USDA Natural Resources
Conservation Service

Ecological site R065XY011NE
Sandy 14-17" PZ

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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.

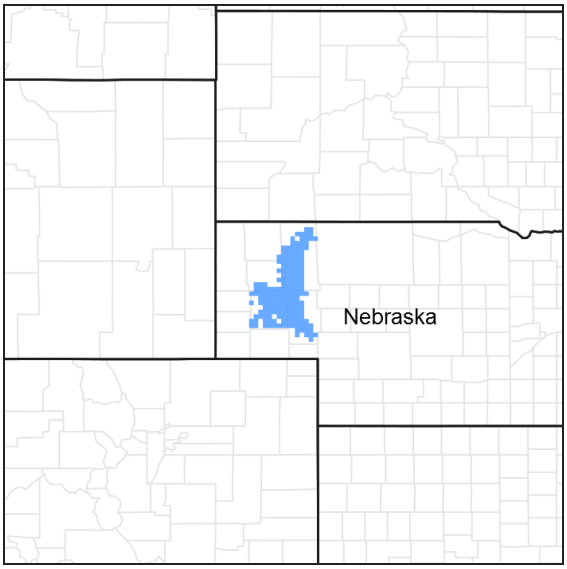


Figure 1. Mapped extent

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): 065X–Nebraska Sand Hills

The Nebraska Sand Hills (MLRA 65) is located in Nebraska (98 percent) and South Dakota (2 percent) and encompasses approximately 13.2 million acres (534,201 hectares) or 20,625 square miles (53,420 square kilometers). The largest town in the MLRA is North Platte, Nebraska and numerous small towns and villages are located within the MLRA, including the county seats of Arthur, Bartlett, Bassett, Brewster, Greeley, Hyannis, Mullen, Thedford, and Tryon, Nebraska. The Niobrara River is near the northern boundary while the North Platte River flows along the southwest boundary of the area. The North Loup, Middle Loup, Calamus, Snake, and Dismal Rivers and Long Pine Creek occur in the central and eastern portion of the area.

Fort Niobrara, Crescent Lake, and Valentine National Wildlife Refuges and portions of the Nebraska National Forest, including the Bessey Ranger District and Samuel R. McKelvie National Forest, are located within this MLRA. The Bessey Ranger District includes the largest human-planted forest in the United States and is home to the Bessey Tree Nursery which is listed on the National Register of Historic Places.

This MLRA is defined by an 8,000 year-old landscape of sand hills dominated by rolling to steep sand dunes with narrow, elongated, nearly level to steeply sloping valleys between the dunes. Dune heights range from 10 to 400 feet (3 to 130 meters) and slopes may exceed twenty-five percent. Dune complexes often extend for several miles in a northwest to southeast direction. These Quaternary sand dunes are derived from the underlying Tertiary

Ogallala and Arikaree Groups, which formed when rivers deposited sediments from erosional detritus after the uplift of the Rocky Mountains to the west. The Nebraska Sand Hills are the largest sand dune area in the Western Hemisphere and one of the largest grass-stabilized dune regions in the world. The soils of the MLRA are principally derived from deep eolian sand.

The Ogallala aquifer underlies the MLRA and is the most extensive and heavily used aquifer of the high plains between the Rocky Mountains and Mississippi River. The aquifer is at its thickest in the Sand Hills which are a primary recharge are for the aquifer. Numerous small permanent and intermittent lakes and wetlands occur in the MLRA. While the dominant source of water for these lakes is precipitation, groundwater discharge is important to maintaining these lakes especially in drier years. A number of these lakes, especially in the western portion of the MLRA are alkaline.

Considered to be a western extension of the tallgrass prairie, the matrix vegetation is a unique mix of species that is sometimes identified as Sandhills Prairie. Sand bluestem, prairie sandreed, Indiangrass, switchgrass, sand lovegrass, little bluestem, and needle and thread are the primary grasses. Porcupinegrass is a significant cool-season grass in the eastern portion of the MLRA while blue grama and hairy grama are important warm-season grasses in the western portion due to differences in precipitation. Soils which have a high water table support a tallgrass prairie dominated by big bluestem, switchgrass, Indiangrass, prairie cordgrass, and a variety of grass-likes. The endangered plant blowout penstemon (Penstemon haydenii) is found in this MLRA.

More than ninety percent of the land in MLRA 65 is native grassland utilized by grazing livestock. Areas along streams and in subirrigated valleys are utilized for prairie hay. Wetlands, legume hay, and irrigated cropland make up the balance of the land area with corn being the principal irrigated crop.

Wildlife flourishes in this native grassland environment. Historically large bison herds occupied the landscape. White-tailed deer, mule deer, pronghorn, black tailed jackrabbit, and coyote are now the major mammalian species. Upland sandpiper, lark bunting, grasshopper sparrow, western meadowlark, long-billed curlew, sharp-tailed grouse, and greater prairie chicken are common avian species. The mosaic of grassland and wetlands provide excellent habitat for wading and shorebird species as well.

This landscape serves as a backdrop for a disturbance-driven ecosystem, which developed under the influences of herbivory, fire, and periodic long-term drought. Historically, these processes created a heterogeneous mosaic of plant communities and vegetative structure across the region. Any given site in this landscape experienced fire every six to ten years. Fires were caused by lightning strikes and also were set by Native Americans, who used fire for warfare, signaling, and to refresh the native grasses. Indigenous peoples understood the value of fire as a tool and that the highly palatable growth following a fire provided excellent forage for their horses and attracted grazing animals such as bison, elk, and pronghorn.

The natural fire regime has been disrupted by aggressive fire suppression policies which have facilitated woody species encroachment by both native and introduced shrubs and trees into the native prairie. The most common encroacher is eastern redcedar. While eastern redcedar is native to the landscape, it was present only in trace amounts due to the periodic fires. Widespread plantings of windbreaks with eastern redcedar as a primary component have provided a seed source for this aggressive woody plant causing encroachment into native grasslands, especially in the eastern and central Sand Hills. This encroachment causes significant forage loss for domestic livestock and degrades the native wildlife habit. Since it is not a root-sprouter, eastern redcedar is very susceptible to fire when under six feet tall making management with prescribed fire very effective when applied before trees reach this stage.

Classification relationships

►EPA Ecoregions (Omernik 1997)◄
I – Great Plains (9)
II – West-Central Semi-Arid Prairies (9.3)
III – Nebraska Sandhills (44)
IV – Sandhills (44a), Alkaline Lakes Area (44b), Wet Meadow and Marsh Plain (44c), Lakes Area (44d)

►Fenneman (1916) Physiographic Regions ◄
Division – Interior Plains

Province – Great Plains
Section – High Plains

►USDA-USFS (2007) Ecoregions◄
Domain – Dry
Division – Temperate Steppe
Province – Great Plains Steppe (332)
Section – Mixed Grass Steppe

►USDA-NRCS (2022)◄
Land Resource Region – G, Central Feed Grains and Livestock Region
Major Land Resource Area (MLRA) –65, Nebraska Sand Hills

Ecological site concept

There is a significant decline in precipitation from east to west across MLRA 65 which impacts plant community composition and annual production. For the purpose of ecological site development, the Sandy ecological site is divided into three ecological sites to address this precipitation gradient and its impacts to the site. The Sandy 14-17" precipitation zone (PZ) typically occurs west of a line that extends from central Garden County, Nebraska to Ellsworth, Nebraska, to central Sheridan County.

The Sandy 14-17" PZ ecological site is a run-off site that occurs on interdunes. Slopes are 3 percent or less. The soils are very deep, somewhat excessively drained, and formed in eolian sand. Surface and subsoil textures are typically loamy fine sand. The surface layer is at least 7 inches thick.

The historic native vegetation of the Sandy 14-17" PZ ecological site is Sandhills Prairie. Vegetation in the Reference Plant Community (1.1) consists of a mixture of warm-season tall- and midgrasses and cool-season grasses. The dominant grasses are sand bluestem, prairie sandreed, and needle and thread. The plant community includes a diverse population of forbs. Shrubs typically found include sand sagebrush, prairie sagewort, and rose. In the absence of fire and woody species management the Sandy 14-17" PZ ecological site is susceptible to encroachment by woody species, especially eastern red cedar.

Associated sites

R065XY012NE	**Sands 14-17" PZ** The Sands 14-17" PZ ecological site is often found adjacent to, but on a higher landscape position from the Sandy 14-17" PZ ecological site.
R065XY029NE	**Sandy Lowland** The Sandy Lowland ecological site is often found adjacent to, but on a lower landscape position from the Sandy 14-17" PZ ecological site.

Similar sites

R065XY012NE	**Sands 14-17" PZ** Sands 14-17" PZ and Sandy 14-17" PZ ecological sites occur in the sandhills landscape, and the soils of both sites are similar. Soil surface textures of Sandy 14-17" PZ sites are loamy fine sand, and the soils have a dark surface layer that is more than seven inches thick. Soil surface textures of Sands 14-17" PZ sites are fine sand and loamy fine sand, and the soils have a dark surface layer that is less than seven inches thick.
R065XY029NE	**Sandy Lowland** Sandy Lowland and Sandy 14-17" PZ ecological sites occur in the sandhills landscape, and the soils of both sites are similar. Soil surface textures of Sandy 14-17" sites are loamy fine sand and there is not a season high water table. Soil surface textures of Sandy Lowland sites are fine sandy loam to fine sand and there is a seasonal high-water table at 36 to 60 inches.

Table 1. Dominant plant species

Tree	Not specified

Shrub	Not specified
Herbaceous	(1) *Andropogon hallii* (2) *Calamovilfa longifolia*

Physiographic features

The Sandy 14-17" PZ ecological site is found in the sand hills landscape on interdunal landforms. This area consists of Quaternary sand dunes. The sands are derived from the underlying Tertiary Ogallala and Arikaree Groups. These units formed when rivers deposited sediments that originated as erosional detritus following the uplift of the Rocky Mountains to the west.

Table 2. Representative physiographic features

Landforms	(1) Sandhills > Interdune
Runoff class	Negligible
Flooding frequency	None
Ponding frequency	None
Elevation	600–1,201 m
Slope	0–3%
Water table depth	152 cm
Aspect	Aspect is not a significant factor

Climatic features

The mean average annual precipitation in the western portion of this MLRA is typically 14 to 17 inches but has varied from 12 to 20 inches in the driest to wettest season. Approximately 70 percent of the annual precipitation occurs during the growing season from mid-April to late September. The average annual snowfall varies from about 34 inches to about 42 inches. The wind velocity is high throughout the year, averaging 10 to 12 miles per hour. Maximum wind velocities generally occur in the spring.

The average date of first frost in the fall is September 25, and the last frost in the spring is about May 8. July is the hottest month and January is the coldest. It is not uncommon for the temperature to reach 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 with temperatures dropping to as low as negative 30 degrees Fahrenheit.

Growth of native cool-season plants begins in late March and continues to late June. Native warm-season plants begin growth in mid-May and continue to late August. Green up of cool-season plants may occur in September and October when adequate soil moisture is present.

Table 3. Representative climatic features

Frost-free period (characteristic range)	97-111 days
Freeze-free period (characteristic range)	126-133 days
Precipitation total (characteristic range)	432-457 mm
Frost-free period (actual range)	94-116 days
Freeze-free period (actual range)	124-135 days
Precipitation total (actual range)	406-457 mm
Frost-free period (average)	104 days
Freeze-free period (average)	130 days
Precipitation total (average)	432 mm

Climate stations used

- (1) ALLIANCE MUNI AP [USW00024044], Alliance, NE
- (2) CRESCENT LAKE NWR [USC00252000], Oshkosh, NE
- (3) ELLSWORTH 15 NNE [USC00252647], Ellsworth, NE

Influencing water features

None

Soil features

The soils associated with the Sandy 14-17" PZ site very deep, somewhat excessively drained, and formed in eolian sand. Slopes range from 0 to 3 percent. The soil surface texture is typically loamy fine sand and subsurface soil textures are sand, fine sand, or loamy fine sand. The A horizon is typically 10 to 19 inches and soils have a dark surface layer that is more than 7 inches thick.

Runoff is generally low due to the moderate to low slope gradient and the high intake rate of these soils. Rills and gullies should not be present. Water flow patterns, if present, are barely distinguishable. Some pedestalling of plants may occur but are not evident on casual observation and occur on less than 5 percent of the plants. Litter typically falls in place and signs of movement are uncommon. Chemical and physical crusts are rare to not present. Cryptobiotic crusts are present, typically covering 1 to 2 percent of the soil surface.

The major soil series correlated to the Sandy 14-17" PZ ecological site is Dunday. Additional information can be found in the various soil survey reports. Contact the local USDA Service Center for soil survey reports that include more details specific to your location or visit Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov).

Table 4. Representative soil features

Parent material	(1) Eolian sands
Surface texture	(1) Loamy fine sand
Family particle size	(1) Sandy
Drainage class	Somewhat excessively drained
Permeability class	Rapid
Soil depth	203 cm
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-101.6cm)	8.13–11.18 cm
Calcium carbonate equivalent (0-101.6cm)	0%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	6.1–7.3
Subsurface fragment volume <=3" (Depth not specified)	0%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

Sandy 14-17" PZ ecological sites developed under Northern Great Plains climatic conditions, light to severe grazing by bison and other large herbivores, sporadic natural or man-caused fire, and other biotic and abiotic factors that typically influence soil and site development. This continues to be a disturbance-driven site with herbivory, fire, and variable climate being the primary disturbances. Changes occur in the plant communities due to short-term weather variations, impacts of native and exotic plant and animal species, and management actions.

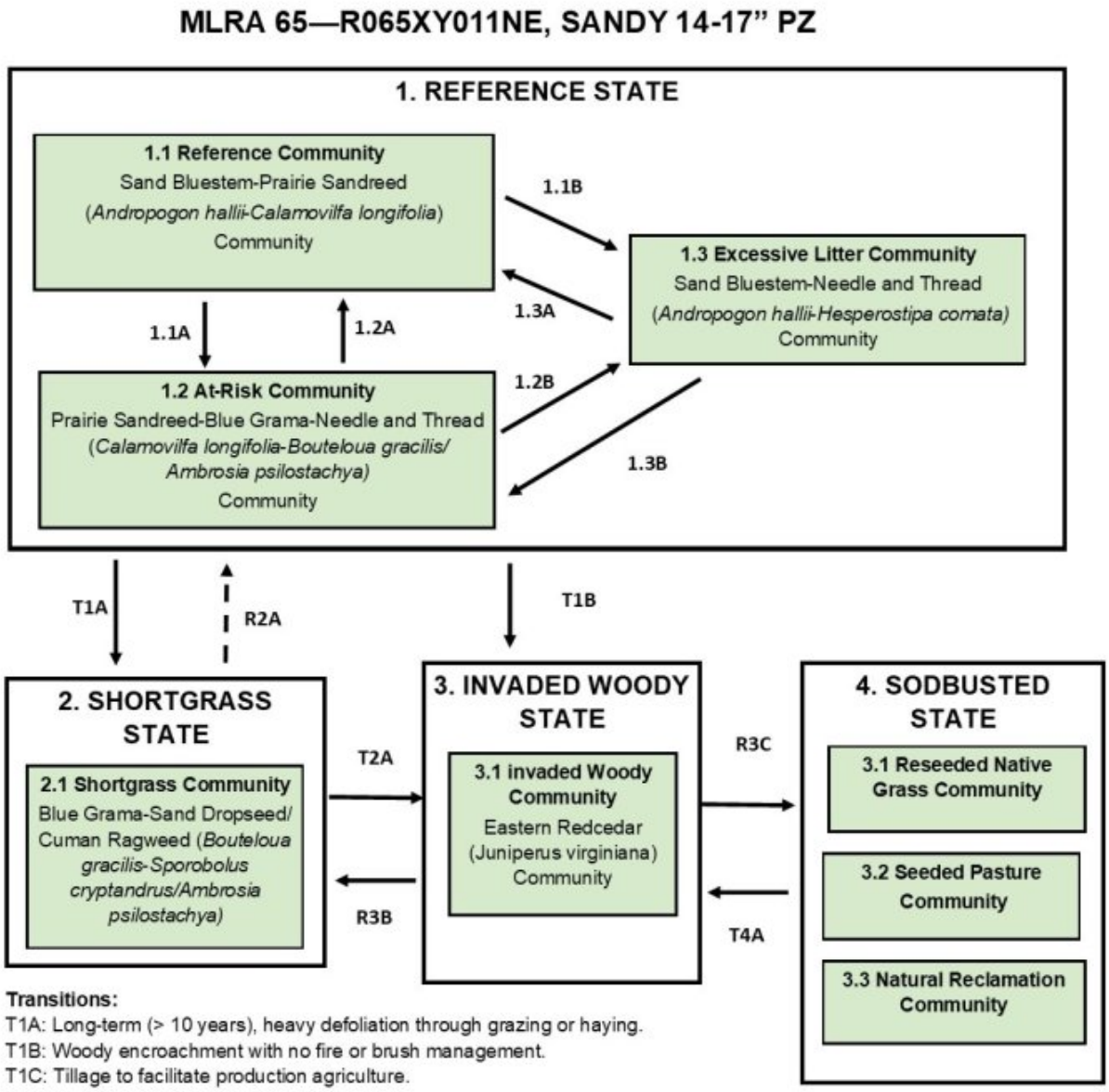
Historically, large areas of blowing sand resulted in the active movement of the sand dunes. Evaporation from the soil surface was extremely high due to the large areas of bare ground, lack of litter, and sparse plant populations. The transpiration rate of these sparse plant populations was also high due to the harsh soil environment. Occasional wildfires, severe grazing by transient bison herds, and drought contributed to instability of the sand dunes causing the dunes to fluctuate through multiple stages of plant succession over time. Early perennial plants such as sandhill muhly, blowout grass, and blowout penstemon were common due to their ability to tolerate the movement of the sand and droughty conditions. As these plants began to colonize and stabilize the sand movement, other perennials such as prairie sandreed, sand bluestem, hairy grama, lemon scurfpea, and rose slowly became evident on the site. Annual plants such as sandbur, woolly Indianwheat, annual buckwheat, and prairie sunflower eventually colonized the areas between the perennials. The plant diversity allows for high resistance to drought. The site is extremely resilient, and well adapted to Northern Great Plains climatic conditions.

The introduction of domestic livestock by European settlers along with season-long, continuous grazing had a profound impact on the vegetation of the Sandy 14-17" PZ ecological site. Season-long, continuous grazing causes a repeated removal of the growing point and excessive defoliation of the leaf area of the more palatable warm-season tallgrasses, reducing the ability of the plants to harvest sunlight thereby depleting root reserves and subsequently decreasing root mass. The ability of the plants to compete for nutrients is impaired, resulting in decreased vigor and eventual mortality. Species that evade negative grazing impacts through mechanisms such as a growing season adaptation (i.e., cool-season), growing points located near the soil surface, a shorter structure, or reduced palatability will increase. As this site deteriorates, sand bluestem and prairie sandreed decrease in frequency and production while needle and thread and blue grama increase. As this management continues, needle and thread and other palatable cool-season grasses decrease. . In the absence of periodic fire this site is susceptible to encroachment by woody species, especially eastern red cedar.

The State and Transition Model (STM) is depicted below and includes a Reference State (1), a Shortgrass State (2), and an Invaded Woody State (3), and a Sodbusted State (4). Each state represents the crossing of a major ecological threshold due to the alteration of the functional dynamic properties of the ecosystem. The primary properties observed to determine this change are soil stability, vegetative communities, and the hydrologic function. Each state may have one or more plant communities that fluctuate in species composition and abundance within the normal parameters of the state. Within each state, communities may degrade or recover in response to natural and man caused disturbances such as variation in the degree and timing of herbivory, presence or absence of fire, and climatic and local climatic fluctuations especially in the precipitation regime. The processes that cause the movement between the states and communities are discussed in more detail in the state and community description following the model diagram.

Interpretations are primarily based on the Reference Community (1.1), which has been determined by study of rangeland relic areas, areas protected from excessive disturbance, and areas under long-term rotational grazing regimes. Trends in plant community dynamics ranging from heavily grazed to lightly grazed areas, seasonal use pastures, and historical accounts have been used as well. Plant communities, states, transitional pathways, and thresholds have been determined through similar studies and experience.

State and transition model



Transitions:

T1A: Long-term (> 10 years), heavy defoliation through grazing or haying.
T1B: Woody encroachment with no fire or brush management.
T1C: Tillage to facilitate production agriculture.
T2A: Woody encroachment with no fire or brush management.
T2B: Tillage to facilitate production agriculture.
T4A: Woody encroachment with no fire or brush management.

Restorations:

R2A: Long-term (> 15 years) prescribed grazing with adequate growing season recovery time. This restoration may not be feasible.
R3A: Prescribed burning, timber harvest, brush management.
R3B: Prescribed burning, timber harvest, brush management.
R3C: Prescribed burning, timber harvest, brush management.

Community Pathways:

1.1A: Continuous season long, continuous seasonal, or rotational grazing with inadequate growing season recovery time or haying with inadequate recovery time.
1.1B: Prolonged absence (> 5 years) of grazing, haying, and no fire.
1.2A: Prescribed grazing or haying, with adequate growing season recovery periods..
1.2B: Prolonged absence (> 5 years) of grazing, haying, and no fire.
1.3A: Prescribed grazing, prescribed burning.
1.3B: Prescribed grazing, prescribed burning.

Figure 8. State and Transition Model Diagram, Sandy 14-17" PZ Ecological Site, MLRA 65.

State 1
Reference State

The Reference State (1) describes the range of vegetative communities that occur on the Sandy 14-17" PZ ecological site where the range of natural variability under historic conditions and disturbance regimes is mostly intact. The Reference State developed under the combined influences of climatic conditions, periodic fire activity, grazing by large herbivores, and impacts from small mammals and insects. High perennial grass cover and production allows for increased soil moisture retention, vegetative production and overall soil quality. Natural fire played a significant role in the succession of this site by limiting the extent of shrubs. Wildfires have been actively controlled in recent times, reducing plant species diversity, especially forb diversity. The Reference State includes three community phases which are the Reference Community (1.1), the At-Risk Community (1.2) and the Excessive Litter Community (1.3), The Reference Community serves as a description of the native plant community that naturally occurs on the site when the natural disturbance regimes are intact or closely mimicked by management practices. The At-Risk Community results from management actions that are unfavorable for a healthy Reference Community. The Excessive Litter Community occurs when herbivory and fire are eliminated from the landscape.

Dominant plant species

- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass
- blue grama (*Bouteloua gracilis*), grass

Community 1.1
Reference Community

Interpretations are primarily based on the Reference or Sand Bluestem-Prairie Sandreed (*Andropogon hallii-Calamovilfa longifolia*) Community (1.1). This plant community serves as a description of the native plant community that occurs on the site when the historic disturbance regimes are intact or are closely mimicked by management practices. This phase is dynamic, with fluid relative abundance and spatial boundaries between the dominant structural vegetative groups. These fluctuations are primarily driven by different responses of the species to fire and grazing events and to changes in precipitation timing and abundance. This site developed with grazing by large herbivores and is well suited for grazing by domestic livestock. This plant community can be found on areas that are managed with prescribed grazing, prescribed burning, and may be found on areas receiving occasional periods of short-term rest. This plant community consists primarily of warm-season, tall- and midgrasses. Sand bluestem and prairie sandreed are the dominant grasses. Grasses of secondary importance include needle and thread, little bluestem, switchgrass, and blue grama. Sedges occur in the understory. Forbs typically include stiff sunflower, bractless blazing star, scurfpeas, and beardtongues. Sand sagebrush, prairie sagewort, and rose are common shrubs. The potential vegetative composition is 80 to 90 percent grasses, 5 to 10 percent forbs, and 1 to 10 percent shrubs by weight. This resilient community is well adapted to the Northern Great Plains climatic conditions. Plant diversity promotes strong drought tolerance, site and soil stability, a functional hydrologic cycle, and a high degree of biotic integrity. These factors create a suitable environment for a healthy and sustainable plant community.

Dominant plant species

- big bluestem (*Andropogon gerardii*), 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	1676	1855	2365
Forb	101	157	219
Shrub/Vine	17	118	219
Total	**1794**	**2130**	**2803**

Figure 10. Plant community growth curve (percent production by month). NE6534, NE/SD Sandhills, Native Grasslands. Warm-season dominant, cool-season subdominant, mid- and tallgrasses.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		5	5	15	25	30	10	7	3		

Community 1.2
At-Risk Community

The At-Risk or Prairie Sandreed-Blue Grama-Needle and Thread (*Calamovilfa longifolia-Bouteloua gracilis-Hesperostipa comata*) Community (1.2) develops with continuous seasonal grazing, continuous season-long grazing, or rotational grazing with inadequate growing season recovery time. As compared to the Reference Community (1.1), species diversity is reduced due to continued defoliation of warm-season tall- and midgrasses during their critical growth periods. While both sand bluestem and prairie sandreed are reduced, prairie sandreed remains a dominant species. Blue grama and needle and thread have significantly increased in abundance. Prairie sandreed, blue grama, and needle and thread are the dominant grasses. Grasses or grass-like plants of secondary importance include sand bluestem and sand dropseed. Blue grama has increased due to its ability to withstand heavy grazing. Cuman ragweed, prairie spiderwort, and scurfpeas are frequent forbs. Pricklypears, sand sagebrush, and prairie sagewort are common shrubs. The potential vegetative composition ranges from 80 to 90 percent grasses or grass-like plants, 5 to 10 percent forbs, and 1 to 10 percent shrubs. With heavy, continuous, season long grazing or with the continuation of the management that caused this community to develop, warm-season tall- and midgrasses and cool-season bunch grasses will be further reduced. Warm-season shortgrasses will increase. With this shift in species composition and the resulting impacts to soils and hydrology, the community will be at risk of crossing an ecological threshold and transitioning to the Shortgrass State (2).

Dominant plant species

- prairie sandreed (*Calamovilfa longifolia*), grass
- blue grama (*Bouteloua gracilis*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass

Table 6. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1423	1597	2096
Forb	17	101	185
Shrub/Vine	17	95	185
Total	**1457**	**1793**	**2466**

Figure 12. Plant community growth curve (percent production by month). NE6534, NE/SD Sandhills, Native Grasslands. Warm-season dominant, cool-season subdominant, mid- and tallgrasses.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		5	5	15	25	30	10	7	3		

Community 1.3
Excessive Litter Community

The Excessive Litter or Sand Bluestem-Needle and Thread (*Andropogon hallii-Hesperostipa comata*) Community (1.3) develops when the natural disturbances of livestock grazing and fire have been removed from the land for a prolonged period (more than five years). Plant litter accumulates rapidly. As the undisturbed duff layer deepens, infiltration of precipitation is interrupted and evaporation increases significantly, simulating drought-like conditions. Bunchgrasses develop dead centers and rhizomatous grasses form small colonies due to a lack of tiller stimulation. Plant frequency and production decrease. Pedestalling is usually evident. As grazing and fire continue to be excluded from the land, litter levels will increase to the point that few plants remain. As the accumulated litter decays, large areas of bare ground will develop, and non-native grasses will begin to invade the plant community. Sand bluestem and needle and thread are the dominant grasses. Other grasses present may include prairie sandreed, sand dropseed, switchgrass, and prairie Junegrass. The dominant forbs typically include Cuman

ragweed and annual sunflower. The dominant shrubs present include rose and sand sagebrush. The potential vegetative composition is 85 to 95 percent grasses and grass-likes, 1 to 10 percent forbs, and 1 to 5 percent shrubs. As compared to the Reference Community (1.1), plant diversity has decreased. Plants occur in individual colonies. A high amount of litter covers the soil between widely dispersed mature plants. As the litter layer thickens, the health and vigor of native, warm-season, tall- and midgrasses declines. Soil erosion and runoff are not significantly different from that of the Reference Community. Infiltration of precipitation has decreased, and evaporation has increased reducing the amount of soil moisture. This plant community will change rapidly when grazing by domestic livestock or fire are reintroduced. If the intensity and duration of the disturbance is inadequate, the plant community will easily return to the Excessive Litter Community.

Dominant plant species

- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass

Table 7. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1311	1642	1737
Forb	17	95	185
Shrub/Vine	17	56	95
Total	**1345**	**1793**	**2017**

Figure 14. Plant community growth curve (percent production by month). NE6536, NE/SD Sandhills, Native Grass, Non-Use. Warm-season dominant, cool-season subdominant, excessive litter.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	5	15	20	20	20	10	7	3	0	0

Pathway 1.1A
Community 1.1 to 1.2

Grazing management that includes continuous season long grazing, continuous seasonal grazing, or rotational grazing with inadequate growing season recovery time will move the Reference Community (1.1) to the At-Risk Community (1.2). Continued annual haying will also cause this shift.

Pathway 1.1B
Community 1.1 to 1.3

Prolonged (greater than five years) absence of the natural disturbances of herbivory and fire will move the Reference Community (1.1) to the Excessive Litter Community (1.3).

Pathway 1.2A
Community 1.2 to 1.1

At-Risk Community (1.2) can return to the Reference Community (1.1) with implementation of prescribed grazing with adequate growing season recovery time between grazing events. Grazing in the spring or fall with deferment during the rapid growth period of warm-season tallgrasses will accelerate this change in plant community. When the land is utilized as hayland, haying every other year will facilitate the return to Reference Community.

Pathway 1.2B
Community 1.2 to 1.3

Prolonged (more than five years) absence of the natural disturbances of herbivory and fire will move the At-Risk Community (1.2) to the Excessive Litter Community (1.3).

Pathway 1.3A
Community 1.3 to 1.1

Reintroduction of the natural processes of herbivory and fire will return the Excessive Litter Community (1.3) to the Reference Community (1.1). If grazing and fire were absent for extensive periods of time, their reintroduction will move the plant community to the At-Risk Community (1.2) and several additional years of prescribed grazing will be needed for the community to return to the Reference Community.

Pathway 1.3B
Community 1.3 to 1.2

Reintroduction of the natural processes of herbivory and fire will return the Excessive Litter Community (1.3) to the At-Risk Community (1.2).

State 2
Shortgrass State

The Shortgrass State (2) transitioned from the Reference State (1) and much of the native warm-season tall- and midgrass components have been replaced by warm-season shortgrasses and upland sedges. This State is the result of long-term grazing management that did not provide adequate recovery time for warm-season tall- and midgrasses and mid-statured cool-season grasses. This management is typically heavy, continuous, season long grazing but heavy, rotational grazing with inadequate growing season recovery periods can also cause this transition. Over time, repeated annual haying during the rapid growth period of warm-season tallgrasses with inadequate growing recovery periods will also cause this transition. The loss of warm-season tall- and midgrasses negatively impacts energy flow, nutrient cycling, and hydrologic function. Runoff is higher and infiltration is lower than the Reference State. This state is very resistant to change. The Shortgrass State includes the Shortgrass Community (2.1).

Dominant plant species

- blue grama (*Bouteloua gracilis*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass

Community 2.1
Shortgrass Community

The Shortgrass or Blue Grama-Sand Dropseed/Cuman Ragweed (Bouteloua Gracilis-*Sporobolus cryptandrus*/*Ambrosia psilostachya*) Community (2.1) develops with long-term heavy grazing with inadequate growing season recovery periods. Typically, this type of grazing is continuous season long, but the community may also develop with heavy rotational grazing when plants have not recovered before pastures are re-entered or in moderately stocked large pastures where animals graze individual plants repeatedly. With continued grazing pressure, native shortgrasses and non-native, cool-season invasive grasses become dominant with only trace remnants of the more palatable grasses. Continuous and heavy grazing pressure will maintain this community in a sod-bound condition. Blue grama and sand dropseed dominate the site. Needle and thread and western wheatgrass may also be present as secondary species. Sedges may be common. Cuman ragweed, annual buckwheat, and tarragon are common forbs. Prairie sagewort and pricklypears are common shrubs. The potential vegetative composition is 75 to 85 percent grasses and grass-likes, 5 to 15 percent forbs, and 1 to 10 percent shrubs. Compared to the Reference Community (1.1) warm-season tall- and midgrasses are substantially reduced and may be absent while warm-season shortgrasses have significantly increased. Biotic integrity is reduced as compared to the Reference Community (1.1). The loss of warm-season tall- and midgrasses has negatively impacted energy flow and nutrient cycling. The hydrologic cycle has been impaired by the high density of shallow rooted grasses and the lace of surface litter, which respectively decrease infiltration and increase evaporation. Soil erosion is low. This plant community is resistant to change due to the high density of the shortgrass component of the community and its low percentage of bare ground. Under disturbance, this plant community has limited resilience due to the low species diversity. Plant diversity is low both in terms of individual species and functional or structural groups.

Dominant plant species

- blue grama (*Bouteloua gracilis*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass
- sedge (*Carex*), other herbaceous

Table 8. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	835	1042	1250
Forb	56	123	191
Shrub/Vine	6	67	129
Total	**897**	**1232**	**1570**

Figure 16. Plant community growth curve (percent production by month). NE6535, NE/SD Sandhills Blue Grama dominant. Warm-season dominant, short grass.

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

State 3
Invaded Woody State

The Invaded Woody State (3) is the result of woody encroachment. Once the tree canopy cover reaches 15 percent with an average tree height exceeding five feet, the threshold to the Invaded Woody State has been crossed. Woody species are increasing due to the lack of prescribed fire, brush management, or other woody tree removal. Typical ecological impacts are a loss of native grasses, reduce diversity of functional and structural groups, reduced forage production, and reduced soil quality. Prescribed burning, wildfire, timber harvest and brush management will move the Invaded Woody State toward a grass dominated state. If the Invaded Woody State transitioned from the Shortgrass State (2) or the Sodbusted State (4), the land cannot return to the Reference State (1) as the native plant community, soils, and hydrologic function had been too severely impacted prior to the woody encroachment to allow the return to the Reference State through woody species removal alone. The Invaded Woody State includes one community, the Invaded Woody Community (3.1).

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- sand sagebrush (*Artemisia filifolia*), shrub
- soapweed yucca (*Yucca glauca*), shrub
- blue grama (*Bouteloua gracilis*), grass
- hairy grama (*Bouteloua hirsuta*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass

Community 3.1
Invaded Woody Community

The Invaded Woody Community or Eastern Redcedar (*Juniperus virginiana*) Community (3.1) has at least 15 percent canopy cover consisting of trees generally 5 feet or taller. Encroaching trees are primarily eastern redcedar. In some situations, the dominant woody species are shrubs, typically sand sagebrush or soapweed yucca. In the absence of fire and brush management, this ecological site is very susceptible to eastern redcedar seedling invasion, especially when adjacent to a seed source. Eastern redcedar can eventually dominate the site resulting in a closed canopy monoculture which drastically reduces forage production, and which has limited value for either livestock grazing or wildlife habitat. With long-term fire suppression, this plant community will develop extensive ladder fuels which can lead to a removal of most tree species with a wildfire. With properly managed intensive grazing, encroachment of deciduous trees will typically be minimal; however, this will not impact encroachment of coniferous species. The herbaceous component decreases proportionately in relation to the percent canopy cover, with the reduction being greater under a coniferous overstory. Eastern redcedar control can usually be accomplished with prescribed burning while the trees are six feet tall or less and fine fuel production is greater than

1,500 pounds per acres. Larger redcedars can also be controlled with prescribed burning, but successful application requires the use of specifically designed ignition and holding techniques (https://www.loesscanyonsburning group.com). Resprouting brush must be chemically treated immediately after mechanical removal to achieve effective treatment. Often the forb component will initially increase following tree removal. To prevent return to a woody dominated community, ongoing brush management such as hand cutting, chemical spot treatments, or periodic prescribed burning is required. This plant community is resistant to change and resilient given normal disturbances. In higher canopy cover situations, the soil erosion will increase in relation the plant community from which this plant community originated. The hydrologic function is also significantly altered under higher canopy cover. Infiltration is reduced and runoff is typically increased because of a lack of herbaceous cover and the rooting structure provided by the herbaceous species. Total annual production during an average year varies significantly, depending on the production level prior to encroachment and the percentage of canopy cover.

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- sand sagebrush (*Artemisia filifolia*), shrub
- soapweed yucca (*Yucca glauca*), shrub
- blue grama (*Bouteloua gracilis*), grass
- hairy grama (*Bouteloua hirsuta*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass

State 4
Sodbusted State

The threshold to the Sodbusted State (4) is crossed as a result of mechanical disturbance to facilitate production agriculture. If farming operations are suspended, the site can be seeded to native grasses resulting in the Reseeded Native Grass Community (4.1), be seeded to a tame pasture forage mixture resulting in the Seeded Pasture Community (4.2) or be abandoned with no seeding which will result in the Natural Reclamation Community (4.3). Permanent alterations of the soil, plant community, and hydrologic cycle make restoration to the Reference State (1) extremely difficult, if not impossible.

Community 4.1
Reseeded Native Grass Community

The Reseeded Native Grass Community (4.1) does not contain native remnants, and varies considerably depending upon the seed mixture, the degree of soil erosion, the age of the stand, fertility management, and past grazing management. Native rangeland and grasslands seeded to native species are ecologically different and should be managed separately. Factors such as functional group, species, stand density, and improved varieties all impact the production level and palatability of the seedings. Species diversity is often limited, and when grazed in conjunction with native rangelands, uneven forage utilization may occur. Total annual production during an average year varies significantly depending upon precipitation, management, and grass species seeded. Prescribed grazing including appropriate utilization levels, adequate growing-season recovery periods, and timing of grazing that favor the productivity, health, and vigor of the seeded species is required to maintain this community. Periodic prescribed burning and brush management may also be needed.

Community 4.2
Seeded Pasture Community

The Seeded Pasture Community (4.2) does not contain native remnants and varies considerably depending upon the extent of soil erosion, the species seeded, the quality of the stand that was established, the age of the stand, and management of the stand since establishment. There are several factors that make seeded tame pasture a different grazing resource than native rangeland and land seeded to a native grass mixture. Factors such as species selected, stand density, improved varieties, and harvest efficiency all impact production levels and palatability. Species diversity on seeded tame pasture is often limited to a few species. When seeded pasture and native rangelands or seeded pasture and seeded rangeland are in the same grazing unit, uneven forage utilization will occur. Improve forage utilization and stand longevity by managing this community separately from native rangelands or land seeded to native grass species. Total annual production during an average year varies significantly depending on the level of management and species seeded. Improved varieties of warm-season or

cool-season grasses are recommended for optimum forage production. Fertilization, weed management, and prescribed grazing including appropriate utilization levels, adequate growing-season recovery periods, and timing of grazing that favor the productivity, health, and vigor of the seeded species are required to maintain this community. Periodic prescribed burning and brush management may also be needed.

Community 4.3
Natural Reclamation Community

The Natural Reclamation Community (4.3) consists of annual and perennial early successional species. Perennial threeawns, sand dropseed, and annual grasses are common species. These sites have been farmed and abandoned without being reseeded. Soil organic matter and carbon reserves are reduced, soil structure is changed, and a plowpan or compacted layer can form, which decreases water infiltration. Residual synthetic chemicals may remain from farming operations. In early successional stages, this community is not stable. The hazard of erosion is a resource concern. Total annual production during an average year varies significantly depending on the succession stage of the plant community and any management applied to the system.

Transition T1A
State 1 to 2

The Reference State (1) transitions to the Shortgrass State (2) in response to long-term (greater than ten years), heavy, repeated defoliation of the key forage species (sand bluestem and prairie sandreed) by grazing or haying. This change typically occurs with long-term heavy, continuous season long grazing but heavy rotational grazing without adequate recovery periods may also cause this transition. The Reference State loses a significant proportion of warm-season, tall- and midgrasses and crosses a threshold to the Shortgrass State. Deep rooted plants are replaced by shallow rooted, sod-forming grasses which tend to form root mats and water infiltration is reduced. Forage production and plant species diversity has declined. Initially, the plant community will be a mosaic, with shortgrass and mixed grass communities intermingled but as the management continues the plant community becomes dominated by shortgrasses and non-native cool-season grasses such as cheatgrass or Kentucky bluegrass may be significant.

Transition T1B
State 1 to 3

Long-term (more than ten years) disruption of the natural fire regime and the encroachment of invasive exotic and native woody species with no woody species management can cause the Reference State (1) to transition to the Invaded Woody State (3).

Transition T1C
State 1 to 4

The Reference State (1) has been significantly altered by tillage to facilitate production agriculture. When the land is no longer cropped, the resulting state is the Sodbusted State (4). The disruption to the plant community, the soil, and the hydrology of the system make restoration to a true Reference State unlikely.

Restoration pathway R2A
State 2 to 1

Long-term (more than 15 years) prescribed grazing with adequate growing season recovery periods will move the Shortgrass State (2) toward the Reference State (1). The amount of time required for, and feasibility of this restoration depends upon the abundance of warm-season tall- and midgrasses and cool-season bunch grasses remaining in the plant community. This restoration may not be feasible.

Transition T2A
State 2 to 3

Long-term (more than ten years) disruption of the natural fire regime and the encroachment of invasive exotic and native woody species with no woody species management can cause the Shortgrass State (2) to transition to the

Invaded Woody State (3).

Transition T2B
State 2 to 4

The Shortgrass State (2) has been significantly altered by tillage to facilitate production agriculture. When the land is no longer cropped, the resulting state is the Sodbusted State (4).

Restoration pathway R3A
State 3 to 1

The Invaded Woody State (3) can be restored to the Reference State (1) through prescribed burning, wildfire, timber harvest, or brush management. The forb component may initially increase following tree removal. Ongoing brush management such as hand cutting, chemical spot treatments, or periodic prescribed burning is required to prevent a return to the Invaded Woody State. The heavier the existing canopy cover, the greater the energy input required to return to the Reference State. The amount of time required for the herbaceous vegetation of the Reference State to return depends upon the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from the Shortgrass State (2) or the Sodbusted State (4) cannot be restored to the Reference State through the removal of woody species as the native plant community, soils, and hydrologic function have been too severely impacted for that restoration to occur with brush management alone.

Restoration pathway R3B
State 3 to 2

The Invaded Woody State (3) can be restored to the Shortgrass State (2) through prescribed burning, wildfire, timber harvest, or brush management. The forb component may initially increase following tree removal. Ongoing brush management such as hand cutting, chemical spot treatments, or periodic prescribed burning is required to prevent a return to the Invaded Woody State. The heavier the existing canopy cover, the greater the energy input required to return to the Reference State. The amount of time required for the herbaceous vegetation of the Shortgrass State to return depends upon the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from the Shortgrass State cannot be restored to the Reference State through the removal of woody species as the native plant community, soils, and hydrologic function have been too severely impacted for that restoration to occur with brush management alone.

Restoration pathway R3C
State 3 to 4

The Invaded Woody State (3) can be restored to the Sodbusted State (4) through prescribed burning, wildfire, timber harvest, or brush management. The forb component may initially increase following tree removal. Ongoing brush management such as hand cutting, chemical spot treatments, or periodic prescribed burning is required to prevent a return to the Invaded Woody State. The heavier the existing canopy cover, the greater the energy input required to return to the Sodbusted State by management practices. Land that transitioned to the Invaded Woody State from the Sodbusted State cannot be restored to the Reference State (1) through the removal of woody species as the native plant community, soils, and hydrologic function have been too severely impacted for that restoration to occur with removal of brush alone.

Transition T4A
State 4 to 3

Long-term (more than ten years) disruption of the natural fire regime and the encroachment of invasive exotic and native woody species with no woody species management can cause the Sodbusted State (4) to transition to the Invaded Woody State (3).

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)

Group	Common Name	Symbol	Scientific Name	(kg/hectare)	(%)
Grass/Grasslike					
1	**Native Warm-Season Tallgrass**			639–1597	
	sand bluestem	ANHA	*Andropogon hallii*	639–852	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	532–745	–
	switchgrass	PAVI2	*Panicum virgatum*	0–213	–
	Grass, perennial	2GP	*Grass, perennial*	0–43	–
2	**Native Warm-Season Midgrass**			43–213	
	little bluestem	SCSC	*Schizachyrium scoparium*	0–213	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–106	–
	sand lovegrass	ERTR3	*Eragrostis trichodes*	0–106	–
	Grass, perennial	2GP	*Grass, perennial*	0–43	–
3	**Native Warm-Season Shortgrass**			106–213	
	blue grama	BOGR2	*Bouteloua gracilis*	106–213	–
	Grass, perennial	2GP	*Grass, perennial*	0–106	–
4	**Native Cool-Season Grass**			106–319	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	106–213	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–106	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–106	–
	Grass, perennial	2GP	*Grass, perennial*	0–43	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0–21	–
5	**Grass-like**			43–213	
	sedge	CAREX	*Carex*	0–106	–
	threadleaf sedge	CAFI	*Carex filifolia*	0–43	–
Forb					
6	**Forb**			106–213	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–43	–
	Forb, annual	2FA	*Forb, annual*	0–43	–
	Forb, perennial	2FP	*Forb, perennial*	0–43	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–21	–
	thistle	CIRSI	*Cirsium*	0–21	–
	Texas croton	CRTE4	*Croton texensis*	0–21	–
	common sunflower	HEAN3	*Helianthus annuus*	0–21	–
	prairie sunflower	HEPE	*Helianthus petiolaris*	0–21	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–21	–
	dotted blazing star	LIPU	*Liatris punctata*	0–21	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–21	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–21	–
	bractless blazingstar	MENU	*Mentzelia nuda*	0–21	–
	white penstemon	PEAL2	*Penstemon albidus*	0–21	–
	broadbeard beardtongue	PEAN4	*Penstemon angustifolius*	0–21	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–21	–
	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	0–21	–

	white heath aster	SYER	*Symphyotrichum ericoides*	0–21	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–21	–
	hoary verbena	VEST	*Verbena stricta*	0–21	–
Shrub/Vine					
7	**Shrub**			21–213	
	rose	ROSA5	*Rosa*	0–106	–
	sand sagebrush	ARFI2	*Artemisia filifolia*	0–106	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–106	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–43	–
	soapweed yucca	YUGL	*Yucca glauca*	0–43	–
	Subshrub (<.5m)	2SUBS	*Subshrub (<.5m)*	0–43	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–43	–
	brittle pricklypear	OPFR	*Opuntia fragilis*	0–21	–

Table 10. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Native Warm-Season Tallgrass**			538–897	
	prairie sandreed	CALO	*Calamovilfa longifolia*	448–628	–
	sand bluestem	ANHA	*Andropogon hallii*	90–269	–
	switchgrass	PAVI2	*Panicum virgatum*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
2	**Native Warm-Season Midgrass**			90–179	
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–179	–
	little bluestem	SCSC	*Schizachyrium scoparium*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
	sand lovegrass	ERTR3	*Eragrostis trichodes*	0–36	–
3	**Native Warm-Season Shortgrass**			90–269	
	blue grama	BOGR2	*Bouteloua gracilis*	90–269	–
	sandhill muhly	MUPU2	*Muhlenbergia pungens*	0–36	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
4	**Native Cool-Season Grass**			90–269	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	90–269	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–36	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–36	–
5	**Grass-like**			0–90	
	sedge	CAREX	*Carex*	0–90	–
	threadleaf sedge	CAFI	*Carex filifolia*	0–36	–
8	**Non-Native Cool-Season Grass**			0–36	
	cheatgrass	BRTE	*Bromus tectorum*	0–18	–
	Grass, annual	2GA	*Grass, annual*	0–18	–

	Grass, perennial	2GP	*Grass, perennial*	0–18	–
Forb					
6	**Forb**			90–179	
	Forb, perennial	2FP	*Forb, perennial*	0–54	–
	Forb, annual	2FA	*Forb, annual*	0–36	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–36	–
	thistle	CIRSI	*Cirsium*	0–36	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–36	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–18	–
	Rocky Mountain beeplant	CLSE	*Cleome serrulata*	0–18	–
	Texas croton	CRTE4	*Croton texensis*	0–18	–
	common sunflower	HEAN3	*Helianthus annuus*	0–18	–
	prairie sunflower	HEPE	*Helianthus petiolaris*	0–18	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–18	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–18	–
	dotted blazing star	LIPU	*Liatris punctata*	0–18	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–18	–
	bractless blazingstar	MENU	*Mentzelia nuda*	0–18	–
	white penstemon	PEAL2	*Penstemon albidus*	0–18	–
	broadbeard beardtongue	PEAN4	*Penstemon angustifolius*	0–18	–
	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	0–18	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–18	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–18	–
	hoary verbena	VEST	*Verbena stricta*	0–18	–
Shrub/Vine					
7	**Shrub**			18–179	
	sand sagebrush	ARFI2	*Artemisia filifolia*	0–90	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–90	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–36	–
	rose	ROSA5	*Rosa*	0–36	–
	soapweed yucca	YUGL	*Yucca glauca*	0–36	–
	brittle pricklypear	OPFR	*Opuntia fragilis*	0–18	–

Table 11. Community 1.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Native Warm-Season Tallgrass**			538–986	
	sand bluestem	ANHA	*Andropogon hallii*	269–448	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	269–448	–
	switchgrass	PAVI2	*Panicum virgatum*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
2	**Native Warm-Season Midgrass**			0–179	

	sand lovegrass	ERTR3	*Eragrostis trichodes*	0–90	–
	little bluestem	SCSC	*Schizachyrium scoparium*	0–90	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
3	**Native Warm-Season Shortgrass**			0–90	
	blue grama	BOGR2	*Bouteloua gracilis*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
4	**Native Cool-Season Grass**			179–538	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	179–359	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	18–179	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–90	–
	Grass, perennial	2GP	*Grass, perennial*	0–36	–
5	**Grass-like**			0–90	
	sedge	CAREX	*Carex*	0–90	–
8	**Non-Native Cool-Season Grass**			0–36	
	cheatgrass	BRTE	*Bromus tectorum*	0–18	–
	Grass, annual	2GA	*Grass, annual*	0–18	–
	Grass, perennial	2GP	*Grass, perennial*	0–18	–
Forb					
6	**Forb**			18–179	
	Forb, annual	2FA	*Forb, annual*	0–90	–
	Forb, perennial	2FP	*Forb, perennial*	0–36	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–36	–
	prairie sunflower	HEPE	*Helianthus petiolaris*	0–36	–
	common sunflower	HEAN3	*Helianthus annuus*	0–36	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–18	–
	bractless blazingstar	MENU	*Mentzelia nuda*	0–18	–
	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	0–18	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–18	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–18	–
	thistle	CIRSI	*Cirsium*	0–18	–
	Texas croton	CRTE4	*Croton texensis*	0–18	–
Shrub/Vine					
7	**Shrub**			18–90	
	sand sagebrush	ARFI2	*Artemisia filifolia*	0–90	–
	rose	ROSA5	*Rosa*	0–90	–
	Subshrub (<.5m)	2SUBS	*Subshrub (<.5m)*	0–36	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–36	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–36	–
	brittle pricklypear	OPFR	*Opuntia fragilis*	0–18	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–18	–
	soapweed yucca	YUGL	*Yucca glauca*	0–18	–

Table 12. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Native Warm-Season Tallgrass**			62–247	
	sand bluestem	ANHA	*Andropogon hallii*	0–247	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	62–185	–
	Grass, perennial	2GP	*Grass, perennial*	0–25	–
	switchgrass	PAVI2	*Panicum virgatum*	0–12	–
2	**Native Warm-Season Midgrass**			62–247	
	sand dropseed	SPCR	*Sporobolus cryptandrus*	62–185	–
	little bluestem	SCSC	*Schizachyrium scoparium*	0–62	–
	Grass, perennial	2GP	*Grass, perennial*	0–25	–
	sand lovegrass	ERTR3	*Eragrostis trichodes*	0–25	–
3	**Native Warm-Season Shortgrass**			123–308	
	blue grama	BOGR2	*Bouteloua gracilis*	123–247	–
	sandhill muhly	MUPU2	*Muhlenbergia pungens*	0–62	–
	Grass, perennial	2GP	*Grass, perennial*	0–25	–
4	**Native Cool-Season Grass**			62–247	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	62–185	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–62	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0–62	–
	Grass, perennial	2GP	*Grass, perennial*	0–37	–
	Indian ricegrass	ACHY	*Achnatherum hymenoides*	0–25	–
5	**Grass-like**			62–123	
	threadleaf sedge	CAFI	*Carex filifolia*	0–62	–
	sedge	CAREX	*Carex*	0–62	–
8	**Non-Native Cool-Season Grass**			0–62	
	cheatgrass	BRTE	*Bromus tectorum*	0–62	–
	Grass, perennial	2GP	*Grass, perennial*	0–62	–
	Grass, annual	2GA	*Grass, annual*	0–62	–
Forb					
6	**Forb**			62–185	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–123	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–62	–
	Forb, perennial	2FP	*Forb, perennial*	0–62	–
	Forb, annual	2FA	*Forb, annual*	0–25	–
	thistle	CIRSI	*Cirsium*	0–25	–
	annual buckwheat	ERAN4	*Eriogonum annuum*	0–25	–
	prairie sunflower	HEPE	*Helianthus petiolaris*	0–25	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–25	–
	bractless blazingstar	MENU	*Mentzelia nuda*	0–25	–
	beardtongue	PENST	*Penstemon*	0–12	–

	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	0–12	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–12	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–12	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–12	–
	hoary verbena	VEST	*Verbena stricta*	0–12	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–12	–
	dotted blazing star	LIPU	*Liatris punctata*	0–12	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–12	–
	Rocky Mountain beeplant	CLSE	*Cleome serrulata*	0–12	–
	Texas croton	CRTE4	*Croton texensis*	0–12	–
Shrub/Vine					
7	**Shrub**			12–123	
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–62	–
	rose	ROSA5	*Rosa*	0–62	–
	sand sagebrush	ARFI2	*Artemisia filifolia*	0–62	–
	prairie sagewort	ARFR4	*Artemisia frigida*	0–62	–
	Subshrub (<.5m)	2SUBS	*Subshrub (<.5m)*	0–25	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	0–25	–
	brittle pricklypear	OPFR	*Opuntia fragilis*	0–12	–
	soapweed yucca	YUGL	*Yucca glauca*	0–12	–

Animal community

LIVESTOCK - GRAZING INTERPRETATIONS:
Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide year-long forage for cattle, sheep, or horses. During the dormant period, the protein levels of the forage may be lower than the minimum needed to meet livestock (primarily cattle and sheep) requirements. The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. With consultation of the land manager, more intensive
grazing management may result in improved harvest efficiencies and increased carrying capacity.

Production and Carrying Capacity*
►Reference Community (1.1)
Average Production (lb./acre, air-dry): 1,900
Stocking Rate (AUM/acre): 0.52
►At-Risk Community (1.2)
Average Production (lb./acre, air-dry): 1,600
Stocking Rate (AUM/acre): 0.44
►Excessive Litter Community (1.3)
Average Production (lb./acre, air-dry): 1,600
Stocking Rate (AUM/acre): 0.44
►Shortgrass Community (2.1)
Average Production (lb./acre, air-dry): 1,100
Stocking Rate (AUM/acre): 0.30

*Based upon the following conditions: continuous season-long grazing by cattle under average growing conditions, 25 percent harvest efficiency. Air dry forage requirements based on 3 percent of animal body weight, or 912 lbs/AU/month.

WILDLIFE INTERPRETATIONS:
The Sandhills Prairie ecosystem consists of diverse grassland habitats interspersed with varying densities of Sandhills lakes and limited woody riparian corridors. The majority of this ecosystem is intact. These habitats historically provided critical life cycle components for the grassland birds, prairie dogs, and herds of roaming bison, elk, and pronghorn. Bobcats, wolves, and mountain lions occupied the apex predator niche. Diverse populations of small mammals and insects still provide a bountiful prey base for raptors and omnivores such as coyotes, foxes, raccoons, and opossums. In addition, a wide variety of reptiles and amphibians thrive in this landscape.

The Sandhills Prairie was a disturbance-driven ecosystem with fire, herbivory, and climate functioning as the primary disturbances. Following European settlement, elimination of fire and overgrazing altered the appearance and functionality of the ecosystem. Bison and prairie dogs were historically keystone species, but free-roaming bison herds have been extirpated in this region. The loss of bison and fire as ecological drivers influenced the character of the remaining native grasslands and the habitats that they provide. Fragmentation in MLRA 65 is limited and area sensitive grassland birds such as greater prairie chicken and sharp-tailed grouse continue to thrive here. The mosaic of sites continues to provide habitat for species requiring unfragmented grasslands, providing upland nesting habitat for grassland birds and game birds, nesting and escape cover for waterfowl, forbs and insects for brood-rearing habitat, and a forage source for small and large herbivores.

In the absence of fire and grazing, heavy litter buildup can occur on this site hindering the movement of young birds, especially quail and prairie chickens. Increased litter buildup results in decreased forb abundance and diversity and an accompanying decrease in insects, a critical food source for young birds. Introduced species such as cheatgrass, Kentucky bluegrass, and introduced forbs may be present but degradation of the biotic integrity from non-native species in this precipitation zone on ecological site is limited.

Disruption of the natural fire regime and accompanying woody encroachment is the greatest threat to ecosystem dynamics in this MLRA. Lack of fire facilitates tree and shrub encroachment degrades grassland habitats and creates habitats that favor generalist species such as American robin and mourning dove. Woody species provide perches for raptors, increasing the predation mortality on native bird populations. Woody encroachment is most severe in the eastern half of the MLRA but is a threat across the MLRA.

Hydrological functions

Water is the principal factor limiting forage production on the Sandy 14-17" PZ ecological site. Shrub invasion greatly exacerbates this issue. Control of invasive shrubs by prescribed fire and mechanical means are important tools in maintaining the site as a grassland.

Soils are typically in hydrologic group D. Infiltration rate is moderately slow to slow. Runoff potential for this site varies from low to very high depending on soil hydrologic group, slope and ground cover.

Recreational uses

This site provides hunting for upland game species along with hiking, photography, bird watching, and other opportunities. The site supports a wide variety of grasses and wildflowers which bloom from spring through fall and have an aesthetic value that appeals to visitors.

Wood products

Although several tree species invade this site, they usually do not reach sufficient size to produce wood products except for firewood.

Other products

The deep, productive nature of the soils associated with this site make it attractive for a variety of other land uses.

When in large blocks on flatter slopes, they are preferred cropland soils. Introduced pasture plants do well on these soils.

Other information

Revision Notes: “This PROVISIONAL ecological site concept has been through the Quality Control and Quality Assurance processes to ensure that the site meets the NESH standards for a provisional ecological site that provides basic compiled information in one location. This site should not be considered an Approved ESD until further data entry and editing is completed.

Site Development and Testing Plan:
Future work is needed to validate the information in this Provisional Ecological Site Description. Additional data collection and evaluation may also be needed to develop this ESD to the Approved, then Correlated level. This could include field activities to collect low, medium and high intensity sampling, soil correlations, and analysis of that data. Field reviews of the project plan 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. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team. The project plan is ES-R065XY013NE - MLRA 65.

Inventory data references

Information presented here has been derived from NRCS clipping data and other inventory data. Field observations from range trained personnel was also used. Those involved in developing this site include Dave Cook, Rangeland Management Specialist, NRCS; Dwight Hale, Engineer, NRCS; Sheila Luoma, Resource Conservationist, NRCS; Marla Shelbourn, Rangeland Management Specialist, NRCS; Dave Steffen, Rangeland Management Specialist, NRCS.

There are 3 SCS-RANGE-417 records available from Garden, Morrill, and Sheridan counties. The sample period is from 1970 to 1998.

Other references

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Approval

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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)	Original Author: Stan Boltz. Version V participants: Dave Cook, Emily Helms, Jeff Nichols, Myra Richardson, Nadine Bishop
Contact for lead author	Jeff Nichols: jeffrey.nichols@usda.gov
Date	11/30/2024
Approved by	Suzanne Mayne-Kinney
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** None. Rills are not expected on this site.

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2. **Presence of water flow patterns:** None. Water flow patterns are not expected on this site.

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3. **Number and height of erosional pedestals or terracettes:** None. Erosional pedestals or terracettes are not expected.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is typically 5 percent or less. Multi-year drought and/or wildfire can increase bare ground to 10 percent for up to two years following the disturbance.

   Bare ground is exposed mineral soil that is not covered by vegetation (basal and/or foliar canopy), standing dead vegetation, gravel/rock, and visible biological crust (e.g., lichen, mosses, algae).

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5. **Number of gullies and erosion associated with gullies:** None. Gullies are not expected on this site.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** None. Wind-scoured areas and depositional areas are not expected on this site.

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7. **Amount of litter movement (describe size and distance expected to travel):** Litter should fall in place. Slight amount of movement of fine litter from water is possible, but not normal. Litter movement from wind is not expected.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil stability ratings should typically be 5 to 6, normally 6. Surface organic matter adheres to the soil surface. Soil surface fragments will typically retain structure indefinitely when dipped in distilled water.

   Surface erosion by water rarely occurs due to rapid infiltration, but surface may be susceptible to wind erosion when vegetative cover is reduced due to multi-year drought, wildfire, or multi-year heavy grazing. Biological crusts may be present and may serve to provide resistance to erosion.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** The A-horizon should be 3 to 10 inches (10-25 cm) thick, with the deeper A-horizon occurring on interdunes and nearly level landscape positions. Soil colors range from grayish brown, dark grayish brown, to dark gray (values of 4 to 5) when dry and very dark grayish brown, dark grayish brown, or very dark brown (values of 2 to 3) when moist. Structure is typically granular.

   Dunday is the major soil series correlated to this ecological site.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The functional/structural groups provide a combination of rooting depths and structure which positively influences infiltration. Combination of shallow and deep rooted species (rhizomatous, warm-season tall- and midgrasses and tufted perennial cool season grasses) with fine and coarse roots positively influences infiltration.

    The expected composition of the plant community is 80 to 90 percent perennial grasses and grass-likes, 5 to 10 percent forbs, and 1 to 10 percent shrubs. The perennial grass and grass-like component is made up of warm-season tallgrasses (30-75%); warm-season midgrasses (2-10%), cool-season grasses (5-15%); warm-season shortgrasses (5-10%); and grass-likes (2-10%).

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None. Compaction layers should not be present.

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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: Phase 1.1
    1. Native, perennial, warm-season, tallgrass, 570--1425 #/ac, 30-75%, 2 species minimum: sand bluestem, prairie sandreed, switchgrass.

    Phase 1.2
    1. Native, perennial, warm-season, tallgrass, 480-800 #/ac, 30-50%, 2 species minimum: sand bluestem, prairie sandreed, switchgrass.

    Phase 1.3

1. Native, perennial, warm-season, tallgrass, 480-880 #/ac, 30-55%, 2 species minimum: sand bluestem, prairie sandreed, switchgrass.
2. Native, perennial, cool-season grass, 160-480 #/ac, 10-30%, 1 species minimum: needle and thread, Indian ricegrass, prairie Junegrass.

Sub-dominant: Phase 1.1
1. Native, perennial, cool-season grass, 95-285 #/ac, 5-10%, 1 species minimum: needle and thread, Indian ricegrass, prairie Junegrass, western wheatgrass.

Phase 1.2
1. Native, perennial, cool-season grass, 80-240 #/ac, 5-15%, 1 species minimum: needle and thread, Indian ricegrass, prairie Junegrass, western wheatgrass.
2. Native, perennial, warm-season shortgrass, 80-240 #/ac, 5-15%, 1 species minimum: blue grama, sandhill muhly.

Other: Minor - Phase 1.1
1. Native, perennial, warm-season shortgrass, 95-190 #/ ac, 5-10%: blue grama.
2. Native, perennial and annual forbs, 95-190#, 5-10%: forbs present vary from location to location.
3. Native, perennial, warm-season midgrass, 38-190 #/ac, 2-10%: little bluestem, sand lovegrass, sand dropseed.
4. Grass-likes, 38-190 #/ac, 2-10%: sedges.
5. Shrubs, 19-190 #/ac, 1-10%: sand sagebrush, prairie sagewort, brittle pricklypear, plains pricklypear, rose, soapweed yucca.

Minor - Phase 1.2
1. Native, perennial, warm-season midgrass, 80-160 #/ac, 5-10%: sand lovegrass, little bluestem, sand dropseed.
2. Native, perennial and annual forbs, 80-160 #/ac, 5-10%: forbs present vary from location to location.
3. Shrubs, 16-160 #/ac, 1-10%: sand sagebrush, prairie sagewort, brittle pricklypear, plains pricklypear, rose, soapweed yucca.
4. Grass-likes, 0-80 #/ac, 0-5%: sedges.

Minor - Phase 1.3
1. Native, annual and perennial forbs, 16-160 #/ac, 1-10%: forbs present vary from location to location.
2. Native, perennial, warm-season midgrass, 0-160 #/ac, 0-10%: sand lovegrass, little bluestem, sand dropseed.
3. Shrubs, 16-80 #/ac, 1-5%: sand sagebrush, prairie sagewort, brittle pricklypear, plains pricklypear, rose, soapweed yucca.
4. Native, perennial, warm-season shortgrass, 0-80 #/ac, 0-5%: blue grama.
5. Grass-likes, 0-80 #/ac, 0-5%: sedges.

Trace - Phase 1.2
1. Non-native, cool-season grass, 0-32 #ac, 0-2%: cheatgrass.

Trace - Phase 1.3
1. Non-native, cool-season grass, 0-32 #ac, 0-2%: cheatgrass.

Additional: The Reference Community (1.1) includes seven functional/structural groups which are in order of relative abundance native, perennial, warm-season tallgrass; native perennial, cool-season grass; native perennial, warm-season shortgrass=forb; native, perennial, warm-season midgrass=grass-like; shrubs.

The At-Risk Community (1.2) includes eight functional/structural groups which are in order of relative abundance native, perennial, warm-season tallgrass; native, perennial, cool-season grass=native, perennial, warm-season shortgrass; native, perennial, warm-season midgrass=native forb; shrub; grass-likes; non-native, cool-season grass.

The Excessive Litter Community (1.3) includes eight functional/structural groups which are in order of relative abundance native, perennial, warm-season tallgrass; native, perennial cool-season grass; forb; native perennial, warm-season

midgrass; forb; shrub; native, perennial, warm-season shortgrass=grass-like; non-native, cool-season grass.

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Very little evidence of decadence or mortality. Bunch grasses have strong, healthy centers and shrubs have few dead stems. The exception is the potential of up to 15 percent mortality of warm-season bunch grasses during multi- year drought cycles.

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14. **Average percent litter cover (%) and depth (in):** Plant litter cover is evenly distributed throughout the site and is expected to be 50 to 70 percent and at a depth of 0.25 to 0.50 inch (0.65-1.3 cm). Litter cover during and following drought can range from 40 to 50 percent.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** The representative value (RV) for annual production is 1,900 pounds per acer on an air dry weight basis. Low and high production years should yield 1,600 and 2,500 pounds per acre respectively.

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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:** Annual bromes (cheatgrass and Japanese/field) and common mullein are known invasives that have the potential to be dominant or co-dominant on the site. Consult the state noxious weed and state watch lists for potential invasive species on each ecological site.

    NOTE: Invasive plants (for the purposes of the IIRH protocol) are plant species that are typically not found on the ecological site or should only be in trace or minor categories under the natural disturbance regime and have the potential to become a dominant or codominant species on the site if their establishment and growth are not actively controlled by natural disturbances or management interventions. Species listed characterize degraded states AND have the potential to become a dominant or co-dominant species.

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17. **Perennial plant reproductive capability:** All perennial species exhibit high vigor relative to recent weather conditions. Perennial grasses should have vigorous rhizomes or tillers; vegetative and reproductive structures are not stunted. All perennial species should be capable of reproducing annually.
