# Ecological site R069XY019CO
# Deep Sand

Last updated: 9/07/2023
Accessed: 11/23/2024

## 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.

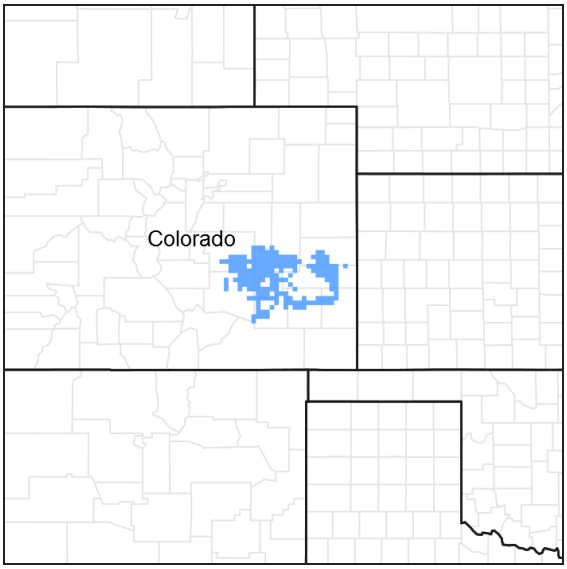



**Figure 1. Mapped extent**

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): 069X–Upper Arkansas Valley Rolling Plains

MLRA 69 is located in the Arkansas Watershed of southeastern (SE) Colorado. It consists of rolling plains, river valleys, and canyonlands. The Arkansas River flows from the Rocky Mountains to Kansas. Tributaries include the Huerfano, and Purgatoire Rivers. The MLRA is traversed by Interstate 25 and U.S. Highway 50, and includes the cities of Pueblo, La Junta, and Lamar. Other cities include Cañon City, and Walsenburg. Bent's Fort was once a major trading post along the Santa Fe Trail. The majority of land use is rangeland (greater than 75 percent), and 6 percent cropland. The remainder is urban, recreation, etc. Land ownership is mostly private. Federal lands include U.S. Forest Service Comanche National Grassland, Department of Defense Piñon Canyon Maneuver Site and Fort Carson. There is a minor amount of Bureau of Land Management and other federal land. State areas include Pueblo and John Martin reservoirs. Elevations MLRA-wide are 3,700 to 6,400 feet.

The "Dust Bowl" region (1930s) included SE Colorado, which is periodically affected by severe drought. Dust storms may form during drought years, in windy periods. Annual precipitation is 10 to 16 inches. 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. Evapotranspiration rates are high. Winter temperatures may be subzero. Snowfall varies from 20 to 40 inches per year. Blizzards can form quickly.

## Classification relationships

MLRA 69 is in the Piedmont and Raton Sections of the Great Plains Province. The MLRA is further defined by Land Resource Units (LRUs) A, B, and C. The modal concepts of each LRU can be defined by soil properties and annual precipitation zones (PZ). Other features, such as climate, geology, landforms, and key vegetation, further refine these concepts and are described in the Ecological Site Description (ESD).

LRU A (10 to 12 inches PZ) is 2.4 million acres in the central portion of MLRA 69. There is irrigated cropland in the Arkansas Valley. Precipitation is too limited for dryland crops. Most of LRU A is rangeland, and includes the Comanche National Grassland (FS). This LRU is in portions of Bent, Crowley, Otero, and Pueblo counties. Soil Moisture Regime is Ustic Aridic. The Mean Annual Air Temperature (MAAT) is 51 to 54 degrees Fahrenheit.

LRU B (12 to 14 inches PZ) is 4.7 million acres and includes portions of Baca, Bent, Crowley, El Paso, Fremont, Kiowa, Las Animas, Lincoln, Prowers, and Pueblo counties. Most of the LRU is in rangeland. Land uses include irrigated and dry cropland, small acreage and urban ownership. Land east of Interstate 25 remains largely agricultural. Canyonlands are in the southern half and include Piñon Canyon Maneuver Site and the Picket Wire Canyon of the Comanche National Grasslands. Soil moisture regime is Ustic Aridic. The mean annual air temperature is 50 to 54 degrees Fahrenheit.

The Deep Sand Ecological Site, LRUs A and B, was developed from an earlier version of the Sands Ecological Site (2004, renamed Deep Sand Ecological Site in 2007). This earlier version of the Sands Ecological Site (2004) was based on input from Natural Resources Conservation Service (formerly Soil Conservation Service) and historical information obtained from the Deep Sand Range Site descriptions (1975, revised 1983). 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

The Deep Sand Ecological Site is in an upland position on plains with slopes of more than 10 percent. This site is on stabilized dunes and normally doesn't contain blowouts.

## Associated sites

| | |
|---|---|
| R069XY021CO | **Choppy Sands**<br>Choppy Sands Ecological Site is commonly adjacent to Deep Sands Ecological Site. |
| R069XY026CO | **Sandy Plains**<br>Sandy Plains Ecological Site is commonly adjacent to Deep Sands Ecological Site. |

## Similar sites

| | |
|---|---|
| R069XY031CO | **Sandy Bottomland**<br>Sandy Bottomlands Ecological Site is a run-on site with slopes of less than 10 percent. |
| R069XY021CO | **Choppy Sands**<br>Choppy Sands Ecological Site has blowouts present. |

**Table 1. Dominant plant species**

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

## Physiographic features

This site occurs on plains.

**Table 2. Representative physiographic features**

| | |
|---|---|
| Landforms | (1) Dune<br>(2) Hill<br>(3) Ridge |
| Runoff class | Very low to low |
| Flooding frequency | None |
| Ponding frequency | None |
| Elevation | 1,128–1,554 m |
| Slope | 1–25% |
| Ponding depth | 0 cm |
| Water table depth | 152 cm |
| Aspect | Aspect is not a significant factor |

## Climatic features

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 and can range from 20 to 40 inches per year. Winds are estimated to average 6 to 7 miles per hour annually. Daytime winds are generally stronger than nighttime winds. Occasional strong storms may bring brief periods of high winds with gusts to more than 60 miles per hour. The average length of the freeze-free period (28 °F) is 168 days. The average last freeze in the spring is April 22nd, and the average date of first freeze in fall is October 7th. The average length of the frost-free period (32 °F) is 149 days. The last frost in the spring is May 5th, and the average date for first frost in the fall (32 °F), is October 1. July is the hottest month, and January is the coldest. It is not uncommon for temperature to exceed 100 degrees Fahrenheit during the summer. Summer humidity is low and evaporation is high. The winters are characterized with frequent northerly winds, producing severe cold and temperatures dropping to -30 degrees Fahrenheit.

LRU A, in the Arkansas River Valley, is the hottest and driest portion of the MLRA. Mean Annual Precipitation (MAP) is 10 to 12 inches, and Mean Annual Air Temperature (MAAT) is 51 to 54 degrees Fahrenheit. LRU B is the largest extent. MAP is 12 to 14 inches, and MAAT is 50 to 54 degrees Fahrenheit.

**Table 3. Representative climatic features**

| | |
|---|---|
| Frost-free period (characteristic range) | 127-134 days |
| Freeze-free period (characteristic range) | 149-161 days |
| Precipitation total (characteristic range) | 305-356 mm |
| Frost-free period (actual range) | 121-135 days |
| Freeze-free period (actual range) | 141-164 days |
| Precipitation total (actual range) | 279-406 mm |
| Frost-free period (average) | 129 days |
| Freeze-free period (average) | 153 days |
| Precipitation total (average) | 330 mm |

## Climate stations used

- (1) CHERAW 1 N [USC00051539], La Junta, CO
- (2) LA JUNTA 20 S [USC00054726], La Junta, CO
- (3) ROCKY FORD 2 SE [USC00057167], Rocky Ford, CO
- (4) ORDWAY 21 N [USC00056136], Ordway, CO
- (5) PUEBLO MEM AP [USW00093058], Pueblo, CO
- (6) EADS [USC00052446], Eads, CO

- (7) ORDWAY 2 ENE [USC00056131], Ordway, CO
- (8) PUEBLO RSVR [USC00056765], Pueblo, CO
- (9) TACONY 13 SE [USC00058157], Boone, CO

## Influencing water features

There are no water features associated with this site.

## Wetland description

N/A

## Soil features

The soils of this site are very deep. They are excessively drained with rapid or very rapid permeability. The surface layer thickness ranges from 2 to 8 inches thick. The soil moisture regime is ustic aridic. The soil temperature regime is mesic. Parent material kind is eolian sands. Major soil series correlated to this ecological site include Valent and Wigton.

Revisions to soil surveys are on-going. For the most recent updates, visit the Web Soil Survey, the official site for latest 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<br>(2) Sand |
| Drainage class | Excessively drained |
| Permeability class | Very rapid to rapid |
| Soil depth | 152–203 cm |
| Surface fragment cover <=3" | 0% |
| Surface fragment cover >3" | 0% |
| Available water capacity (0-101.6cm) | 4.06–12.19 cm |
| Calcium carbonate equivalent (0-101.6cm) | 0–5% |
| Electrical conductivity (0-101.6cm) | 0 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" (0cm) | 0–5% |
| Subsurface fragment volume >3" (0cm) | 0% |

## Ecological dynamics

The information in this ESD, including the state-and-transition model (STM), was developed using archeological and historical data, professional experience, and scientific studies. The information is representative of a complex set of plant communities. 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.

Not all scenarios or plants are included. Key indicator plants, animals, and ecological processes are described to inform land management decisions.

This region was historically occupied by large grazing animals, such as bison, along with pronghorn and mule deer. Deer and pronghorn are widely distributed throughout the MLRA. This is an important site for livestock grazing, especially cattle.

This is a mixed tallgrass and midgrass prairie with a diverse forb and shrub component. Sand bluestem (warm-season, tall bunchgrass) and prairie sandreed (warm-season, tall rhizomatous grass) are primary. Secondary components include midgrasses, such as needle and thread and Indian ricegrass (cool-season bunchgrass) and little bluestem (warm-season bunch). Forbs, such as lemon scurfpea, are common. Shrubs include sand sagebrush and western sandcherry.

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. Recent drought events have increased mortality of blue grama significantly in some locales, along with other bunchgrasses, such as sand bluestem, little bluestem, needle and thread, Fendler threeawn, and squirreltail. Historic fire frequency (pre-industrial) is estimated at 15 to 20 years (Guyette, 2012), randomly distributed, and started by lightning at various times throughout the growing season. Early human inhabitants were also likely to start fires (deliberate or accidental).

Southeastern Colorado was strongly affected by extended drought conditions in the “Dust Bowl” period of the 1930s, 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. “During periods of drought, high winds give rise to the dust storms which are especially characteristic of the southeastern plains (WRCC, 2022).” Recent drought events have increased mortality of blue grama upwards of 80 percent in some locales. The long-term effects of these latest drought years have yet to be determined.

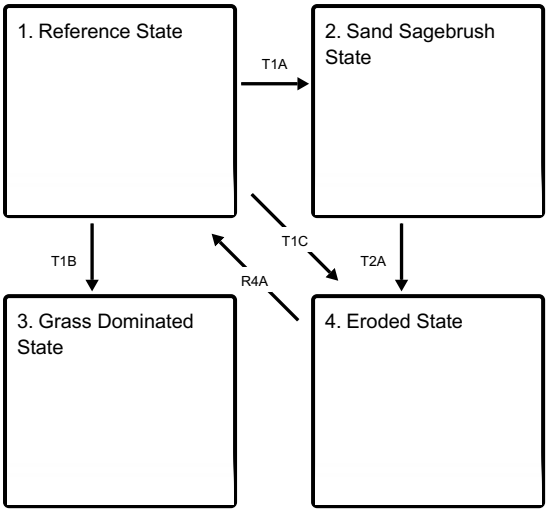
Growth of native cool-season plants begins about April 15 and continues to mid-June. Native warm-season plants begin growth about May 1 and continue to about August 15. Regrowth of cool-season plants occurs in September and October in most years, depending on moisture. For detailed information, visit the Western Regional Climate Center website at https://wrcc.dri.edu/.

Continuous grazing without adequate recovery opportunities following each grazing event during the growing season initially causes blue grama and sand sagebrush to increase. Species such as sand bluestem, yellow Indiangrass, switchgrass, prairie sandreed, western sandcherry, leadplant, and palatable forbs decrease in frequency and production. Brush management (spraying) initially reduces sand sagebrush and other forbs and shrubs. Brush management followed by continuous grazing can eliminate remaining grasses, favoring sagebrush. Prescribed grazing that allows adequate recovery periods following brush management results in a grass-dominated plant community. Long-term non-use, continuous grazing, fire, brush management, or any type of physical disturbance can lead to serious erosion problems on these fragile soils.

Drier and warmer climatic conditions exist in the central portion of MLRA 69. This area includes the eastern half of Pueblo county, northern Otero, extreme northwestern Bent, western edge of Kiowa, southern edge of Lincoln and all of Crowley County. These conditions are primarily caused by a rain shadow effect from the southern Rocky Mountains. Evapotranspiration rates (atmospheric demand) are higher in this area of MLRA 69. Total annual production is typically lower.

## State and transition model

**Ecosystem states**




**T1A** - Continuous heavy grazing. Lack of fire.

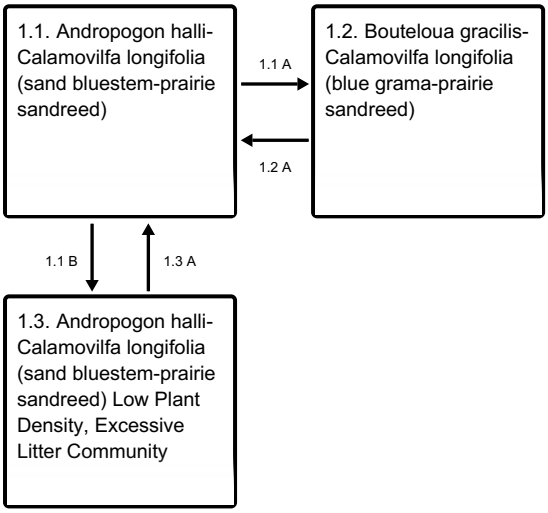
**T1B** - Chemical brush management. Prescribed grazing. Fire.

**T1C** - Non-use. Lack of fire.

**T2A** - Continuous, heavy grazing. Chemical brush control.

**R4A** - Prescribed grazing. Prescribed fire.

**State 1 submodel, plant communities**



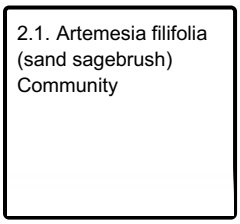

**1.1 A** - Heavy, long-term grazing. Lack of fire.

**1.1 B** - Non-use. Lack of fire.

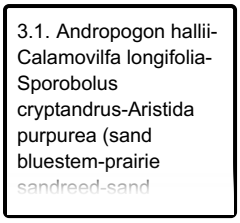
**1.2 A** - Prescribed grazing. Prescribed fire.

**1.3 A** - Prescribed grazing. Prescribed fire.

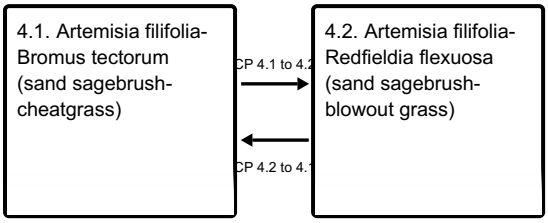
**State 2 submodel, plant communities**



**State 3 submodel, plant communities**




**State 4 submodel, plant communities**




**CP 4.1 to 4.2** - Prescribed grazing. Prescribed burning.

**CP 4.2 to 4.1** - Continuous, heavy grazing. Lack of fire.

## State 1
## Reference State

The Reference State is characterized by three community phases that exist within the natural range of variability for the site. These phases are maintained by a historic fire frequency estimated to be on 15 to 20 year intervals (Guyette and others, 2012) grazing by large ungulates, and adequate recovery periods. High production of perennial grasses and extensive soil cover allow for increased soil moisture retention, vegetative production, and overall soil quality.

### Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- western sandcherry (*Prunus pumila var. besseyi*), shrub
- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass

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

**Figure 8. Reference Plant Community, Kiowa County**

This is the interpretive plant community and is considered to be the reference plant community. This plant community evolved with grazing by large herbivores, is well suited for grazing by domestic livestock, and is in areas that are properly managed with grazing that allows for adequate recovery periods following each grazing occurrence during the growing season. The reference plant community consists chiefly of tall, warm-season grasses. Principal

dominants are sand bluestem, prairie sandreed, and switchgrass. Subdominant grasses include Indiangrass, needle and thread, blue grama, and little bluestem. Significant forbs and shrubs are lemon scurfpea, dotted gayfeather, prairie clovers, leadplant, and western sandcherry. The potential vegetation is about 70 to 85 percent grasses and grass-like plants, 10 to 15 percent forbs, and 5 to 15 percent woody plants. This plant community is well adapted to the Northern Great Plains climatic conditions and is resistant to many disturbances, except continuous grazing, plowing, uncontrolled fire events, and urban as well as other land use development. The diversity in plant species allows for high drought tolerance. Plant litter is properly distributed with very little movement off-site. 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 900 to 2000 pounds of air-dry vegetation per acre per year depending on weather conditions and will average 1500 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 | 768 | 1302 | 1726 |
| Forb | 163 | 211 | 258 |
| Shrub/Vine | 78 | 168 | 258 |
| **Total** | **1009** | **1681** | **2242** |

**Figure 10. Plant community growth curve (percent production by month). CO6905, Warm-season dominant, cool-season sub-dominant; MLRA-69; upland coarse-textured soils.**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 5 | 10 | 22 | 35 | 15 | 10 | 3 | 0 | 0 | 0 |

## Community 1.2
## Bouteloua gracilis-Calamovilfa longifolia (blue grama-prairie sandreed)

This plant community evolves with heavy, continuous grazing without adequate recovery periods between grazing events during the growing season. 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, red threeawn, slimflower scurfpea, hairy goldaster, croton, western ragweed, stickleaf, lupine, loco, and milkvetch have increased. 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, and key shrub components and an increase in warm-season shortgrass have altered the biotic integrity of this plant community. Nutrient cycle, water cycle, and energy flow may be impaired. The production varies from 400 to 1200 pounds of air-dry vegetation per acre per year depending on weather conditions and amount of mid- and tallgrass species still present. Production averages 850 pounds of air-dry vegetation per acre per year.

### Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- western sandcherry (*Prunus pumila var. besseyi*), shrub
- blue grama (*Bouteloua gracilis*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass

**Figure 11. Plant community growth curve (percent production by month). CO6905, Warm-season dominant, cool-season sub-dominant; MLRA-69; upland coarse-textured soils.**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 5 | 10 | 22 | 35 | 15 | 10 | 3 | 0 | 0 | 0 |

## Community 1.3
## Andropogon halli-Calamovilfa longifolia (sand bluestem-prairie sandreed) Low Plant Density, Excessive Litter Community

This plant community results from a lack of grazing for long periods of time in the absence of fire. Plant composition is similar to the reference plant community. In time, however, individual species production and frequency lowers. Much of the nutrients are tied up in excessive litter. The semiarid environment and the absence of animal traffic to break down litter slows nutrient cycling. Aboveground litter also limits sunlight from reaching plant crowns. Many plants, especially bunchgrasses, die off. Thick litter and absence of grazing or fire reduce seed germination and establishment. This plant community changes rapidly with prescribed grazing which allows animal impact and adequate recovery periods between grazing events. Production can vary from 100 to 1000 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). CO6906, Warm-season dominant, cool-season sub-dominant, excess litter; MLRA-69; upland coarse-textured soils.**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 5 | 10 | 25 | 30 | 15 | 10 | 3 | 2 | 0 | 0 |

## Pathway 1.1 A
## Community 1.1 to 1.2

Recurring heavy, seasonal grazing without adequate recovery opportunity between grazing periods moves this plant community toward the 1.2 community. Reduced production and erosion are a concern. Interruption of the historic fire regime exacerbates this process.

## Pathway 1.1 B
## Community 1.1 to 1.3

Non-use and lack of fire shift this plant community to the Low Plant Density, Excessive Litter Plant Community.

## Pathway 1.2 A
## Community 1.2 to 1.1

Prescribed grazing that allows adequate recovery opportunity between grazing events and proper stocking will shift this plant community back to the reference plant community. Appropriately timed prescribed fire accelerates this process.

### Conservation practices

| |
|---|
| Prescribed Burning |
| Prescribed Grazing |

## Pathway 1.3 A
## Community 1.3 to 1.1

Grazing that allows for adequate recovery periods following each grazing event can shift this plant community toward the reference plant community. This transition is driven by the restoration of processes within the natural range of variability for the site and can happen relatively fast. Prescribed fire can also restore this community.

**Conservation practices**

| |
|---|
| Prescribed Burning |
| Prescribed Grazing |

## State 2
## Sand Sagebrush State

The state is dominated by sand sagebrush, resulting in a lack of resilience and resistance to disturbances. Site stability and hydrologic function along with biological diversity are greatly reduced.

**Dominant plant species**

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

## Community 2.1
## Artemesia filifolia (sand sagebrush) Community

This plant community is dominated by sand sagebrush and very little understory. Favorable species that remain are few and are protected by the sagebrush. This plant community develops under long-term continuous grazing, followed by chemical brush management, even if one-season grazing deferment is used. Chemical brush management initially reduces the sagebrush. Spraying may reduce or eliminate other native forbs and shrubs (broadleaf's) during treatment. Continuous grazing (post-treatment) further reduces or eliminates the remaining grasses while sand sagebrush remains. Subsequent brush management treatments where there is no herbaceous understory leave the site susceptible to soil erosion and blowouts, with sand sagebrush persisting. Species diversity and production have dropped substantially. Litter levels are low. Watershed function and carbon sequestration are greatly reduced. Nutrient cycle and energy flow are impaired. Blowouts can form or enlarge rather easily. Flow paths can become connected, and runoff is possible during intense storms. Desertification is obvious. Production can vary from 50 to 800 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
- threeawn (*Aristida*), grass
- blue grama (*Bouteloua gracilis*), grass

**Figure 13. Plant community growth curve (percent production by month). CO6907, Warm-season dominant; MLRA-69; upland coarse-textured soils.**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 5 | 30 | 40 | 20 | 5 | 0 | 0 | 0 | 0 |

## State 3
## Grass Dominated State

This is a state managed to control sand sage and enhance grass dominance. The vegetative community can vary from dominance by prairie sandreed and sand bluestem to sand dropseed and red threeawn.

**Dominant plant species**

- prairie sandreed (*Calamovilfa longifolia*), grass
- sand bluestem (*Andropogon hallii*), grass
- threeawn (*Aristida*), grass

- sand dropseed (*Sporobolus cryptandrus*), grass

## Community 3.1
## Andropogon hallii-Calamovilfa longifolia-Sporobolus cryptandrus-Aristida purpurea (sand bluestem-prairie sandreed-sand dropseed-red threeawn)

This plant community develops with chemical brush management and prescribed grazing. The brush management not only controls the sand sagebrush but may also remove other native (non-targeted) forbs and shrubs. The community can vary from predominately sand dropseed and red threeawn to nearly pure stands of prairie sandreed and sand bluestem. The species and amounts can vary considerably depending on what was present when the brush management was applied, how long ago it was applied, what kind of prescribed grazing was applied, and how long the prescribed grazing was in effect. There is little plant diversity because most of the forbs and shrubs have been eliminated by brush control efforts. Nutrient and water cycling is impaired due to lack of deep-rooted shrubs, forbs, and native, nitrogen fixing legumes. Erosion can vary, depending on production and density of grasses. Production can vary from 250 to 1300 pounds of air-dry vegetation per acre per year depending on the grass species present, their density, and weather conditions.

### Dominant plant species

- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass
- purple threeawn (*Aristida purpurea*), grass

**Figure 14. Plant community growth curve (percent production by month). CO6905, Warm-season dominant, cool-season sub-dominant; MLRA-69; upland coarse-textured soils.**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 5 | 10 | 22 | 35 | 15 | 10 | 3 | 0 | 0 | 0 |

## State 4
## Eroded State

This state consists of shrubs, less-palatable forbs, and annual and early perennial grasses.. Continuous, heavy grazing without providing adequate recovery opportunity following grazing events and lack of fire are the drivers of the process. Blowouts can develop.

### Dominant plant species

- sand sagebrush (*Artemisia filifolia*), shrub
- cheatgrass (*Bromus tectorum*), grass
- blowout grass (*Redfieldia*), grass
- sixweeks fescue (*Vulpia octoflora*), grass

## Community 4.1
## Artemisia filifolia-Bromus tectorum (sand sagebrush-cheatgrass)

This early succession 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. Production can vary greatly depending on the plant density and weather conditions in any year. Cheatgrass, Japanese brome, kochia, Russian thistle, sunflower, pigweed, sixweeks fescue, and annual buckwheat are common. Wind erosion is a concern. Total annual production can vary from 0 to 150 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

## Community 4.2
## Artemisia filifolia-Redfieldia flexuosa (sand sagebrush-blowout grass)

This plant community develops with prescribed grazing from the annuals plant community. Common species include sandhill muhly, blowout grass, Hood's phlox, wormwood sagebrush, and lemon scurfpea. Wind erosion is a resource concern, and blowouts can be present. Total annual production can vary from 50 to 250 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 CP 4.1 to 4.2
## Community 4.1 to 4.2

Prescribed grazing that allows adequate recovery periods between grazing events and appropriately timed prescribed burning move this plant community toward the 4.2 community.

### Conservation practices

| |
|---|
| Prescribed Burning |
| Prescribed Grazing |

## Pathway CP 4.2 to 4.1
## Community 4.2 to 4.1

lack of fire and continuous, heavy grazing without adequate recovery periods following each grazing event move this plant community toward the 4.1 community. Blowout conditions can develop.

## Transition T1A
## State 1 to 2

Continuous, heavy grazing and lack of fire eliminate tallgrasses, palatable forbs, and palatable shrubs, moving this plant community across an ecological threshold to the Sand Sagebrush State. If this treatment continues long enough, accelerated erosion occurs.

## Transition T1B
## State 1 to 3

Chemical brush management, fire, and prescribed grazing move this plant community across an ecological threshold toward the Grass Dominated State. Loss of palatable forbs, native legumes, and palatable shrubs is a concern.

## Transition T1C
## State 1 to 4

Long-term non-use and lack of fire result in increased plant mortality and eventually an increase in bare ground resulting in moving toward the eroded state. This transition may take greater than 25 years to accomplish.

## Transition T2A
## State 2 to 4

Continuous, heavy grazing, chemical brush management, or both trigger accelerated erosion causing this plant community to move to the eroded state. Wind erosion may be a concern. Blowouts can be a common occurrence in

this state.

## Restoration pathway R4A
## State 4 to 1

Prescribed fire, long-term prescribed grazing that allows adequate recovery periods, and proper stocking rate eventually move this plant community toward the reference state, assuming an adequate vegetative source is available. This transition may take greater than 25 years to achieve.

### Conservation practices

| |
|---|
| Prescribed Burning |
| Prescribed Grazing |

## 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 | | | | 1177–1429 | |
| | sand bluestem | ANHA | *Andropogon hallii* | 336–504 | – |
| | prairie sandreed | CALO | *Calamovilfa longifolia* | 252–336 | – |
| | switchgrass | PAVI2 | *Panicum virgatum* | 168–336 | – |
| | Indiangrass | SONU2 | *Sorghastrum nutans* | 84–168 | – |
| | needle and thread | HECOC8 | *Hesperostipa comata ssp. comata* | 84–118 | – |
| | little bluestem | SCSC | *Schizachyrium scoparium* | 50–118 | – |
| | blue grama | BOGR2 | *Bouteloua gracilis* | 50–118 | – |
| | Grass, perennial | 2GP | *Grass, perennial* | 17–84 | – |
| | blowout grass | REFL | *Redfieldia flexuosa* | 17–50 | – |
| | sideoats grama | BOCU | *Bouteloua curtipendula* | 17–50 | – |
| | sand dropseed | SPCR | *Sporobolus cryptandrus* | 17–50 | – |
| | western wheatgrass | PASM | *Pascopyrum smithii* | 17–34 | – |
| | sandhill muhly | MUPU2 | *Muhlenbergia pungens* | 17–34 | – |
| | Indian ricegrass | ACHY | *Achnatherum hymenoides* | 17–34 | – |
| | hairy grama | BOHI2 | *Bouteloua hirsuta* | 17–34 | – |
| | sun sedge | CAINH2 | *Carex inops ssp. heliophila* | 17–34 | – |
| | Schweinitz's flatsedge | CYSC3 | *Cyperus schweinitzii* | 0–34 | – |
| | squirreltail | ELEL5 | *Elymus elymoides* | 0–17 | – |
| | thickspike wheatgrass | ELLAL | *Elymus lanceolatus ssp. lanceolatus* | 0–17 | – |
| | Fendler threeawn | ARPUL | *Aristida purpurea var. longiseta* | 0–17 | – |
| | thin paspalum | PASE5 | *Paspalum setaceum* | 0–17 | – |
| | prairie Junegrass | KOMA | *Koeleria macrantha* | 0–17 | – |
| **Forb** | | | | | |
| 2 | | | | 168–252 | |
| | Forb, perennial | 2FP | *Forb, perennial* | 17–50 | – |
| | othake | PASP | *Palafoxia sphacelata* | 0–34 | – |
| | lemon scurfpea | PSLA3 | *Psoralidium lanceolatum* | 17–34 | – |

| | | | | | |
|---|---|---|---|---|---|
| | silky prairie clover | DAVI | *Dalea villosa* | 17–34 | – |
| | annual buckwheat | ERAN4 | *Eriogonum annuum* | 17–34 | – |
| | shaggy dwarf morning-glory | EVNU | *Evolvulus nuttallianus* | 0–17 | – |
| | phlox heliotrope | HECO5 | *Heliotropium convolvulaceum* | 0–17 | – |
| | stiff sunflower | HEPAP2 | *Helianthus pauciflorus ssp. pauciflorus* | 0–17 | – |
| | hairy false goldenaster | HEVI4 | *Heterotheca villosa* | 0–17 | – |
| | bush morning-glory | IPLE | *Ipomoea leptophylla* | 0–17 | – |
| | common starlily | LEMO4 | *Leucocrinum montanum* | 0–17 | – |
| | dotted blazing star | LIPU | *Liatris punctata* | 0–17 | – |
| | rush skeletonplant | LYJU | *Lygodesmia juncea* | 0–17 | – |
| | tenpetal blazingstar | MEDE2 | *Mentzelia decapetala* | 0–17 | – |
| | Colorado four o'clock | MIMU | *Mirabilis multiflora* | 0–17 | – |
| | whitest evening primrose | OEAL | *Oenothera albicaulis* | 0–17 | – |
| | crownleaf evening primrose | OECO2 | *Oenothera coronopifolia* | 0–17 | – |
| | Carolina larkspur | DECAV2 | *Delphinium carolinianum ssp. virescens* | 0–17 | – |
| | painted milkvetch | ASCEF | *Astragalus ceramicus var. filifolius* | 0–17 | – |
| | groundplum milkvetch | ASCR2 | *Astragalus crassicarpus* | 0–17 | – |
| | Texas croton | CRTE4 | *Croton texensis* | 0–17 | – |
| | white prairie clover | DACA7 | *Dalea candida* | 0–17 | – |
| | nineanther prairie clover | DAEN | *Dalea enneandra* | 0–17 | – |
| | purple prairie clover | DAPUP | *Dalea purpurea var. purpurea* | 0–17 | – |
| | upright prairie coneflower | RACO3 | *Ratibida columnifera* | 0–17 | – |
| | white heath aster | SYERE | *Symphyotrichum ericoides var. ericoides* | 0–17 | – |
| | prairie spiderwort | TROC | *Tradescantia occidentalis* | 0–17 | – |
| | meadow deathcamas | ZIVE | *Zigadenus venenosus* | 0–17 | – |
| | gilia beardtongue | PEAM | *Penstemon ambiguus* | 0–17 | – |
| | prostrate pigweed | AMAL | *Amaranthus albus* | 0–17 | – |
| | Cuman ragweed | AMPS | *Ambrosia psilostachya* | 0–17 | – |
| | tarragon | ARDR4 | *Artemisia dracunculus* | 0–17 | – |
| | white sagebrush | ARLU | *Artemisia ludoviciana* | 0–17 | – |
| | crested pricklypoppy | ARPO2 | *Argemone polyanthemos* | 0–11 | – |
| | snowball sand verbena | ABFR2 | *Abronia fragrans* | 0–11 | – |
| | broadbeard beardtongue | PEAN4 | *Penstemon angustifolius* | 0–11 | – |
| | sanddune cryptantha | CRFE3 | *Cryptantha fendleri* | 0–11 | – |
| **Shrub/Vine** | | | | | |
| 3 | | | | 84–252 | |
| | western sandcherry | PRPUB | *Prunus pumila var. besseyi* | 34–84 | – |
| | leadplant | AMCA6 | *Amorpha canescens* | 34–84 | – |
| | sand sagebrush | ARFI2 | *Artemisia filifolia* | 17–84 | – |
| | Shrub (>.5m) | 2SHRUB | *Shrub (>.5m)* | 17–50 | – |

| | | | | | |
|---|---|---|---|---|---|
| | soapweed yucca | YUGL | *Yucca glauca* | 0–34 | – |
| | skunkbush sumac | RHTR | *Rhus trilobata* | 0–17 | – |
| | prairie rose | ROAR3 | *Rosa arkansana* | 0–17 | – |
| | spreading buckwheat | EREF | *Eriogonum effusum* | 0–17 | – |
| | plains pricklypear | OPPO | *Opuntia polyacantha* | 0–17 | – |

## 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.

Reference Plant Community:
The grasses, forbs, and shrubs in this plant community provide habitat for reptiles such as western rattlesnake and bullsnake. The structural diversity in the plant community on this site provides habitat for Cassin's and Brewer's sparrow, lark bunting, scaled quail, and ferruginous and Swainson's hawks. The combination of mid-tall grasses and shrubs provides habitat for lesser prairie chicken in the eastern part of this ecological site. Small mammals, such as white-tailed jackrabbit, badger, swift fox, and several species of mice, are common in this plant community. Pronghorn is a typical ungulate in this community.

1.2, 1.3 Plant Communities:
As these communities develop into an open landscape, the wildlife species shift away from reference plant community species and toward the species that prefer unvegetated areas and short plants. Texas short-lizard, six-lined racerunner, and black-tailed jackrabbit would be expected more frequently here than in the reference community. In addition, mountain plover, black-tailed prairie dog, and burrowing owl might use these communities where slopes are less than five percent and vision is unobstructed.

State 2 Plant Communities:
Species typically associated with sand sagebrush communities are eastern fence lizard, scaled quail, lesser prairie chicken, pronghorn, and mule deer. These species would be expected in these plant communities in all or parts of MLRA 69.

Grass Dominated State:
This plant community can be quite variable. The wildlife species expected here would be those listed for the plant community most similar to this 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.

Plant Community Production (lbs./acre) and Stocking Rate (AUM/acre)
Reference Plant Community - (1500) (0.41)
Community 1.1 - (850) (0.23)

The vegetative production for the remaining communities is highly variable.

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.

All recommendations are guidelines. Actual stocking rates should be determined on-site.

## 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. 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 & 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 are 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 are complete to Provisional level.
NOTE: Annual Production Table and Species Composition List are from the “Previously Approved” ESD (2004). These need review for future updates at the next Approved level. Minor edit was made to Species Composition List.

Each Alternative State/Community:Complete to Provisional level. Narrative for each state and community has been updated.

Action Item: Need to find supporting data for The Sand Sagebrush and Grass Dominant Plant Communities. Further group discussion is needed.

Supporting Information (Site Interpretations, Assoc. & Similar Sites, Inventory Data References, Agency/State Correlation, References):
Updated. All “Required” items are complete to Provisional level.

Animal Community Wildlife Interpretations:First “overview” paragraph retained.
Individual Plant Community phase interpretations are removed and need to be updated at next “Approved” level.

Livestock Interpretations:
Updated to reflect the plant community name revisions. The Stocking rate calculations remain the same because they are based on the “Legacy” Total Annual Production table.
The stocking rate calculations need to be updated when Total Annual Production and Plant Community annual production is revised at the next “Approved” level.

Hydrology:
From “Previously Approved” ESD (2004). This needs to be updated at next “approved” level.

Other Site Interpretation:
Recreational Uses, Wood Products, Other Products, and Plant Preferences table, and Rangeland Health Reference Sheet carried over from “Previously Approved” ESD (2004).

Rangeland Health Reference Sheet:
From “Previously Approved” ESD (2004). This needs to be updated at the “Approved” level. Note: Deep Sand ESD is not in LRU C.

“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 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 Association LandtypeLandtype 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, % 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.

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## Other references

Data collection for this ecological site was done in conjunction with the progressive soil surveys within the Upper Arkansas Valley (MLRA 69) of Colorado. The site has been mapped and correlated with soils in the following soil surveys: Baca County, Bent County, Crowley County, El Paso County Area, Fremont County Area, Huerfano County Area, Kiowa County, Las Animas County: Parts of Huerfano and Las Animas, Lincoln County, Otero County, Prowers County, and Pueblo Area: Parts of Pueblo and Custer Counties.

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Those involved in developing earlier versions of this site description include: Ben Berlinger, rangeland management specialist (RMS); Scott Woodall, RMS; Lee Neve, soil scientist; Julie Elliott, RMS; Terri Skadeland, Colorado State biologist; and Herman Garcia, Colorado State RMS.

## 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) | Ben Berlinger, Kimberly Diller, Daniel Nosal |
| Contact for lead author | Ben Berlinger, Area Rangeland Management Specialist, La Junta, CO, |
| Date | 01/12/2005 |
| Approved by | Rachel E. Murph, State Rangeland Management Specialist |
| 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 present, water flow patterns are broken, irregular in appearance, or discontinuous with numerous debris dams or vegetative barriers, usually following intense rainfall events.

3. **Number and height of erosional pedestals or terracettes:** Pedestalled plants caused by wind erosion are minor. Terracettes are nonexistent.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** The site has 3 percent or less bare ground, with bare patches ranging from 3-5 inches in diameter. Prolonged drought or wildfire events cause bare ground to increase upwards to 10-15 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:** Minor wind scouring naturally occurs on knolls. An increase in wind erosion can result from disturbances, such as wildfire, extended drought, and rodent activity.

7. **Amount of litter movement (describe size and distance expected to travel):** Litter should be 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 storm.

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 1-3 percent. Soils are very deep, pale brown, weak coarse granular to crumbly structure, at a 0-5 inch depth.

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 bunch grass >>

    Sub-dominant: Warm-season, tall rhizomatous > shrubs > warm-season, mid bunchgrass = cool-season, mid bunchgrass > warm season short bunchgrass >

    Other: Leguminous forbs > warm-season forbs > cool-season forbs > warm-season, mid rhizomatous > cool-season, mid rhizomatous

    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/decadence during and following drought.

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

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 900 lbs/ac low precipitation years; 1500 lbs/ac average precipitation years; 2000 lbs/ac high precipitation years. After extended drought or the first growing season following wildfire, production may be significantly reduced by 300 – 600 lbs/ac).

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 fire or extended drought, Russian thistle, kochia, Rocky Mountain beeplant may invade assuming a seed source is available.

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