wells, and Springfield. Land ownership is mostly private. Federal lands include Pawnee and Comanche National Grasslands (U.S. Forest Service), Sand Creek Massacre National Historic Site (National Park Service), and Rocky Mountain Arsenal National Wildlife Refuge (U.S. Fish & Wildlife Service). State Parks include Cherry Creek and Chatfield Reservoirs, and Barr and Jackson Lakes.

This region is periodically affected by severe drought, including the historic “Dust Bowl” of the 1930s. Dust storms may form during drought years in windy periods. Elevations range from 3,400 to 6,000 feet. The Average annual precipitation ranges from 14 to17 inches per year and ranges from 13 inches to over 18 inches, depending upon location. Precipitation occurs mostly during the growing season, often during rapidly developing thunderstorms. Mean annual air temperature (MAAT) is 48 to 52 degrees Fahrenheit. Summer temperatures may exceed 100

degrees Fahrenheit. Winter temperatures may be sub-zero, and snowfall varies from 20 to 40 inches per year. Snow cover frequently melts between snow events.

LRU notes

Land Resource Unit (LRU) A is the northeast portion of MLRA 67B, to an extent of approximately 9 million acres. Most of the LRU is rangeland, and includes the Pawnee National Grassland. Dryland winter wheat/fallow rotations (that may include dryland corn, sunflowers, and sorghum) are grown in most counties. Irrigated cropland is utilized in the South Platte Valley. Small acreage and urban ownership are more concentrated on the Front Range. This LRU is found in portions of Adams, Arapahoe, Elbert, Kit Carson, Larimer, Lincoln, Logan, Washington, and Weld counties. Other counties include Boulder, Cheyenne, Denver, Jefferson, and Yuma. The soil moisture regime is aridic ustic. The mean annual air temperature (MAAT) is 50 degrees Fahrenheit.

LRU B is in the southeast portion of MLRA 67B (2.6 million acres) and includes portions of Baca, Bent, Cheyenne, Kiowa, Las Animas, and Prowers counties. Most of the LRU remains in rangeland and includes the Comanche National Grassland. On the farmed land, a system of dryland winter wheat/fallow rotations (that may include dryland corn, sunflowers, and sorghum) is implemented. Irrigated cropland is found in the Arkansas Valley. The soil moisture regime is aridic ustic and the MAAT is 52 degrees Fahrenheit.

LRU C occurs in portions of Morgan and Weld counties (approximately 1.2 million acres). Most of LRU C is in rangeland. On the farmed land, a system of dryland winter wheat/fallow rotations (that may include dryland corn, sunflowers, and sorghum) is implemented. The soil moisture regime is ustic aridic and the MAAT is 48 degrees Fahrenheit.

Classification relationships

MLRA 67B is in the Colorado Piedmont and Raton Sections of the Great Plains Province (USDA, 2006). The MLRA is further defined by Land Resource Units (LRUs) A, B, and C. Features such as climate, geology, landforms, and key vegetation further refine these concepts and are described in other sections of the Ecological Site Description (ESD).NOTE: To date, these LRUs are DRAFT.

Relationship to Other Hierarchical Classifications:
NRCS Classification Hierarchy: Physiographic Division, Physiographic Province, Physiographic Section, Land Resource Region, Major Land Resource Area, Land Resource Unit (Fenneman, 1946).
USFS Classification Hierarchy: Domain, Division, Province, Section, Subsection,
Land Type Association: Land Type, Land Type Phase (Cleland et al, 1997).

REVISION NOTES:
The Deep Sand Ecological Site was developed by an earlier version of the Sands Ecological Site (2004, revised 2007). That Ecological Site was based on input from Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service) and historical information obtained from the Sands Range Site descriptions (1975). This ESD meets the Provisional requirements of the National Ecological Site Handbook (NESH). This ESD will continue refinement towards an Approved status according to the NESH.

Ecological site concept

This Ecological Site is a run-off site on slopes that are greater than five percent. It is deeper than 40 inched to bedrock, and there are no rock fragments on the surface or in the subsurface. The surface and subsurface textures are sand, loamy sand, or sandy loam and there are no apparent cat-steps or terracettes.

Associated sites

R067BY031CO	**Sandy Bottomland** This ecological site is commonly adjacent.
R067BY024CO	**Sandy Plains** This ecological site is commonly adjacent.

R067BY022CO	**Choppy Sands** This ecological site is commonly adjacent.

Similar sites

R067BY022CO	**Choppy Sands** The Choppy Sands Ecological Site has a rough, steep, dune-type appearance and cat-steps or terracettes are typically apparent.
R067BY031CO	**Sandy Bottomland** The Sandy Bottomland Ecological Site is a run-on site.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Amorpha canescens* (2) *Prunus pumila var. besseyi*
Herbaceous	(1) *Andropogon hallii* (2) *Calamovilfa longifolia*

Physiographic features

This site occurs on undulating to rolling dunes and hills in dune fields.

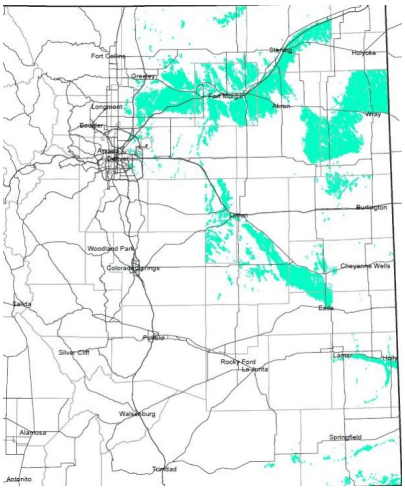


Figure 2. The distribution of the Deep Sands site in MLRA 67B.

Table 2. Representative physiographic features

Landforms	(1) Dune (2) Hill
Runoff class	Negligible to low
Flooding frequency	None
Ponding frequency	None
Elevation	1,036–1,829 m
Slope	6–24%
Ponding depth	0 cm
Water table depth	203 cm
Aspect	Aspect is not a significant factor

Climatic features

Average annual precipitation across the MLRA extent is 14 to 17 inches, and ranges from 13 to over 18 inches, depending on location. Precipitation increases from north to south. Mean Annual Air Temperature (MAAT) is 50 degrees Fahrenheit in the northern part and increases to 52 degrees Fahrenheit in the southern part. Portions of Morgan and Weld counties are cooler and drier, the MAAT is 48 degrees Fahrenheit, and average precipitation is 13 to14 inches per year.
Two-thirds of the annual precipitation occurs during the growing season from mid-April to late September. Snowfall averages 30 inches per year, area-wide, but varies by location from 20 to 40 inches per year. Winds are estimated to average 9 miles per hour annually. Daytime winds are generally stronger than at night, and occasional strong storms may bring periods of high winds with gusts to more than 90 mph. High-intensity afternoon thunderstorms may arise. The average length of the freeze-free period (28 degrees Fahrenheit) is 155 days from April 30th to October to 3rd. The average frost-free period (32 degrees Fahrenheit) is 136 days from May 11th to September 24th. July is the hottest month, and December and January are the coldest months. Summer temperatures average 90 degrees Fahrenheit and occasionally exceed 100 degrees Fahrenheit. Summer humidity is low and evaporation is high. Winters are characterized with frequent northerly winds, producing severe cold with temperatures occasionally dropping to -30 degrees Fahrenheit or lower. Blizzard conditions may form quickly. For detailed information, visit the Western Regional Climate Center website:
Western Regional Climate Center Historical Data Western U.S. Climate summaries, NOAA Coop Stations Colorado http://www.wrcc.dri.edu/summary/Climsmco.html.

Table 3. Representative climatic features

Frost-free period (characteristic range)	119-129 days
Freeze-free period (characteristic range)	134-151 days
Precipitation total (characteristic range)	356-432 mm
Frost-free period (actual range)	102-132 days
Freeze-free period (actual range)	126-156 days
Precipitation total (actual range)	356-432 mm
Frost-free period (average)	121 days
Freeze-free period (average)	142 days
Precipitation total (average)	381 mm

Climate stations used

- (1) CHEYENNE WELLS [USC00051564], Cheyenne Wells, CO
- (2) FT MORGAN [USC00053038], Fort Morgan, CO
- (3) SPRINGFIELD 7 WSW [USC00057866], Springfield, CO
- (4) FLAGLER 1S [USC00052932], Flagler, CO
- (5) KIT CARSON [USC00054603], Kit Carson, CO
- (6) LIMON WSMO [USW00093010], Limon, CO
- (7) BRIGGSDALE [USC00050945], Briggsdale, CO
- (8) BRIGHTON 3 SE [USC00050950], Brighton, CO
- (9) BYERS 5 ENE [USC00051179], Byers, CO
- (10) GREELEY UNC [USC00053553], Greeley, CO
- (11) NUNN [USC00056023], Nunn, CO

Influencing water features

There are no water features associated with this site.

Soil features

The soils on this site are very deep, somewhat excessively to excessively drained soils that formed from eolian sand. They typically have a rapid to very rapid permeability class, but range to moderately rapid in some soils. The soil moisture regime is typically ustic aridic, but ranges to aridic ustic in some soils. The soil temperature regime is

mesic.

The surface layer of the soils in this site are typically loamy sand or sand, but may include loamy fine sand. The surface layer ranges from 4 to 10 inches thick. The subsoil is typically loamy sand or sand, but may include sandy loam. Soils in this site are typically leached of free carbonates to a depth of 40 inches or more, but can be at the surface to 8 inches in some soils. These soils are susceptible to erosion by wind. The potential for wind erosion accelerates with a decrease in vegetative cover, clay percentage, and/or particle size. Blowouts occur where the surface has been disturbed and is void of vegetation.

Major soil series correlated to this ecological site include: Blakeland, Dailey, Dwyer, Osgood (sand), Truckton (loamy sand), Valent, and Vona (loamy sand).

Other soil series that have been correlated to this site, but may eventually be re-correlated include: Tivoli.

*Features listed in parenthesis “( )” relates to the surface texture of the soil.

The attributes listed below represent 0 to 40 inches in depth or to the first restrictive layer.

Note: Revisions to soil surveys are on-going. For the most recent updates, visit the Web Soil Survey, the official site for soils information: http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Table 4. Representative soil features

Parent material	(1) Eolian sands
Surface texture	(1) Loamy sand (2) Sand (3) Loamy fine sand
Drainage class	Somewhat excessively drained to excessively drained
Permeability class	Moderately rapid to very rapid
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	3.81–15.24 cm
Calcium carbonate equivalent (0-101.6cm)	0–15%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	6.6–7.8
Subsurface fragment volume <=3" (Depth not specified)	0–3%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

The information in this ESD, including the state-and-transition model diagram (STM), was developed using archeological and historical data, professional experience, and scientific studies. The information is representative of a dynamic set of plant communities that represent the complex interaction of several ecological processes. The plant composition has been determined by study of rangeland relic areas, areas protected from excessive disturbance, seasonal use pastures, short duration or time-controlled grazing strategies, and historical accounts.

The degree of grazing has a significant impact on the ecological dynamics of the site. This region was historically occupied by large grazing animals, such as bison, elk, pronghorn, and mule deer. Grazing by these large herbivores, along with climatic and seasonal weather fluctuations, had a major influence on the ecological dynamics of the site. Deer and pronghorn are widely distributed throughout the MLRA. Secondary influences of herbivory by species such as prairie dogs and other small rodents, insects, and root-feeding organisms continues to impact the vegetation.

Historically, grazing patterns by herds of large ungulates were driven by water distribution, precipitation events, drought events, and fire. It is believed that grazing periods would have been shorter, followed by longer recovery periods. These large migrating herds impacted the ecological processes of nutrient and hydrologic cycles, by urination, trampling (incorporation of litter into the soil surface), and breaking of surface crust, (which increases water infiltration).

Today, livestock grazing, especially beef cattle has been a major influence on the ecological dynamics of the site. Grazing management, coupled with the effects of annual climatic variations, largely dictates the plant communities for the site.

Recurrent drought has historically impacted the vegetation of this region. Changes in species composition vary depending upon the duration and severity of the drought cycle and prior grazing management. Drought events since 2002 have significantly increased mortality of blue grama and buffalograss in some locales.

This site developed with occasional fire as part of the ecological processes. Historic fire frequency (pre-industrial) is estimated at 10 to14 years (Guyette, 2012), randomly distributed, and started by lightning at various times throughout the growing season. Early human inhabitants also were likely to start fires for various reasons (deliberate or accidental). It is believed that fires were set as a management tool for attracting herds of large migratory herbivores (Stewart, 2002). The impact of fire over the past 100 years has been relatively insignificant due to the human control of wildfires and the lack of acceptance of prescribed fire as a management tool.

Mechanical treatment consisting of contour pitting, furrowing, terracing, chiseling, and disking has been practiced in the past. It was theorized that the use of this high-input technology would improve production and plant composition on rangeland. These high-cost practices have shown to have no significant long-term benefits on production or plant composition and have only resulted in a permanently rough ground surface. Prescribed grazing that mimics the historic grazing of herds of migratory herbivores, as described earlier, has been shown to result in desired improvements based on management goals for this ecological site.

Eastern Colorado was strongly affected by extended drought conditions in the “Dust Bowl” period of the 1930’s, with recurrent drought cycles in the 1950s and 1970s. Extreme to exceptional drought conditions have re-visited the area from 2002 to 2012, with brief interludes of near normal to normal precipitation years. Long-term effects of these latest drought events have yet to be determined. Growth of native cool-season plants begins about April 1 and continues to mid-June. Native warm-season plants begin growth about May 1 and continue to about August 15. Regrowth of cool-season plants occurs in September in most years, depending on the availability of moisture.

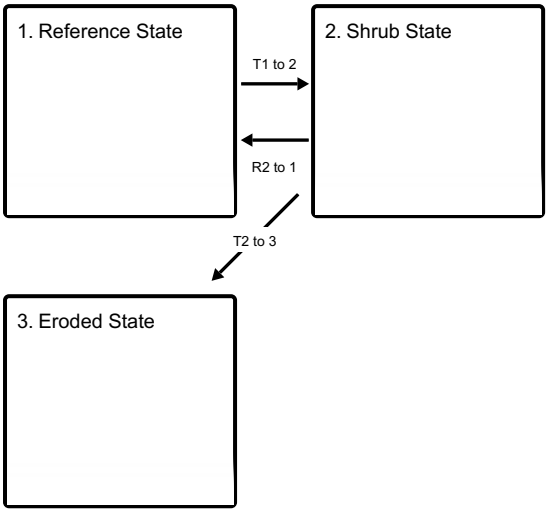
The Deep Sand ecological site is characterized by three states: Reference, Shrub, and Eroded State. The Reference State is characterized by a dominance of warm-season tallgrasses (sand bluestem, prairie sandreed, switchgrass, and Indiangrass). The Shrub State is dominated by sand sagebrush and a minor component of understory species. The Eroded State is characterized by annual forbs and grasses (burningbush, Russian thistle, cheatgrass) and early successional plants (sandhill muhly, sand dropseed, Fendler threeawn, and lemon scurfpea).

Grazing by large herbivores without adequate recovery periods causes sand bluestem, prairie sandreed, switchgrass, and Indiangrass to decrease. Sagebrush increases along with blue grama. Prairie sandreed may persist in remnant amounts protected by remaining shrubs. Cool-season grasses such as needle and thread, Indian ricegrass, and western wheatgrass decreases in frequency and production. Key shrubs such as western sandcherry and leadplant decrease in frequency and production. Pacific peavine, purple prairie clover, and other highly palatable forbs also decrease. Sand dropseed, Fendler threeawn, annuals, and bare ground increase under heavy, continuous grazing or long- term non-use. Other areas of this ecological site have been converted to suburban residence and small acreages, especially near the larger communities.

This ecological site occurs on nearly level to undulating topography. This site is found adjacent to the Sandy Plains and Choppy Sands ecological sites. The flatter slopes are preferred by livestock, which can lead to grazing distribution problems. Prescribed grazing management strategies help distribute grazing more evenly. Other techniques such as water locations, strategic salt and mineral placement, and herding help to distribute grazing on this site.

State and transition model

Ecosystem states

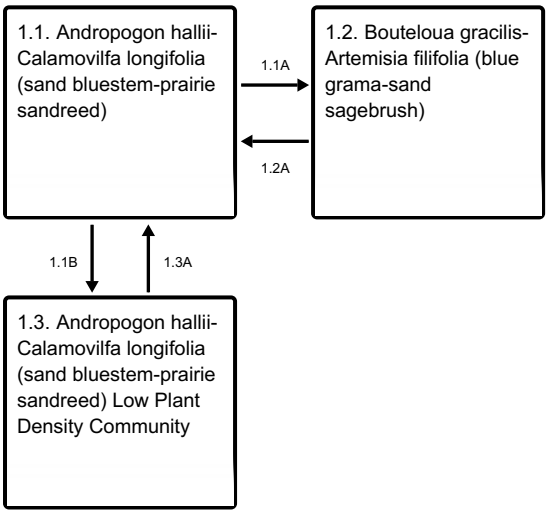


T1 to 2 - Excessive grazing. Lack of fire.

R2 to 1 - Prescribed grazing. Prescribed fire. Brush management.

T2 to 3 - Excessive grazing.

State 1 submodel, plant communities



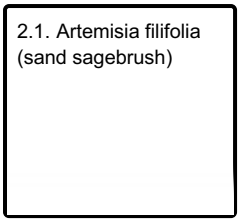
1.1A - Excessive grazing. Lack of fire.

1.1B - Non-use. Lack of fire.

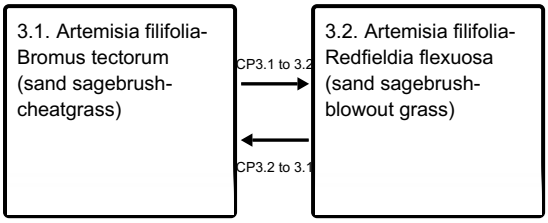
1.2A - Prescribed grazing. Prescribed fire.

1.3A - Prescribed grazing. Prescribed burning.

State 2 submodel, plant communities



State 3 submodel, plant communities



CP3.1 to 3.2 - Prescribed grazing.

CP3.2 to 3.1 - Excessive grazing.

State 1
Reference State

The Reference State is defined by three native plant communities that are a result of periodic fire (or lack of fire), drought, herbivory, and ungulate grazers (or non-use). These events are part of the natural disturbance regime and climatic processes that contribute to the development of the site. The reference plant community (1.1) consists of tall, mid, short, warm, and cool-season grasses, forbs and shrubs. This plant community is dominated by warm-season tallgrasses. The 1.2 community is dominated by blue grama and sand sagebrush and is at risk of exceeding the resilience limits of the Reference State and transitioning to the Shrub State. The 1.3 community resembles the reference plant community with lower plant density and excessive amounts of litter. A loss of plant cover and an increase in bare ground creates the probability of wind erosion. Drought-induced wind scouring coupled with disturbance (wildfire, continuous grazing, rodents, and vehicle traffic) can lead to blowouts and possibly an active sand dune. Extreme care and management should be taken when managing these areas.

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- western sandcherry (*Prunus pumila var. besseyi*), shrub
- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass

Community 1.1
Andropogon hallii-Calamovilfa longifolia (sand bluestem-prairie sandreed)

The interpretive plant community for this site is the reference plant community. This plant community evolved with grazing by large herbivores, is well suited for grazing by domestic livestock, and can be found on areas that are properly managed with grazing. This community consists chiefly of warm-season tallgrasses. Principle dominants are sand bluestem, prairie sandreed, switchgrass, and Indiangrass. Sub-dominant grasses include needle and thread, blue grama, and little bluestem. Significant forbs and shrubs are pacific peavine, prairie clovers, dotted blazing star (aka dotted gayfeather), leadplant, western sandcherry, and sand sagebrush. The potential vegetation is about 70 to 85 percent grasses and grass-like plants, 8 to 15 percent forbs and 7 to 15 percent woody plants. Grazing that allows for adequate recovery periods after each grazing event and proper stocking maintain this plant community. Spring grazing and summer deferment reduce the cool-season component and increase the warm-season component. Spring deferment and summer grazing increase the cool-season and decrease the warm-season component. This plant community is resistant to many disturbances except excessive, uncontrolled fire events, lack of fire, and urban as well as other land use development. The diversity in plant species allows for high drought tolerance. Plant litter is uniformly distributed with very little movement off-site and natural plant mortality is very low. This is a sustainable plant community in terms of soil stability, watershed function, and biologic integrity.

Production in this community can vary from 1,200 to 2,400 pounds of air-dry vegetation per acre per year depending on weather conditions and averages 1,850 pounds.

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- western sandcherry (*Prunus pumila var. besseyi*), shrub
- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1059	1614	2051
Forb	151	235	319
Shrub/Vine	135	224	319
Total	**1345**	**2073**	**2689**

Figure 10. Plant community growth curve (percent production by month). CO6709, Warm-season dominant, cool-season subdominant; MLRA-67B; upland coarse textured soils..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	2	7	25	35	15	10	5	1	0	0

Community 1.2
Bouteloua gracilis-Artemisia filifolia (blue grama-sand sagebrush)

Sand bluestem, prairie sandreed, yellow Indiangrass, switchgrass, western sandcherry, and leadplant have decreased in frequency and production. Blue grama and sand sagebrush are the dominant species. Sand dropseed, Fendler threeawn, slimflower scurfpea, hairy goldenaster, croton, Cuman ragweed, stickleaf, lupine, loco, and milkvetch have also increased. Spring grazing and summer deferment reduces the cool-season component (needle and thread, western wheatgrass, Indian ricegrass, and sedges) of this plant community and increases the warm-season component. Spring deferment and summer grazing increase the cool-seasons and decreases the warm-seasons (sand bluestem, prairie sandreed, switchgrass). This plant community is relatively stable but at risk of losing some of the tallgrass species, palatable forbs, and shrubs. The reduction of tallgrass species, nitrogen-fixing forbs, key shrub component, and increased warm-season shortgrass has altered the biotic integrity. The nutrient cycle, water cycle, and energy flow may be impaired. It will require considerable time and expense to return this community once it crosses a threshold to the shrub state. The production varies from 500 to 1,300 pounds of air-dry vegetation per acre per year depending on weather conditions and amount of mid and tallgrass species still present. Production averages 950 pounds of air-dry vegetation per acre per year.

Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- blue grama (*Bouteloua gracilis*), grass

Figure 11. Plant community growth curve (percent production by month). CO6710, Warm-season dominant; MLRA-67B; upland coarse-textured soils..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	20	40	20	10	5	0	0	0

Community 1.3
Andropogon hallii-Calamovilfa longifolia (sand bluestem-prairie sandreed) Low Plant Density Community

Plant composition is similar to the reference plant community, however, individual species production and frequency

is lower. Much of the nutrients are tied up in excessive litter. The semiarid environment and the absence of animal traffic impairs nutrient cycling. Standing dead canopy limits sunlight from reaching plant crowns. Many plants, especially bunchgrasses, die off. Increased litter and absence of grazing or fire reduce seed germination and establishment. This plant community changes rapidly with grazing and fire. Long term non-use causes plant decadence and mortality to increase, and erosion (blowouts, wind scoured areas) occurs as bare ground increases. Once this happens it will require increased energy input in terms of practice cost and management to bring back. Production can vary from 100 to 1,000 pounds of air-dry vegetation per acre per year depending on weather conditions and the plants that are present.

Dominant plant species

- leadplant (*Amorpha canescens*), shrub
- western sandcherry (*Prunus pumila var. besseyi*), shrub
- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass

Figure 12. Plant community growth curve (percent production by month). CO6711, Warm-season dominant, cool-season subdominant, excess litter; MLRA-67B; upland coarse texture soil..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	2	8	20	35	17	10	5	3	0	0

Pathway 1.1A
Community 1.1 to 1.2

Excessive grazing and lack of fire converts the reference plant community to a community of blue grama and sand sagebrush, with decreased amounts of warm-season tallgrasses.

Pathway 1.1B
Community 1.1 to 1.3

Non-use and lack of fire shifts this plant community to the 1.3 community.

Pathway 1.2A
Community 1.2 to 1.1

Appropriately timed prescribed grazing and prescribed fire restore this community to the reference community.

Conservation practices

Prescribed Burning
Prescribed Grazing

Pathway 1.3A
Community 1.3 to 1.1

Grazing management that allows for adequate recovery periods, proper stocking, and prescribed fire shift this community toward the reference plant community.

Conservation practices

Prescribed Burning
Prescribed Grazing

State 2
Shrub State

The Reference State has been driven beyond the limits of ecosystem resilience and has crossed a threshold to the Shrub State. The designation of the Shrub State denotes changes in plant species composition. Litter distribution, nutrient cycling, and carbon sequestration are not uniform. Litter levels are high and nutrients are cycling primarily under sagebrush. The water cycle is impaired. Dense shrub canopy and increased bare ground reduce effective precipitation and infiltration through evaporation and interception. Energy flow is impaired. Warm-season grasses, forbs, and shrubs have largely been replaced by a dominance of sand sagebrush. Wind scour can occur and enlarge to form blowouts. Water flow becomes connected and runoff is possible during intense storms. Desertification is advanced. Species diversity has substantially decreased. Production varies with the density and vigor of sand sagebrush. Cheatgrass can significantly invade this plant community. This change in plant species affects the hydrology, erosion potential, forage production, and wildlife habitat. Understory plants may be negatively affected by shrubs reducing the availability of light, soil moisture, and soil nutrients. As the size and density of shrubs increase, the cover and productivity of understory plants decrease. As establishment of shrubs increase, fine-fuel loads decrease. Prescribed fire can become an ineffective tool.

Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- Fendler threeawn (*Aristida purpurea var. longiseta*), grass
- sandhill muhly (*Muhlenbergia pungens*), grass
- cheatgrass (*Bromus tectorum*), grass

Community 2.1
Artemisia filifolia (sand sagebrush)

This plant community is dominated almost entirely by sand sagebrush with little understory. Favorable species that remain are few and are protected by the sagebrush. Production varies from 50 to 1,300 pounds of air-dry vegetation (primarily sand sagebrush) per acre per year depending on the amount of sand sagebrush present and weather conditions.

Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- cheatgrass (*Bromus tectorum*), grass
- Fendler threeawn (*Aristida purpurea var. longiseta*), grass

Figure 13. Plant community growth curve (percent production by month). CO6710, Warm-season dominant; MLRA-67B; upland coarse-textured soils..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	20	40	20	10	5	0	0	0

State 3
Eroded State

The Eroded State is characterized by two plant community phases. An ecological threshold has been crossed as a result of this transition. The designation of the Eroded State denotes changes in infiltration, runoff, aggregate stability, and species composition. The changes in water movement and the plant community affect changes in hydrologic functionality, biotic integrity, and soil and site stability. Infiltration, runoff, and soil erosion vary depending on the vegetation present.

Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- Fendler threeawn (*Aristida purpurea var. longiseta*), grass
- blowout grass (*Redfieldia flexuosa*), grass
- sandhill muhly (*Muhlenbergia pungens*), grass
- cheatgrass (*Bromus tectorum*), grass
- Russian thistle (*Salsola*), other herbaceous
- burningbush (*Bassia scoparia*), other herbaceous

Community 3.1
Artemisia filifolia-Bromus tectorum (sand sagebrush-cheatgrass)

This early successional plant community can either be the result of continuous grazing applied to an early perennial plant community, or the result of controlled short-term animal impact and prescribed grazing applied to a blowout. Blowouts develop as a result of long-term, heavy continuous grazing, disturbance (tillage, etc.) or wildfire. Further continuous grazing increases the size of the blowouts. This condition is not stable. It consists of bare areas that are continually eroded by wind. Desertification is well advanced. Production from this plant community phase can vary greatly depending on the plant density and weather conditions in any year. There is an overstory of sand sagebrush. Cheatgrass, Japanese brome, burningbush, Russian thistle, sunflower, pigweed, sixweeks fescue, and annual buckwheat are common. Wind erosion is a concern. Production varies from 0 to 200 pounds per acre of air-dry vegetation per year.

Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- cheatgrass (*Bromus tectorum*), grass
- sixweeks fescue (*Vulpia octoflora*), grass
- Russian thistle (*Salsola*), other herbaceous
- burningbush (*Bassia scoparia*), other herbaceous

Community 3.2
Artemisia filifolia-Redfieldia flexuosa (sand sagebrush-blowout grass)

Commonly found species include sand sagebrush, sandhill muhly, blowout grass, Indian ricegrass, Cuman ragweed, Hoods phlox, and lemon scurfpea. Wind erosion continues to be a concern. Production varies from 50 to 300 pounds per acre of air-dry vegetation per year.

Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- blowout grass (*Redfieldia flexuosa*), grass
- sandhill muhly (*Muhlenbergia pungens*), grass

Pathway CP3.1 to 3.2
Community 3.1 to 3.2

Prescribed grazing with adequate recovery opportunity between grazing events shifts this plant community to the 3.2 community. Controlled animal impact together with an appropriate grazing prescription will begin to heal blowouts and move them toward the 3.2 community.

Conservation practices

Prescribed Grazing

Pathway CP3.2 to 3.1
Community 3.2 to 3.1

Continuous grazing without adequate recovery opportunity between grazing events will shift this plant community back toward the 3.1 Community. Wind erosion is a concern and blowouts can form as a result of this community pathway.

Transition T1 to 2
State 1 to 2

The trigger for this transition is long-term excessive grazing and lack of fire. Due to the increased canopy cover of sand sagebrush there is less infiltration and an increase in interception of rainfall events.

Restoration pathway R2 to 1
State 2 to 1

Appropriately timed prescribed grazing, brush management, and prescribed fire are the tools required to return this state to the Reference State.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

Transition T2 to 3
State 2 to 3

Long-term heavy, continuous grazing without adequate recovery periods results in a shift from the Shrub State to the Eroded State. Ecological function has been compromised. The effects of this ecological threshold being crossed include changes in aggregate stability, nutrient availability, plant cover, and hydrologic function. Accelerated wind erosion can cause the formation of blowouts.

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm Season Tall Rhizomatous**			312–415	
	prairie sandreed	CALO	*Calamovilfa longifolia*	312–415	–
2	**Warm Season Tall Bunchgrass**			622–934	
	sand bluestem	ANHA	*Andropogon hallii*	519–622	–
	switchgrass	PAVI2	*Panicum virgatum*	207–415	–
	Indiangrass	SONU2	*Sorghastrum nutans*	21–63	–
3	**Warm Season Mid Rhizomatous**			0–41	
	blowout grass	REFL	*Redfieldia flexuosa*	21–41	–
	sandhill muhly	MUPU2	*Muhlenbergia pungens*	0–21	–
4	**Warm Season Mid Bunchgrass**			41–146	
	little bluestem	SCSC	*Schizachyrium scoparium*	21–104	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	0–63	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	21–41	–
5	**Warm Seaon Short Bunchgrass**			21–104	
	blue grama	BOGR2	*Bouteloua gracilis*	21–104	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	21–41	–
6	**Cool Season Mid Rhizomatous**			21–41	
	western wheatgrass	PASM	*Pascopyrum smithii*	21–41	–
	thickspike wheatgrass	ELLAL	*Elymus lanceolatus ssp. lanceolatus*	0–21	–
7	**Cool Season Mid Bunchgrass**			63–146	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	63–146	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	21–41	–
	squirreltail	ELELE	*Elymus elymoides ssp. elymoides*	0–21	–

	prairie Junegrass	KOMA	*Koeleria macrantha*	0–21	–
8	**Miscellaneous**			0–21	
	Fendler threeawn	ARPUL	*Aristida purpurea var. longiseta*	0–21	–
	thin paspalum	PASE5	*Paspalum setaceum*	0–21	–
9	**Sedges**			21–41	
	sun sedge	CAINH2	*Carex inops ssp. heliophila*	21–41	–
	Great Plains flatsedge	CYLU2	*Cyperus lupulinus*	0–21	–
	Schweinitz's flatsedge	CYSC3	*Cyperus schweinitzii*	0–21	–
10	**Other Native Grasses**			0–63	
	Grass, perennial	2GP	*Grass, perennial*	0–63	–
Forb					
11	**Legumes**			63–187	
	manystem pea	LAPO2	*Lathyrus polymorphus*	21–63	–
	purple prairie clover	DAPUP	*Dalea purpurea var. purpurea*	21–41	–
	silky prairie clover	DAVI	*Dalea villosa*	21–41	–
	painted milkvetch	ASCEF	*Astragalus ceramicus var. filifolius*	0–21	–
	white prairie clover	DACA7	*Dalea candida*	0–21	–
	nineanther prairie clover	DAEN	*Dalea enneandra*	0–21	–
	lemon scurfpea	PSLA3	*Psoralidium lanceolatum*	0–21	–
12	**Warm Season**			21–166	
	dotted blazing star	LIPU	*Liatris punctata*	21–41	–
	whitest evening primrose	OEAL	*Oenothera albicaulis*	0–21	–
	othake	PASP	*Palafoxia sphacelata*	0–21	–
	upright prairie coneflower	RACO3	*Ratibida columnifera*	0–21	–
	white heath aster	SYERE	*Symphyotrichum ericoides var. ericoides*	0–21	–
	snowball sand verbena	ABFR2	*Abronia fragrans*	0–21	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–21	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	0–21	–
	shaggy dwarf morning-glory	EVNU	*Evolvulus nuttallianus*	0–21	–
	stiff sunflower	HEPAP2	*Helianthus pauciflorus ssp. pauciflorus*	0–21	–
	hairy false goldenaster	HEVI4	*Heterotheca villosa*	0–21	–
	bush morning-glory	IPLE	*Ipomoea leptophylla*	0–21	–
13	**Cool Season**			21–104	
	broadbeard beardtongue	PEAN4	*Penstemon angustifolius*	21–41	–
	scarlet globemallow	SPCO	*Sphaeralcea coccinea*	0–21	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–21	–
	meadow deathcamas	ZIVE	*Zigadenus venenosus*	0–21	–
	Carolina larkspur	DECAV2	*Delphinium carolinianum ssp. virescens*	0–21	–
	common starlily	LEMO4	*Leucocrinum montanum*	0–21	–
14	**Annuals**			0–21	
	annual buckwheat	ERAN4	*Eriogonum annuum*	0–21	

	annual buckwheat	ERAN4	*Eriogonum annuum*	0–21	–
	woolly plantain	PLPA2	*Plantago patagonica*	0–21	–
15	**Other Native Forbs**			41–104	
	Forb, perennial	2FP	*Forb, perennial*	41–104	–
Shrub/Vine					
16	**Sprouters/Rhizomatous**			124–353	
	leadplant	AMCA6	*Amorpha canescens*	41–146	–
	sand sagebrush	ARFI2	*Artemisia filifolia*	21–104	–
	western sandcherry	PRPUB	*Prunus pumila var. besseyi*	41–104	–
	skunkbush sumac	RHTR	*Rhus trilobata*	0–21	–
	prairie rose	ROAR3	*Rosa arkansana*	0–21	–
17	**Half-Shrubs**			0–21	
	spreading buckwheat	EREF	*Eriogonum effusum*	0–21	–
	spiny phlox	PHHO	*Phlox hoodii*	0–21	–
18	**Succulents**			0–21	
	spinystar	ESVIV	*Escobaria vivipara var. vivipara*	0–21	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–21	–
19	**Evergreen**			0–21	
	soapweed yucca	YUGL	*Yucca glauca*	0–21	–
20	**Other Native Shrubs**			21–63	
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	21–63	–

Animal community

WILDLIFE INTERPRETATIONS:

The variety of grasses, forbs, and shrubs on this ecological site in the various plant communities provides habitat for a wide range of wildlife species. Historic large grazers that influenced these plant communities were bison, elk, and pronghorn. Changes over time have resulted in the loss of bison, the reduction in elk numbers, and pronghorn population swings. Domestic grazers now share these habitats with wildlife. The grassland communities of eastern Colorado are home to many bird species. Changes in the composition of the plant community when moving from the reference plant community to other communities on this ecological site may result in dramatic species shifts in the bird community. Because of a lack of permanent water, fish and many amphibians are not expected on this ecological site. Mule and white-tailed deer may use this ecological site, however the shrub cover is too low to expect more than occasional use. The gray wolf and wild bison used this ecological site in historic times. The wolf is thought to be extirpated from Eastern Colorado. Bison in the area are domesticated.

1.1 Reference Plant Community:

The structural diversity in the plant community found on the reference site is attractive to a number of wildlife species. Common bird species expected on in this plant community include Cassin’s sparrow, lark bunting, western meadowlark, and ferruginous and Swainson’s hawk. The combination of mid-tall grasses and shrubs provides habitat for lesser prairie chicken in the southeastern parts of this site. Greater prairie chicken use this site in the northern portion of the MLRA. Scaled quail may also use this community. White-tailed jackrabbit, badger, mule deer, pronghorn, coyote, plains pocket gopher, spotted ground squirrel, and several species of mice are mammals that commonly use this plant community. Reptiles include prairie rattlesnake, bullsnake, western hognose snake, racer, ornate box turtle, and six-lined racerunner.

1.2 Community:

All reference plant community species are expected to be found. The reduction of tall, warm-season grasses may eventually result in decreased nesting habitat for lesser and greater prairie chickens.

1.3 Community:

The same species found in the reference plant community are expected to be found.

2.1 Community:

Due to the loss of species diversity, wildlife use in this community is greatly reduced. Scaled quail may occasionally use these sites due to increased annual forb abundance compared. Other birds and occasionally mule deer may also pass through. Prairie rattlesnakes and other reptiles are still be found. Swainson’s hawk continue to use this site because it will be easy to spot prey.

3.1 Community:

Wildlife use is very limited. Plant diversity and productivity are greatly reduced.

3.2 Community:

The wildlife found here will be similar to the 3.1 community.

GRAZING INTERPRETATIONS:
The following table lists suggested initial stocking rates for an animal unit (1000-pound beef cow) under continuous grazing (yearlong grazing or growing-season-long grazing) based on normal growing conditions. However, continuous grazing is not recommended. These estimates should only be used as preliminary guidelines in the initial stages of the conservation planning process. Often, the existing plant composition does not entirely match any particular plant community described in this ecological site description. Therefore, field inventories are always recommended to document plant composition, total production, and palatable forage production. Carrying capacity estimates that reflect on-site conditions should be calculated using field inventories.

If the following production estimates are used, they should be adjusted based on animal kind or class and on the specific palatability of the forage plants in the various plant community descriptions. Under a properly stocked, properly applied, prescribed grazing management system that provides adequate recovery periods following each grazing event, improved harvest efficiencies eventually result in increased carrying capacity. See USDA-NRCS Colorado Prescribed Grazing Standard and Specification Guide (528).

The stocking rate calculations are based on the total annual forage production in a normal year multiplied by 25 percent harvest efficiency divided by 912.5 pounds of ingested air-dry vegetation for an animal unit per month (AUM).

Plant Community (PC) Production (lbs./acre) and Stocking Rate (AUM/acre)

Reference PC - (1850) (0.51)

1.2 PC - (950) (0.26)

An on-site inventory is required prior to preparing a grazing plan.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangelands in this area provide yearlong forage under prescribed grazing for cattle, sheep, horses and other herbivores. .

Hydrological functions

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group A. Infiltration is high and runoff potential for this site varies from moderate to low depending on ground cover. Areas where ground cover is less than 50 percent have the greatest potential to have reduced infiltration and higher runoff (refer to NRCS Section 4, National Engineering Handbook (USDA–NRCS, 1972–2012) for runoff quantities and hydrologic curves).

Recreational uses

This site provides hunting, hiking, photography, bird watching, and other opportunities. The wide varieties of plants that bloom from spring until fall have an aesthetic value that appeals to visitors.

Wood products

No appreciable wood products are present on the site.

Other products

Site Development and Testing Plan

General Data (MLRA and Revision Notes, Hierarchical Classification, Ecological Site Concept, Physiographic, Climate, and Water Features, and Soils Data):

Updated. All “Required” items complete to Provisional level.

Community Phase Data (Ecological Dynamics, STM, Transition & Recovery Pathways, Reference Plant Community, Species Composition List, Annual Production Table):

Updated. All “Required” items complete to Provisional level.
NOTE: Annual Production Table is from the “Previously Approved” ESD 2004. The Species Composition List is also from the 2004 version, with minor edits. These will need review for future updates at Approved level.

Each Alternative State/Community:

Complete to Provisional level

Supporting Information (Site Interpretations, Assoc. & Similar Sites, Inventory Data References, Agency/State Correlation, References):

Updated. All “Required” items complete to Provisional level.

Livestock Interpretations updated to reflect Total Annual Production revisions in each plant community.

Wildlife interpretations, general narrative, and individual plant communities updated to the Provisional level. Hydrology, Recreational Uses, Wood Products, Other Products, Plant Preferences table, and Rangeland Health Reference Sheet carried over from previously “Approved” ESD 2004.

Reference Sheet

The Reference Sheet was previously approved in 2007.
It will be updated at the next “Approved” level.

“Future work, as described in a project plan, to validate the information in this provisional ecological site description is needed. This will include field activities to collect low and medium intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document.” (NI 430_306 ESI and ESD, April, 2015)

Other information

Relationship to Other Hierarchical Classifications:

NRCS Classification Hierarchy:
Physiographic Divisions of the United States (Fenneman, 1946): Physiographic DivisionPhysiographic

ProvincePhysiographic SectionLand Resource RegionMajor Land Resource Area (MLRA)Land Resource Unit (LRU).
USFS Classification Hierarchy:
National Hierarchical Framework of Ecological Units (Cleland et al, 181-200):
DomainDivisionProvinceSectionSubsectionLandtype AssociationLandtypeLandtype Phase.

Inventory data references

NRI: references to Natural Resource Inventory data
Information presented here has been derived from data collection on private and federal lands using:
• Double Sampling (clipped 2 of 5 plots)*
• Rangeland Health (Pellant et al., 2005)
• Soil Stability (Pellant et al., 2005)
• Line Point Intercept : Foliar canopy, basal cover (Forb, Graminoid, Shrub, subshrub, Lichen, Moss, Rock fragments, bare ground, percent Litter) (Herrick et al., 2005)
• Soil pedon descriptions collected on site (Schoeneberger et al., 2012)

*NRCS double-sampling method, CO NRCS Similarity Index Worksheet 528(1).
Additional reconnaissance data collection using numerous ocular estimates and other inventory data; NRCS clipping data for USDA program support; Field observations from experienced range trained personnel. Specific data information is contained in individual landowner/user case files and other files located in county NRCS field offices.

Those involved in developing the 2004 site description include: Harvey Sprock, Rangeland Management Specialist, CO-NRCS; Ben Berlinger, Rangeland Management Specialist, CO-NRCS; Scott Woodall, Rangeland Management Specialist, CO-NRCS; James Borchert, Soil Scientist, CO-NRCS; Dave Sharman, Resource Conservationist, CO-NRCS; Terri Skadeland, Biologist, CO-NRCS; Dave Cook, Rangeland Management Specialist, NE-NRCS; Chuck Ring, Rangeland Management Specialist, WY-NRCS.

References

Guyette, R.P., M.C. Stambaugh, D.C. Dey, and R. Muzika. 2012. Predicting Fire Frequency with Chemistry and Climate. Ecosystems 15:322–335.

Stewart, O.C., H.T. Lewis, and M.K. Anderson. 2002. Forgotten Fires: Native Americans and the Transient Wilderness. University of Oklahoma Press, Norman, OK. 351p.

Other references

Data collection for this ecological site was done in conjunction with the progressive soil surveys within the 67B Central High Plains (Southern Part) of Colorado. It has been mapped and correlated with soils in the following soil surveys: Adams County, Arapahoe County, Baca County, Bent County, Boulder County, Cheyenne County, El Paso County Area, Elbert County, Eastern Part, Kiowa County, Kit Carson County, Larimer County Area, Las Animas County Area, Lincoln County, Logan County, Morgan County, Prowers County, Washington County, Weld County, Northern Part, and Weld County, Southern Part.

30 Year Climatic and Hydrologic Normals (1981-2010) Reports. National Water and climate Center: Portland, OR. August 2015

ACIS-USDA Field Office Climate Data (WETS), period of record 1971-2000 http://agacis.rcc-acis.org (powered by WRCC) Accessed March 2016

Andrews, R. and R. Righter. 1992. Colorado Birds. Denver Museum of Natural History, Denver, CO. 442

Armstrong, D.M. 1972. Distribution of mammals in Colorado. Univ. Kansas Museum Natural History Monograph #3. 415.

Butler, LD., J.B. Cropper, R.H. Johnson, A.J. Norman, G.L. Peacock, P.L. Shaver, and K.E. Spaeth. 1997, revised 2003. National Range and Pasture Handbook. National Cartography and Geospatial Center's Technical Publishing Team: Fort Worth, TX. http://www.glti.nrcs.usda.gov/technical/publications/nrph.html Accessed August 2015

Clark, J., E. Grimm, J. Donovan, S. Fritz, D. Engrstom, and J. Almendinger. 2002. Drought cycles and landscape responses to past Aridity on prairies of the Northern Great Plains, USA. Ecology, 83(3), 595-601.

Cleland, D., P. Avers, W.H. McNab, M. Jensen, R. Bailey, T. King, and W. Russell. 1997. National Hierarchical Framework of Ecological Units, published in Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources, Yale University Press

Cooperative climatological data summaries. NOAA. Western Regional Climate Center: Reno, NV. Web. http://www.wrcc.dri.edu/climatedata/climsum Accessed August 2015

Egan, Timothy. 2006. The Worst Hard Time. Houghton Mifflin Harcourt Publishing Company: New York, NY.

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong. 1994. Mammals of Colorado. Denver Museum of Natural History, Denver, CO. 467. Hammerson, G.A. 1986. Amphibians and reptiles in Colorado. CO Div. Wild. Publication Code DOW-M-I-3-86. 131.

Herrick, Jeffrey E., J.W. Van Zee, K.M. Haystad, L.M. Burkett, and W.G. Witford. 2005. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems, Volume II. U.S. Dept. of Agriculture, Agricultural Research Service. Jornada Experimental Range, Las Cruces, N.M.

Kingery, H., Ed. (1998) Colorado Breeding Birds Atlas. Dist. CO Wildlife Heritage Foundation: Denver, CO. 636.

National Water & Climate Center. USDA-NRCS. USDA Pacific Northwest Climate Hub: Portland, OR. http://www.wcc.nrcs.usda.gov/ Accessed March 2016

National Weather Service Co-op Program. 2010. Colorado Climate Center. Colorado State Univ. Web. http://climate.atmos.colostate.edu/dataaccess.php March 2016

Pellant, M., P. Shaver, D.A. Pyke, J.E. Herrick. (2005) Interpreting Indicators of Rangeland Health, Version 4. BLM National Business Center Printed Materials Distribution Service: Denver, CO.

PLANTS Database. 2015. USDA-NRCS. Web. http://plants.usda.gov/java/ Accessed August 2015. February 2016

PRISM Climate Data. 2015. Prism Climate Group. Oregon State Univ. Corvallis, OR. http://www.prism.oregonstate.edu/ Accessed August 2015.

Rennicke, J. 1990. Colorado Wildlife. Falcon Press, Helena and Billings, MT and CO Div. Wildlife, Denver CO. 138.

Schoeneberger, P.J., D.A. Wysockie, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center: Lincoln, NE.

The Denver Posse of Westerners. 1999. The Cherokee Trail: Bent's Old Fort to Fort Bridger. The Denver Posse of Westerners, Inc. Johnson Printing: Boulder, CO

U.S. Dept. of Agriculture, Agricultural Research Service. September 1991. Changes in Vegetation and Land Use I eastern Colorado, A Photographic study, 1904-1986.

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

U.S. Dept. of Agriculture, Natural Resources Conservation Service. National Geospatial Center of Excellence. Colorado annual Precipitation Map from 1981-2010, Annual Average Precipitation by State

U.S. Dept. of Agriculture, Natural Resources Conservation Service. 2009. Part 630, Hydrology, National Engineering Handbook

U.S. Dept. of Agriculture, Natural Resources Conservation Service. 1972-2012. National Engineering Handbook Hydrology Chapters. http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?&cid=stelprdb1043063 Accessed August 2015.

U.S. Dept. of Agriculture, Natural Resources Conservation Service. National Soil Survey Handbook title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/ref/?cid=nrcs142p2_054242 Accessed July 2015

U.S. Dept. of Agriculture, Soil Survey Division Staff. 1993. Soil Survey Manual.

U.S. Dept. of Agriculture.1973. Soil Survey of Baca County, Colorado.

U.S. Dept. of Agriculture. 1970. Soil Survey of Bent County, Colorado.

U.S. Dept. of Agriculture. 1968. Soil Survey of Crowley County, Colorado.

U.S. Dept. of Agriculture. 1981 Soil Survey of El Paso County Area, Colorado.

U.S. Dept. of Agriculture. 1995. Soil Survey of Fremont County Area, Colorado.

U.S. Dept. of Agriculture. 1983. Soil Survey of Huerfano County Area, Colorado.

U.S. Dept. of Agriculture.1981. Soil Survey of Kiowa County, Colorado.

Western Regional Climate Center. 2022. Climate of Colorado, climate of the eastern plains. https://wrcc.dri.edu/Climate/narrative_co.php (accessed 9 August 2022).

Additional Literature:

Clark, J., E. Grimm, J. Donovan, S. Fritz, D. Engrstom, and J. Almendinger. 2002. Drought cycles and landscape responses to past Aridity on prairies of the Northern Great Plains, USA. Ecology, 83(3), 595-601.

Collins, S. and S. Barber. (1985). Effects of disturbance on diversity in mixed-grass prairie. Vegetation, 64, 87-94.

Egan, Timothy. 2006. The Worst Hard Time. Houghton Mifflin Harcourt Publishing Company: New York, NY.

Hart, R. and J. Hart. 1997. Rangelands of the Great Plains before European Settlement. Rangelands, 19(1), 4-11.

Hart, R. 2001. Plant biodiversity on shortgrass steppe after 55 years of zero, light, moderate, or heavy cattle grazing. Plant Ecology, 155, 111-118.

Heitschmidt, Rodney K., J.W. Stuth, (edited by). 1991. Grazing Management, an Ecological Perspective. Timberland Press, Portland, OR.

Jackson, D. 1966. The Journals of Zebulon Montgomery Pike with letters & related documents. Univ. of Oklahoma Press, First edition: Norman, OK.

Mack, Richard N., and J.N. Thompson. 1982. Evolution in Steppe with Few Large, Hooved Mammals. The American Naturalist. 119, No. 6, 757-773.

Reyes-Fox, M., Stelzer H., Trlica M.J., McMaster, G.S., Andales, A.A., LeCain, D.R., and Morgan J.A. 2014. Elevated CO2 further lengthens growing season under warming conditions. Nature, April 23 2014.Available online. http://www.nature.com/nature/journal/v510/n7504/full/nature13207.html, accessed March 2017.

Stahl, David W., E.R. Cook, M.K. Cleaveland, M.D. Therrell, D.M. Meko, H.D. Grissino-Mayer, E. Watson, and B.H.

Luckman. Tree-ring data document 16th century megadrought over North America. 2000. Eos, 81(12), 121-125.

The Denver Posse of Westerners. 1999. The Cherokee Trail: Bent's Old Fort to Fort Bridger. The Denver Posse of Westerners, Inc. Johnson Printing: Boulder, CO.

U.S. Dept. of Agriculture. 2004. Vascular plant species of the Comanche National Grasslands in southeastern Colorado. US Forest Service. Rocky Mountain Research Station. Fort Collins, CO.

Zelikova, Tamara Jane, D.M. Blumenthal, D.G. Williams, L. Souza, D.R. LeCain, J.Morgan. 2014. Long-term Exposure to Elevated CO2 Enhances Plant Community Stability by Suppressing Dominant Plant Species in a Mixed-Grass Prairie. Ecology, 2014 issue. Available online. www.pnas.org/cgi/doi/10.1073/pnas.1414659111.

Contributors

Kimberly Diller, Ecological Site Specialist, NRCS MLRA, Pueblo SSO
Andy Steinert, MLRA 67B Soil Survey Leader, NRCS MLRA Fort Morgan SSO
Ben Berlinger, Rangeland Management Specialist, Retired NRCS La Junta, CO
Doug Whisenhunt, Ecological Site Specialist, NRCS MLRA, Pueblo SSO

Approval

Kirt Walstad, 9/08/2023

Acknowledgments

Program Support:
Rachel Murph, NRCS State Rangeland Management Specialist-QC, Denver, CO
David Kraft, NRCS MLRA Ecological Site Specialist-QA, Emporia, KS
Josh Saunders, Rangeland Management Specialist-QC, NRCS Fort Morgan, CO
Patty Knupp, Biologist, Area 3, NRCS Pueblo, CO
Noe Marymor, Biologist, Area 2, NRCS Greeley, CO
Richard Mullaney, Resource Conservationist, Retired, NRCS, Akron, CO
Chad Remley, Regional Director, N. Great Plains Soil Survey, Salina, KS
B.J. Shoup, State Soil Scientist, Denver
Eugene Backhaus, State Resource Conservationist, Denver
Carla Green Adams, Editor, NRCS, Denver, CO

Partners/Contributors:
Rob Alexander, Agricultural Resources, Boulder Parks & Open Space, Boulder, CO
David Augustine, Research Ecologist, Agricultural Research Service, Fort Collins, CO
John Fusaro, Rangeland Management Specialist, NRCS, Fort Collins, CO
Jeff Goats, Resource Soil Scientist, NRCS, Pueblo, CO
Clark Harshbarger, Resource Soil Scientist, NRCS, Greeley, CO
Mike Moore, Soil Scientist, NRCS MLRA Fort Morgan SSO
Tom Nadgwick, Rangeland Management Specialist, NRCS, Akron CO
Dan Nosal, Rangeland Management Specialist, NRCS, Franktown, CO
Steve Olson, Botanist, USFS, Pueblo, CO
Randy Reichert, Rangeland Specialist, Retired, USFS, Nunn, CO
Don Schoderbeck, Range Specialist, CSU Extension, Sterling CO
Terri Schultz, The Nature Conservancy, Ft. Collins, CO
Chris Tecklenburg, Ecological Site Specialist, Hutchison, KS

Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community

cannot be used to identify the ecological site.

Author(s)/participant(s)	Harvey Sprock, Ben Berlinger, Daniel Nosal
Contact for lead author	Harvey Sprock, Area Rangeland Management Specialist, Greeley, CO
Date	11/16/2004
Approved by	Kirt Walstad
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** None

---

2. **Presence of water flow patterns:** Typically none. If flow patterns are present, they are are broken, irregular in appearance or discontinuous with numerous debris dams or vegetative barriers.

---

3. **Number and height of erosional pedestals or terracettes:** Pedestalled plants caused by wind erosion would be minor.

---

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** 3 percent or less bare ground, with bare patches ranging from 3-5 inches in diameter. Prolonged drought or wildfire events will cause bare ground to increase upwards to 5-10 percent with bare patches ranging from 8-12 inches in diameter.

---

5. **Number of gullies and erosion associated with gullies:** None

---

6. **Extent of wind scoured, blowouts and/or depositional areas:** A minor amount of wind scouring may occur on naturally disturbed areas. Fire or extended drought can exacerbate the appearance. Typically, wind scouring is insignificant.

---

7. **Amount of litter movement (describe size and distance expected to travel):** Litter is uniformly distributed with little movement. On steep slopes or knolls, litter may move from a few inches to 1-2 feet depending on intensity of wind or rainfall event.

---

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Stability class rating is anticipated to be 4-5 in the interspaces at soil surface. Soil surface is stabilized by decomposing organic matter. Biological crusts (lichens, algae, cyanobacteria, mosses) may be present on or just below soil surface.

---

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Average SOM ranges from 1-4 percent. Soils are very deep, grayish-brown, weak very fine granular structure.

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Raindrop impact is reduced by the diverse grass, forb, shrub functional/structural groups and root structure. This slows overland flow and provides increased time for infiltration to occur. Extended drought, wildfire or both may reduce basal density, canopy cover, and litter amounts (primarily from tall, warm-season bunch and rhizomatous grasses), resulting in decreased infiltration and increased runoff on steep slopes following intense rainfall events.

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None

---

12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

    Dominant: Warm-season tall bunchgrass >>

    Sub-dominant: Warm-season tall rhizomatous grass > sprouting/leguminous shrubs > other shrubs > cool-season mid bunchgrass > warm-season mid bunchgrass > leguminous forbs >

    Other: Warm-season short bunchgrass = warm-season forbs > cool-season forbs

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Typically minimal. Expect slight short and mid bunchgrass and shrub mortality and decadence during and following drought.

---

14. **Average percent litter cover (%) and depth (in):** Litter cover during and following drought can range from 20-30 percent and 5-15 percent following wildfire.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1200 lbs./ac. low precip years; 1850 lbs./ac. average precip years; 2400 lbs./ac. high precip years. After extended drought or the first growing season following wildfire, production may be significantly reduced by 400 – 750 lbs./ac. or more.

---

16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:** Invasive plants should not occur in reference plant community. Following wildfire or extended

drought, cheatgrass, Russian thistle, burningbush, Rocky Mountain beeplant may invade assuming a seed source is available.

---

17. **Perennial plant reproductive capability:** The only limitations are weather-related, wildfire, natural disease, and insects that may temporarily reduce reproductive capability.
