USDA Natural Resources Conservation Service

Ecological site R065XY055NE
Sands 22-25" 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.

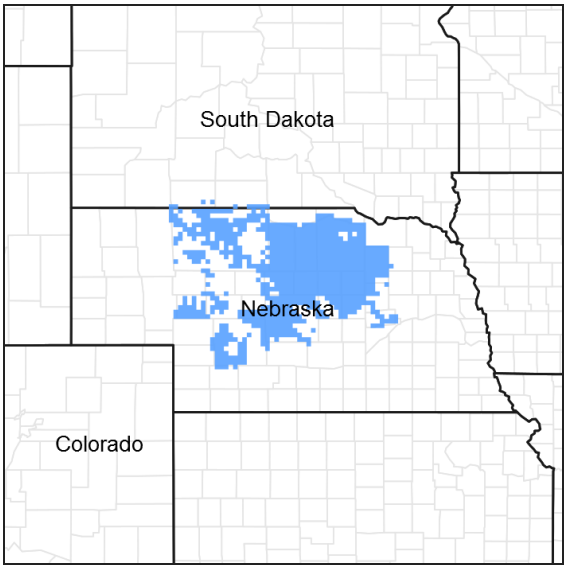

Figure 1. Mapped extent

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

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

►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

►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)

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 Sands ecological site is divided into three ecological sites to address this precipitation gradient and its impacts to the site. The Sands 22-25" precipitation zone (PZ) typically occurs east of a line that extends approximately from central Logan County to Thedford to northwest Blaine County to Wood Lake, Nebraska.

The Sands 22-25" PZ ecological site typically occurs on dunes or hills with slopes of 3 to 24 percent but also occurs on interdunes with slopes of less than 3 percent. The soils are very deep and formed in eolian sand. Surface and subsoil textures are typically loamy fine sand or fine sand. Soils have a dark surface layer that is less than 10 inches thick. Catsteps do not occur on this site.

The historic native vegetation of the Sands 22-25" PZ ecological site is a Sandhills Prairie which is a variation of tallgrass prairie found in the Nebraska Sandhills. Vegetation in the Reference Plant Community (1.1) consists of a mixture of warm- season, tall- and midgrasses and cool-season grasses. Dominant grasses sand bluestem, prairie sandreed, switchgrass, and little bluestem. Indiangrass and sand lovegrass are also common. Needle and thread and porcupinegrass are the dominant cool-season grasses. The plant community includes a diverse population of forbs and typical shrubs include leadplant, western sandcherry, and rose. Long-term excessive grazing pressure will shift the plant community toward one that is dominated by cool-season and warm-season shortgrasses and that is susceptible to invasion by non-native, cool-season grasses. In the absence of fire and brush management, this site is susceptible to woody encroachment especially eastern redcedar.

Associated sites

R065XY054NE	**Sandy 22-25" PZ** Sandy 22-25
R065XY024NE	**Subirrigated** Subirrigated ecological sites are often found intermixed with Sands 22-25
R065XY056NE	**Choppy Sands 22-25" PZ** Choppy Sands 22-25

Similar sites

R065XY054NE	**Sandy 22-25" PZ** Sandy 22-25
R065XY056NE	**Choppy Sands 22-25" PZ** Choppy Sands 22-25

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified

Herbaceous	(1) *Andropogon hallii* (2) *Calamovilfa longifolia*

Physiographic features

The Sands 22-25" PZ ecological site is found in the sand hills landscape typically on dunes but occasionally occurs on interdunes. 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 > Dune
Runoff class	Medium to low
Flooding frequency	None
Ponding frequency	None
Elevation	1,500–3,940 ft
Slope	0–24%
Water table depth	60 in
Aspect	Aspect is not a significant factor

Climatic features

The mean average annual precipitation for the eastern portion of the MLRA typically varies from 22 to 25 inches but has varied from 12 to 34 inches in the driest to wettest season. Approximately 70 percent of the annual precipitation occurs during the growing season of 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 length of the growing season is 138 days, but the growing season has varied from 114 to 168 days. 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 mid to late March and continues to late June. Native warm-season plants begin growth in early 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)	119-127 days
Freeze-free period (characteristic range)	135-145 days
Precipitation total (characteristic range)	24-27 in
Frost-free period (actual range)	113-129 days
Freeze-free period (actual range)	135-146 days
Precipitation total (actual range)	23-27 in
Frost-free period (average)	122 days
Freeze-free period (average)	141 days
Precipitation total (average)	26 in

Climate stations used

- (1) ATKINSON 3SW [USC00250420], Atkinson, NE
- (2) BARTLETT 1S [USC00250525], Bartlett, NE
- (3) BREWSTER [USC00251130], Brewster, NE
- (4) CHAMBERS [USC00251590], Chambers, NE
- (5) ELSMERE 9 ENE [USC00252680], Johnstown, NE
- (6) ERICSON 8 WNW [USC00252770], Burwell, NE
- (7) GREELEY [USC00253425], Greeley, NE
- (8) NEWPORT [USC00255925], Newport, NE
- (9) PURDUM [USC00256970], Purdum, NE
- (10) ROSE 10 WNW [USC00257318], Long Pine, NE
- (11) SWAN LAKE [USC00258360], Amelia, NE

Influencing water features

This plant community is not influenced by the water features commonly associated with this site.

Soil features

The soils associated with the Sands 22-25" PZ ecological site are very deep, excessively drained, and formed in eolian sand. The site typically occurs on dunes or hills with slopes of 3 to 24 percent but it may also occur on interdunes where slopes range from 0 to 3 percent. Catsteps do not occur on this site. Soil surface and subsoil textures are fine sand to loamy fine sand. Soils have a dark surface layer that is less than 10 inches thick. Soil structures are single grain, weak fine granular structure parting to single grain, or weak fine granular.

Runoff as evidenced by patterns of rill, gully, or other water flow is low to very low due to the very high intake rate of these soils. Some pedestalling of plants occurs, but it is not very evident on casual observation and occurs on less than five percent of the plants. Cryptobiotic crusts are present, but their function is not well understood.

Valentine is the only soil series correlated to this site. 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) Fine sand (2) Loamy fine sand
Family particle size	(1) Sandy
Drainage class	Somewhat excessively drained to excessively drained
Permeability class	Rapid
Soil depth	80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	2.1–4.4 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0

Soil reaction (1:1 water) (0-40in)	5.6–7.8
Subsurface fragment volume <=3" (Depth not specified)	0%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

Sands 22-25" 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 site is extremely resilient, and well adapted to Northern Great Plains climatic conditions. The plant diversity allows for high resistance to drought.

The introduction of domestic livestock by European settlers along with season-long, continuous grazing had a profound impact on the vegetation of the Sands 22-25" 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 will decrease in frequency and production while needle and thread and blue grama will increase. As this management continues, needle and thread and other palatable cool-season grasses will decrease, and the non-native cool-season grasses may invade the site.

The State and Transition Model (STM) is depicted below and includes a Reference State (1), an Eroded State (2), a Native/Invaded Grass State (3), a Shortgrass Sod State (4), an Invaded Woody State (5), and a Sodbusted State (6). 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 cycle. 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 fluctuations 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 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

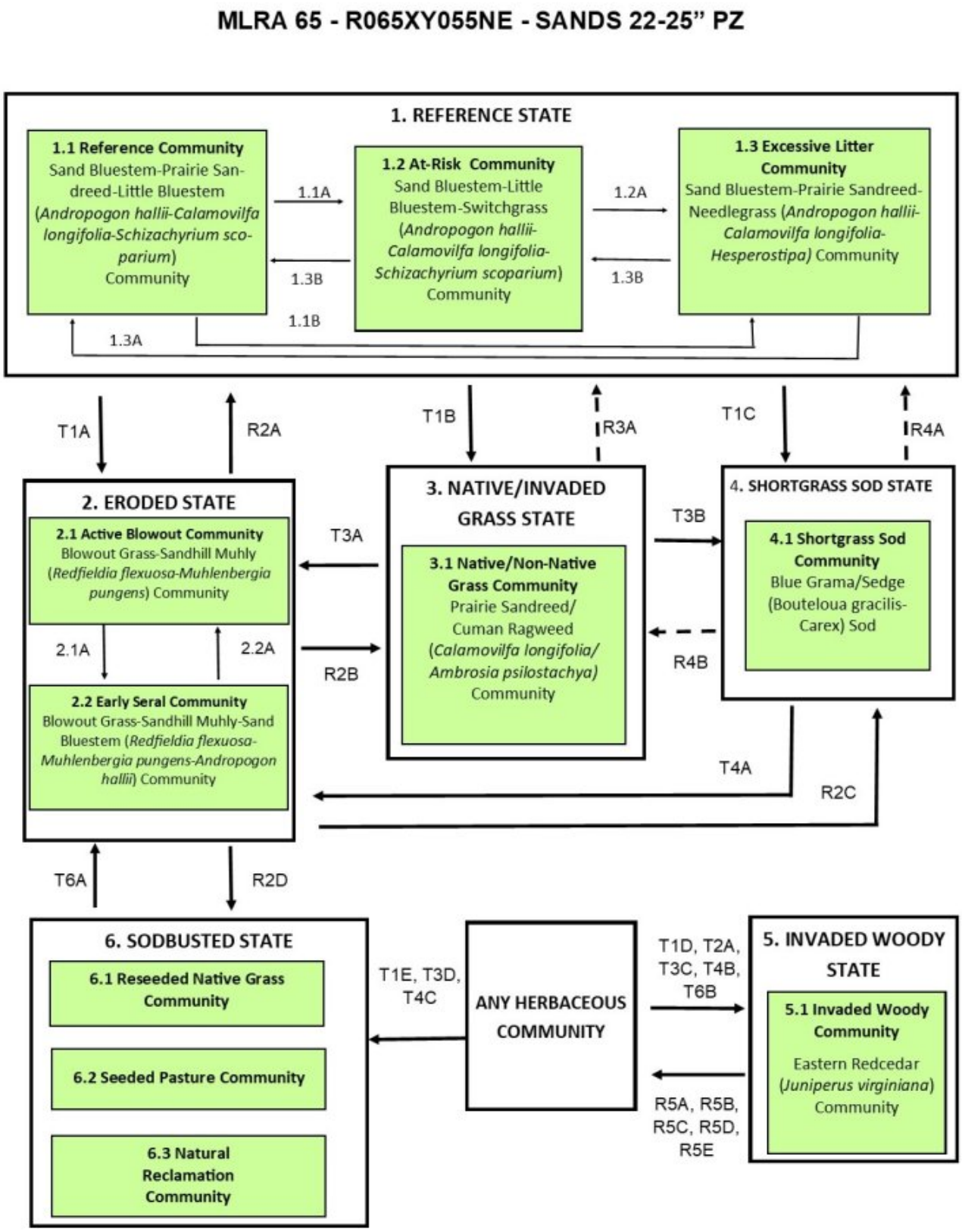

Figure 8. State and Transition Diagram, Sands 22-25 PZ Ecological Site, MLRA 65.

Transitions:
T1A - Frequent and severe defoliation, land disturbance, wind erosion.
T1B - Long-term (> 10 years) , continuous season-long grazing or rotational grazing with inadequate recovery periods.
T1C - Rotational grazing with multiple grazing occupations during the growing season with inadequate growing season recovery time.
T1D - Woody encroachment with no fire or brush management.
T1E - Tillage to facilitate production agriculture.
T2A - Woody encroachment with no fire or brush management.
T3A - Frequent and severe defoliation, land disturbance, wind erosion.
T3B - Rotational grazing with multiple grazing occupations during the growing season with inadequate growing season recovery time.
T3C - Woody encroachment with no fire or brush management.
T3D - Tillage to facilitate production agriculture
T4A - Frequent and severe defoliation, land disturbance, wind erosion.
T4B - Woody encroachment with no fire or brush management.
T4C - Tillage to facilitate production agriculture
T6A - Frequent and severe defoliation, land disturbance, wind erosion.
T6B - Woody encroachment with no fire or brush management.
Restorations:
R2A - Removal of disturbance with long-term (> 10 years) prescribed grazing.
R2B - Removal of disturbance with long-term (> 10 years) prescribed grazing.
R2C - Removal of disturbance with long-term (> 10 years) prescribed grazing.
R2D- Removal of disturbance with long-term (> 10 years) prescribed grazing.
R3A - Long-term (>15 years) prescribed grazing with adequate growing season recovery time. This restoration may not be feasible.
R4A - Long-term (>15 years) prescribed grazing with adequate growing season recovery time. This restoration may not be feasible.
R4B - Long-term (>15 years) prescribed grazing with adequate growing season recovery time. This restoration may not be feasible.
R5A - Prescribed burning, timber harvest, brush management.
R5B - Prescribed burning, timber harvest, brush management.
R5C - Prescribed burning, timber harvest, brush management.
R5D - Prescribed burning, timber harvest, brush management.
R5E - Prescribed burning, timber harvest, brush management.

Community Pathways:
1.1A - Moderate, continuous season-long grazing or rotational grazing with inadequate growing season recovery periods.
1.1B - Prolonged (> 5 years) absence of herbivory and fire.
1.2A - Prescribed grazing with adequate, growing season recovery time.
1.2B - Prolonged (> 5 years) absence of herbivory and fire.
1.3A - Prescribed grazing, prescribed burning.
1.3B - Prescribed grazing, prescribed burning.
2.1A - Prescribed grazing that includes concentrated, short-term animal impact.
2.2B - Continuous, season-long grazing or rotational grazing with inadequate growing season recovery periods.

Figure 9. State and Transition Diagram Legend, Sands 22-25 PZ Ecological Site, MLRA 65.

State 1
Reference State

The Reference State (1) describes the range of vegetative communities that occur on the Sands 22-25" 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. 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
- little bluestem (*Schizachyrium scoparium*), grass
- switchgrass (*Panicum virgatum*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass
- porcupinegrass (*Hesperostipa spartea*), grass

Community 1.1
Reference Community

Interpretations are primarily based on the Reference or Sand Bluestem-Prairie Sandreed-Little Bluestem (*Andropogon hallii-Calamovilfa longifolia-Schizachyrium scoparium*) 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 changes in precipitation timing and abundance, and to fire and grazing events. This site developed with grazing by large herbivores and is well suited for grazing by domestic livestock. This plant community consists chiefly of warm-season, tall- and midgrasses. Sand bluestem, prairie sandreed, and little bluestem are the dominant grasses. Grasses of secondary importance include Indiangrass, switchgrass, needle and thread, porcupinegrass, blue grama, and hairy grama. Sedges occur in the understory. The forb population is diverse. Leadplant, western sandcherry, and rose are common shrubs. This the potential vegetative composition is 80 to 90 percent grasses, 5 to 10 percent forbs, and 1 to 5 percent shrubs by weight. 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, facilitating tree and shrub encroachment. 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 resilient community is well adapted to Northern Great Plains climatic conditions. Plant diversity promotes strong tolerance to drought, 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

- sand bluestem (*Andropogon hallii*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- little bluestem (*Schizachyrium scoparium*), grass

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1750	2325	2790
Forb	125	195	275
Shrub/Vine	25	80	135
Total	**1900**	**2600**	**3200**

Figure 11. 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 Sand Bluestem-Little Bluestem-Switchgrass (*Andropogon hallii-Schizachyrium scoparium-Panicum virgatum*) Community (1.2) develops with moderate continuous season-long grazing or rotational grazing with inadequate growing season recovery time. Most of the palatable plants of the Reference Community (1.1) are present, but production from these grasses is reduced. Warm-season tallgrasses are the dominant component in the plant community. Indiangrass is present at trace amounts or is missing from the plant community, while sand bluestem, needle and thread, and porcupinegrass are reduced. This community has higher overall production of shrubs as compared to the Reference Community and excessive removal of forage will cause a further increase in shrubs. Sand bluestem, little bluestem, switchgrass and prairie sandreed are the dominant grasses. Grasses or grass-like plants of secondary importance include blue grama, hairy grama. The forb component remains diverse and leadplant, western sandcherry, and rose are the dominant shrubs. The potential vegetative composition is 75 to 85 percent grasses or grass-like plants, 5 to 15 percent forbs, and 5 to 10 percent shrubs. Overall, plants have strong, healthy root systems allowing production to increase dramatically with favorable precipitation. The community is drought resistant due to the remaining tall- and midgrass diversity. These warm-season grasses cure well for winter forage stockpiling. Soil health is near optimum. This plant community has slightly less litter as compared to the Reference Community. This plant community is somewhat resistant to change with continued moderate grazing. The resiliency of the plant community is dependent upon the type of management system employed and the intensity and duration of any disturbance. Management that includes adequate growing season recovery time will move the plant community to the Reference Community while increased disturbance, such as drought or heavy grazing, will cause further loss of warm-season tall- and midgrasses and transition to the Shortgrass Sod State (4). Seasonal grazing during the summer will cause the community to transition to the Native/Invaded Grass State (3).

Dominant plant species

- sand bluestem (*Andropogon hallii*), grass
- switchgrass (*Panicum virgatum*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1480	1900	1975
Forb	110	230	375
Shrub/Vine	110	170	250
Total	**1700**	**2300**	**2600**

Figure 13. 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-Prairie Sandreed-Needlegrass-(*Andropogon hallii-Calamovilfa longifolia*-Hesperostipa) Community (1.3) develops when the natural disturbances of livestock grazing and fire have been

removed from the land for a prolonged period of time (more than five years). This plant community is characterized by a high amount of litter covering the soil with widely dispersed mature plants with very few tillers resulting in low vegetative reproduction. Plant litter accumulates rapidly as this community first develops. As the undisturbed duff layer deepens, infiltration of the precipitation is interrupted and evaporation increases significantly, simulating drought-like conditions. Typically, bunchgrasses develop dead centers and rhizomatous grasses form small colonies due to a lack of tiller stimulation. Pedestalling is usually evident. As non-use continues, plant frequency and production decrease. As grazing and fire continue to be excluded from the with continued exclusion of livestock grazing and fire, 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 and will begin to invade the plant community. This community is very vulnerable to encroachment by eastern redcedar. Sand bluestem, prairie sandreed, needle and thread, and porcupinegrass are the dominant grasses. Grasses of secondary importance include little bluestem, switchgrass, and sand lovegrass, The other grasses present vary with the length of use exclusion. The dominant forbs typically include Cuman ragweed and spiny phlox. The shrub community typically includes rose, western sandcherry, and leadplant. The potential vegetative composition is 85 to 95 percent grasses or grass-like plants, 2 to 10 percent forbs, and 2 to 5 percent shrubs. As compared to the Reference Community (1.1), plant diversity has decreased, and native plants tend to occur in individual colonies. This plant community has a high amount of litter covering the soil between widely dispersed mature plants. Soil erosion is low. Infiltration and runoff initially are not significantly different than the Reference Community. As non-use continues, the litter layer thickens, and moisture is held in the litter decreasing infiltration. The health and vigor of native, warm-season, tall- and midgrasses declines as the litter layer thickens. This plant community will change rapidly when grazing by domestic livestock or fire are reintroduced but the longer the period of non-use, the more time is required for the return to the initial community. If the intensity and duration of the disturbance is inadequate, the plant community will rapidly return to the Excessive Litter Community. As non-use continues, non-native cool-season grasses will enter the plant community and if the period of non-use is extensive (ten or more years), the plant community will transition to the Native/Invaded Grass State.

Dominant plant species

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

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1710	2230	2750
Forb	45	85	125
Shrub/Vine	45	85	125
Total	**1800**	**2400**	**3000**

Figure 15. 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

Continuous, season-long grazing or rotational grazing with inadequate growing season recovery periods will move the Reference Community (1.1) to the At- Risk Community (1.2). Heavy grazing accelerates this process.

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 periods. Prescribed burning may accelerate this process.

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 which includes prescribed grazing with adequate growing season recovery periods 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 (more than ten years), 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 return to the Reference Community.

Pathway 1.3B
Community 1.3 to 1.2

Reintroduction of the natural processes of herbivory which includes prescribed grazing with adequate growing season recovery periods and fire will return the Excessive Litter Community (1.3) to the At- Risk Community (1.1).

State 2
Eroded State

The Eroded State (2) can be reached from any plant community in the Reference State (1), Native/Invaded Grass State (3), the Shortgrass Sod State (4), or the Sodbusted State (6). This state is the result of heavy disturbance, which is usually frequent and severe defoliation. The Eroded State can also occur with vehicle traffic, livestock trailing or other heavy disturbances. Long-term drought or dormant season wildfire coupled with the heavy disturbance will accelerate the move to the Eroded State. The Eroded State (2) includes the Blowout Community (2.1) and the Early Seral Community (2.2).

Dominant plant species

- blowout grass (*Redfieldia flexuosa*), grass
- sandhill muhly (*Muhlenbergia pungens*), grass
- sand bluestem (*Andropogon hallii*), grass
- lemon scurfpea (*Psoralidium lanceolatum*), other herbaceous
- Texas croton (*Croton texensis*), other herbaceous
- annual buckwheat (*Eriogonum annuum*), other herbaceous

Community 2.1
Active Blowout Community

The Active Blowout or Blowout Grass-Sandhill Muhly (*Redfieldia flexuosa-Muhlenbergia pungens*) Community (2.1) can be reached from any plant community in Reference State (1), Shortgrass Sod State (3), Invaded Woody State (4), or Sodbusted State (5) in the presence of significant disturbances resulting in frequent defoliation, such as heavy grazing or repeated wildfire, or other heavy land disturbance. The Active Blowout Community is characterized by large areas of blowing sand which results in movement, and possibly enlargement, of the blowout. Under these

conditions, evaporation is extremely high and transpiration by the few existing plants is also high. The bare ground, lack of litter and low plant density all contribute to high evaporation and transpiration. This community is kept in a very low successional stage by the steep side slopes of the blowout, blowing sand, and lack of soil development. Sandhill muhly and blowout grass are present due to their drought tolerance and ability to withstand burial by blowing sand.

Dominant plant species

- blowout grass (*Redfieldia flexuosa*), grass
- sandhill muhly (*Muhlenbergia pungens*), grass

Figure 16. Plant community growth curve (percent production by month). NE6538, NE/SD Sandhills, Active Blowout. Areas of open, blowing sand and pioneer species.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	10	35	30	20	5	0	0	0

Community 2.2
Early Seral Community

As succession progresses, the Blowout Community (2.1) moves toward the Early Seral or Blowout grass-Sandhill Muhly-Sand Bluestem (*Redfieldia flexuosa-Muhlenbergia pungens-Andropogon hallii*) Community (2.2). Sandhill muhly, blowout grass, and sand bluestem are the earliest colonizers. Annual grasses such as sandbur are common. Lemon scurfpea, Texas croton, and common sunflower are frequent forbs. Prairie sandreed, hairy grama, and rose slowly become present the plant community and eventually other warm-season tall- and midgrasses will enter the plant community. Disturbances such as heavy grazing or wildfire will return the community to the Active Blowout Community. Long-term (greater than 10 years) prescribed grazing with incorporation of adequate, growing season recovery periods (deferment) will move the plant community toward the previous state. The slope, aspect, and size of the area, as well as the relative abundance of perennial plants, will influence the amount of time required for this restoration.

Dominant plant species

- blowout grass (*Redfieldia flexuosa*), grass
- sandhill muhly (*Muhlenbergia pungens*), grass
- sand bluestem (*Andropogon hallii*), grass
- lemon scurfpea (*Psoralidium lanceolatum*), other herbaceous
- common sunflower (*Helianthus annuus*), other herbaceous

Pathway 2.1A
Community 2.1 to 2.2

The Active Blowout Community (2.1) can be moved to the Early Seral Community (2.2) by removing the long term, concentrated animal impact or other existing disturbance and replacing it with prescribed grazing that incorporates concentrated short-term animal impact. This short-term animal impact can be achieved through activities such as feeding hay on the blowout. Establishment of vegetation may be accelerated by broadcast seeding a temporary cover crop prior to the removal of animal impact to provide cover to reduce wind erosion.

Pathway 2.2A
Community 2.2 to 2.1

Continuous season long grazing or rotational grazing that does not include adequate growing season recovery time or other disturbance which causes defoliation without allowing time for the grasses to recover will return the Early Seral Community (2.2) to the Active Blowout Community (2.1).

State 3
Native/Invaded Grass State

The Native/Invaded Grass State (3) 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 and non-native, cool-season grasses have invaded the plant community. 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. The management that typically results in the Native/Invaded Grass State is heavy, continuous, grazing during the summer and fall months but heavy rotational grazing with inadequate growing season recovery periods can also cause this transition. The loss of warm-season tall- and midgrasses negatively impacts energy flow and nutrient cycling and alters hydrologic function. Runoff is higher and infiltration is lower than the Reference State. The Native/Invaded Grass State includes the Native/Non-Native Grass Community (3.1).

Dominant plant species

- sand dropseed (*Sporobolus cryptandrus*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- smooth brome (*Bromus inermis*), grass
- blue grama (*Bouteloua gracilis*), grass
- prairie sandreed (*Calamovilfa longifolia*), grass
- needle and thread (*Hesperostipa comata ssp. comata*), grass
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous
- prairie sunflower (*Helianthus petiolaris*), other herbaceous
- common sunflower (*Helianthus annuus*), other herbaceous

Community 3.1
Native/Non-Native Grass Community

The Native/Non-Native Grass or Prairie Sandreed/Ragweed (*Calamovilfa longifolia*/*Ambrosia psilostachya*) Community (3.1) represents a transition from the Reference State (1) across an ecologic threshold. This community typically develops under historic heavy grazing with continued seasonal grazing beginning in early May. The plant community is a mixture of warm-season tallgrasses and cool-season grasses. As compared to the Reference Community (1.1), warm-season tall- and midgrass diversity is greatly reduced as most warm-season tall- and midgrasses are missing or are found only in trace amounts. Forbs and shrubs have increased as a proportion of the plant community. Non-native grasses, typically Kentucky bluegrass or smooth brome, have invaded the plant community non-native grasses are often a subdominant group. The amount of ground cover is higher than expected due to the sod-forming nature of Kentucky bluegrass and smooth brome. Prairie sandreed, Kentucky bluegrass or smooth brome, and sand dropseed are typically the dominant grasses. Other grasses present include blue grama, hairy grama, Scribner's rosettegrass, and needle and thread. Cuman ragweed is the dominant forb. Shrubs have increased in abundance; western snowberry and other shrubs not typically found in the Reference Community are the dominant shrub species. The potential vegetative composition is 60 to 75 percent grasses and grass- likes, 10 to 25 percent forbs, and 10 to 15 percent shrubs. As compared to the Reference Community total annual production is reduced by 25 to 35 percent. Plant diversity is reduced. Litter is lower but soil erosion is low due to the sod-forming nature of the plant community. Infiltration and runoff are not greatly impacted due to the nature of the soils. This plant community is considered stable and is somewhat resistant to change but is a risk of transitioning to the Eroded State (2) with long- term drought or with heavy grazing. The plant community is moderately resilient, and its resiliency depends upon the intensity and duration of disturbances.

Dominant plant species

- prairie sandreed (*Calamovilfa longifolia*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- Cuman ragweed (*Ambrosia psilostachya*), other herbaceous

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1055	1230	1475
Forb	165	300	450
Shrub/Vine	80	170	275
Total	**1300**	**1700**	**2200**

Figure 18. Plant community growth curve (percent production by month). NE6539, NE/SD Sandhills, Native Grass, Disturbed. Warm-season and cool-season co-dominant, short-, mid-, and tallgrasses.

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

State 4
Shortgrass Sod State

The Shortgrass Sod State (4) transitioned from either the Reference State (1) or the Native/Invaded Grass State (3) and much of the native warm-season tall- and midgrass components have been replaced by warm-season shortgrasses and upland sedges. This state occurs with rotational grazing systems which include multiple grazing occupations that do not allow adequate growing season recovery time. The plant community is dominated by warm-season shortgrass, cool-season grass, and grass-likes. The loss of warm-season tall- and midgrasses negatively impacts energy flow and nutrient cycling and alters hydrologic function. Runoff is higher and infiltration is lower than the Reference State. This state is resistant to change. The Shortgrass Sod State includes the Shortgrass Sod Community (4.1).

Dominant plant species

- blue grama (*Bouteloua gracilis*), grass
- hairy grama (*Bouteloua hirsuta*), grass
- sedge (*Carex*), other herbaceous

Community 4.1
Shortgrass Sod Community

The Shortgrass Sod or Blue Grama/Carex (*Bouteloua gracilis*-Carex) Community (4.1) develops from Reference State with rotational grazing systems which have multiple occupations accompanied with inadequate recovery time between occupations. Blue grama is the dominant grass. Hairy grama, sedges, sand dropseed and needle and thread are also common in the plant community. Switchgrass, prairie sandreed, and sand bluestem may also be present. When entry into pastures is delayed until early to mid-June, Kentucky bluegrass or smooth brome will present. Cuman ragweed and prairie sunflower are common forbs. Rose and brittle pricklypear are common shrubs. Compared to the Reference Community (1.1) most warm-season tall- and midgrasses are substantially reduced while warm-season shortgrasses have significantly increased. Cuman ragweed, sedges, and rose have also increased as compared to the Reference Community. Plant diversity is significantly reduced. This plant community resistant to change due to the low percentage of bare ground and the community is highly resilient with disturbances. Soil erosion is low. Hydrologic function is impaired due to a reduction in litter, increased runoff, and reduced infiltration.

Dominant plant species

- blue grama (*Bouteloua gracilis*), grass
- sedge (*Carex*), other herbaceous

Figure 19. 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 5
Invaded Woody State

The Invaded Woody State (5) 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 Eroded State (2), the Native/Invaded Grass State (3), the Shortgrass Sod State (4) or the Sodbusted State (6), 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 (5.1).

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- blue grama (*Bouteloua gracilis*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- sedge (*Carex*), other herbaceous

Community 5.1
Invaded Woody Community

The Invaded Woody Community or Eastern Redcedar (*Juniperus virginiana*) Community (5.1) has at least 15 percent canopy cover consisting of trees generally 5 feet or taller. Encroaching trees are primarily eastern redcedar. Additional woody cover from deciduous trees and shrubs may be present. 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 red cedars 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. 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
- needle and thread (*Hesperostipa comata ssp. comata*), grass
- Kentucky bluegrass (*Poa pratensis*), grass
- prairie Junegrass (*Koeleria macrantha*), grass

- sedge (*Carex*), other herbaceous

Figure 20. Plant community growth curve (percent production by month). NE6542, NE/SD Sandhills, Eastern Redcedar Encroachment. Closed or nearly closed canopy of eastern redcedar.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			10	30	25	20	10	5			

State 6
Sodbusted State

The threshold to the Sodbusted State (6) 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 and forms resulting in the Reseeded Native Grass Community (6.1), be seeded to a tame pasture forage mixture resulting in the Seeded Pasture Community (6.2) or be abandoned with no seeding which will result in the Natural Reclamation Community (6.3). Permanent alterations of the soil, plant community, and hydrologic cycle make restoration to the Reference State (1) extremely difficult, if not impossible.

Community 6.1
Reseeded Native Grass Community

The Reseeded Native Grass Community (6.1) 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. Many of the areas seeded to native grasses before the 1970's are now dominated by little bluestem. 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 6.2
Seeded Pasture Community

The Seeded Pasture Community (6.2) 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 6.3
Natural Reclamation Community

The Natural Reclamation Community (6.3) 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.

Dominant plant species

- Fendler threeawn (*Aristida purpurea var. longiseta*), grass
- sand dropseed (*Sporobolus cryptandrus*), grass

Transition T1A
State 1 to 2

The Eroded State (2) can be reached from any plant community of the Reference State (1). The Eroded State occurs with frequent and severe defoliation. Heavy, continuous grazing most often causes this transition, but it can also occur with rotational grazing when plants are not given adequate growing season recovery time before the paddocks or pastures are re-grazed. This process is accelerated when accompanied by additional disturbances, such as dormant season wildfire or extended drought (generally below average precipitation for 10 or more years). Heavy disturbance, such as vehicle traffic or livestock trailing can also cause this transition. The reduction in plant canopy and litter cover allows wind erosion to develop, creating large areas of blowing sand.

Transition T1B
State 1 to 3

The Reference State (1) transitions to the Native/Invaded Grass State (3) in response to long-term (greater than ten years), heavy, seasonal grazing beginning in June. The Reference State loses a significant proportion of warm-season, tall- and midgrasses and crosses a threshold to the Native/Invaded Grass State. Non-native, cool-season grasses, typically Kentucky bluegrass invade the site, eventually becoming subdominant to co-dominant.

Transition T1C
State 1 to 4

The Reference State (1) typically transitions to the Shortgrass Sod State (3) in response to rotational grazing with multiple grazing occupations during the growing season without adequate growing season recovery time. The Reference State loses a significant proportion of warm-season, tall- and midgrasses and crosses a threshold to the Shortgrass Sod 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 have significantly declined. Initially, the plant community is a mosaic, with shortgrass and mixed grass communities intermingled but as the management continues the plant community becomes dominated by shortgrasses.

Transition T1D
State 1 to 5

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 (5).

Transition T1E
State 1 to 6

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 (6). The disruption to the plant community, the soil, and the hydrology of the system prevent restoration to a true Reference State.

Restoration pathway R2A
State 2 to 1

The Eroded State (2) can be restored to the Reference State (1) with long term (10 or more years) prescribed

grazing. Initially, grazing management that incorporates concentrated short-term animal impact (such as feeding hay on the blowout) will encourage growth of early successional grasses and forbs. When either human-caused disturbance or livestock concentration caused the transition from the Reference State, removal of the disturbance along with appropriate grazing management is needed. With long term prescribed grazing, succession progresses, and the land will eventually return to the Reference State.

Restoration pathway R2B
State 2 to 3

The Eroded State (2) can be restored to the Native/Invaded Grass State (3) with long term (10 or more years) prescribed grazing. Initially, grazing management that incorporates concentrated short- term animal impact (such as feeding hay on the blowout) will encourage growth of early successional grasses and forbs. When either human-caused disturbance or livestock concentration caused the transition to the Eroded State, removal of the disturbance along with appropriate grazing management is needed. With long term prescribed grazing, succession progresses, and the land will eventually return to the Native/Invaded Grass State. Land that entered the Eroded State from the Native/Invaded Grass State, the Shortgrass Sod State (4), or the Sodbusted State (6) cannot return directly to the Reference State (1) as the plant community composition had been significantly altered before the land entered the Eroded State.

Restoration pathway R2C
State 2 to 4

The Eroded State (2) can be restored to the Shortgrass Sod State (4) with long term (10 or more years) prescribed grazing. Initially, grazing management that incorporates concentrated short- term animal impact (such as feeding hay on the blowout) will encourage growth of early successional grasses and forbs. When either human-caused disturbance or livestock concentration caused the transition to the Eroded State, removal of the disturbance along with appropriate grazing management is needed. With long term prescribed grazing, succession progresses, and the land will eventually return to the Shortgrass Sod State. Land that entered the Eroded State from the Native/Invaded Grass State (3), the Shortgrass Sod State, or the Sodbusted State (6) cannot return directly to the Reference State (1) as the plant community composition had been significantly altered before the land entered the Eroded State.

Transition T2A
State 2 to 5

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 Eroded State (2) to transition to the Invaded Woody State (5).

Transition R2D
State 2 to 6

The Eroded State (2) can be returned to the Sodbusted State (6) with long term (10 or more years) prescribed grazing. Initially, grazing management that incorporates concentrated short- term animal impact (such as feeding hay on the blowout) will encourage growth of early successional grasses and forbs. When either human-caused disturbance or livestock concentration caused the transition to the Eroded State, removal of the disturbance along with appropriate grazing management is needed. With long term prescribed grazing, succession progresses, and the land will eventually return to the Sodbusted State. Re-seeding may be needed to return to any community other than the Natural Reclamation Community (6.3).

Restoration pathway R3A
State 3 to 1

Long-term (more than 15 years) prescribed grazing with adequate growing season recovery periods will move the Native/Invaded Grass 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 and the degree to which non-native grasses have invaded the plant community.

This restoration may not be feasible.

Transition T3A
State 3 to 2

The Invaded Native Grass State (3) transitions to the Eroded State (2) with frequent and severe defoliation. Heavy, continuous grazing most often causes this transition, but it can also occur with rotational grazing when plants are not given adequate growing season recovery time before the paddocks or pastures are re-grazed. This process is accelerated when accompanied by additional disturbances, such as dormant season wildfire or extended drought (generally below average precipitation for 10 or more years). Heavy disturbance, such as vehicle traffic or livestock trailing can also cause this transition. The reduction in plant canopy and litter cover allows wind erosion to develop, creating large areas of blowing sand.

Transition T3B
State 3 to 4

The Native/Invaded Grass State (3) typically transitions to the Shortgrass State (4) in response to rotational grazing with multiple grazing occupations during the growing season without adequate growing season recovery time. The Native/Invaded Grass State loses a significant proportion of warm-season, tall- and midgrasses and crosses a threshold to the Shortgrass Sod 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 have significantly declined.

Transition T3C
State 3 to 5

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 Native/Invaded Grass State (3) to transition to the Invaded Woody State (5).

Transition T3D
State 3 to 6

The Native/Invaded Grass State (3) has been significantly altered by tillage to facilitate production agriculture. When the land is no longer cropped, the resulting state is the Sodbusted State (5). The disruption to the plant community, the soil, and the hydrology of the system prevent restoration to a Native/Invaded Grass State.

Restoration pathway R4A
State 4 to 1

Long-term (more than 15 years) prescribed grazing with adequate growing season recovery periods will move the Shortgrass Sod State (4) 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 T4A
State 4 to 2

The Shortgrass State (4) transitions to the Eroded State (2) with frequent and severe defoliation. Heavy, continuous grazing most often causes this transition, but it can also occur with rotational grazing when plants are not given adequate growing season recovery time before the paddocks or pastures are re-grazed. This process is accelerated when accompanied by additional disturbances, such as dormant season wildfire or extended drought (generally below average precipitation for 10 or more years). Heavy disturbance, such as vehicle traffic or livestock trailing can also cause this transition. The reduction in plant canopy and litter cover allows wind erosion to develop, creating large areas of blowing sand.

Restoration pathway R4B
State 4 to 3

Long-term (more than 15 years) prescribed grazing with adequate growing season recovery periods will move the Shortgrass State (4) toward the Native/Invaded Grass State (3). 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 T4B
State 4 to 5

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 Sod State (4) to transition to the Invaded Woody State (5).

Transition T4C
State 4 to 6

The Shortgrass Sod State (4) has been significantly altered by tillage to facilitate production agriculture. When the land is no longer cropped, the resulting state is the Sodbusted State (5). The disruption to the plant community, the soil, and the hydrology of the system prevent restoration to the Shortgrass Sod State.

Restoration pathway R5A
State 5 to 1

The Invaded Woody State (5) 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 Native/Invaded Grass State by management practices. The amount of time required for this restoration to occur depends on the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from the Eroded State (2), the Native/Invasive Grass State (3), the Shortgrass Sod State (4), or the Sodbusted State (6) 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 removal of brush alone.

Restoration pathway R5B
State 5 to 2

The Invaded Woody State (5) can be restored to the Eroded 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 Eroded State by management practices. The amount of time required for this restoration to occur depends on the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from Eroded 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.

Restoration pathway R5C
State 5 to 3

The Invaded Woody State (5) can be restored to the Native/Invaded State (3) 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 Native/Invaded Grass State by management practices. The amount of time required for this

restoration to occur depends on the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from Native/Invaded 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.

Restoration pathway R5D
State 5 to 4

The Invaded Woody State (5) can be restored to the Shortgrass Sod 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 Shortgrass Sod State by management practices. The amount of time required for this restoration to occur depends on the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from Shortgrass Sod 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.

Restoration pathway R5E
State 5 to 6

The Invaded Woody State (5) can be restored to the Sodbusted State (6) 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. The amount of time required for this restoration to occur depends on the severity and duration of the encroachment. Land that transitioned to the Invaded Woody State from 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 T6A
State 6 to 2

Transition T6B
State 6 to 5

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 (5).

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm-Season Tallgrass**			1300–1560	
	sand bluestem	ANHA	*Andropogon hallii*	650–1040	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	390–650	–
	switchgrass	PAVI2	*Panicum virgatum*	260–520	–
	Indiangrass	SONU2	*Sorghastrum nutans*	130–390	–
	Grass, perennial	2GP	*Grass, perennial*	0–130	–
2	**Warm-Season Midgrass**			520–780	
	little bluestem	SCSC	*Schizachyrium scoparium*	390–650	–

	little bluestem	SCSC	*Schizachyrium scoparium*	390–650	
	sand lovegrass	ERTR3	*Eragrostis trichodes*	130–390	–
	Grass, perennial	2GP	*Grass, perennial*	0–130	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–104	–
3	**Warm-Season Shortgrass**			26–260	
	blue grama	BOGR2	*Bouteloua gracilis*	26–260	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	26–130	–
	thin paspalum	PASE5	*Paspalum setaceum*	0–78	–
	Grass, perennial	2GP	*Grass, perennial*	0–52	–
4	**Native Cool-Season Grass**			390–520	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	130–260	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	130–260	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	26–130	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	26–130	–
	Grass, perennial	2GP	*Grass, perennial*	26–78	–
5	**Grass-like**			26–130	
	sedge	CAREX	*Carex*	26–130	–
Forb					
6	**Forbs**			130–260	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–52	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–52	–
	field sagewort	ARCA12	*Artemisia campestris*	0–52	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	0–52	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–52	–
	Carolina puccoon	LICA13	*Lithospermum caroliniense*	0–52	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–52	–
	dotted blazing star	LIPU	*Liatris punctata*	0–52	–
	Forb, perennial	2FP	*Forb, perennial*	0–52	–
	Forb, annual	2FA	*Forb, annual*	0–52	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–26	–
	American bird's-foot trefoil	LOUN	*Lotus unifoliolatus*	0–26	–
	large beardtongue	PEGR7	*Penstemon grandiflorus*	0–26	–
	thistle	CIRSI	*Cirsium*	0–26	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–26	–
	lemon scurfpea	PSLA3	*Psoralidium lanceolatum*	0–26	–
	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	0–26	–
	stiff goldenrod	OLRI	*Oligoneuron rigidum*	0–26	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	0–26	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–26	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–26	–
Shrub/Vine					
7	**Shrubs**			26–130	
	scurfpea	PSORA2	*Psoralidium*	0–78	

	scurfpea	PSORA2	*Psoralidium*	0–78	–
	Forb, perennial	2FP	*Forb, perennial*	0–52	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–52	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–52	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–52	–
	blazing star	LIATR	*Liatris*	0–52	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–26	–
	beardtongue	PENST	*Penstemon*	0–26	–
	thistle	CIRSI	*Cirsium*	0–26	–
	goldenrod	SOLID	*Solidago*	0–26	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–26	–
	spiderwort	TRADE	*Tradescantia*	0–26	–

Table 10. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm-Season Tallgrass**			805–1265	
	sand bluestem	ANHA	*Andropogon hallii*	345–805	–
	switchgrass	PAVI2	*Panicum virgatum*	260–575	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	230–460	–
	Indiangrass	SONU2	*Sorghastrum nutans*	0–115	–
	Grass, perennial	2GP	*Grass, perennial*	0–115	–
2	**Warm-Season Midgrass**			345–690	
	little bluestem	SCSC	*Schizachyrium scoparium*	345–690	–
	purple lovegrass	ERSP	*Eragrostis spectabilis*	0–115	–
	sand lovegrass	ERTR3	*Eragrostis trichodes*	0–115	–
	blowout grass	REFL	*Redfieldia flexuosa*	0–115	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–115	–
	Grass, perennial	2GP	*Grass, perennial*	0–115	–
3	**Warm-Season Shortgrass**			230–345	
	blue grama	BOGR2	*Bouteloua gracilis*	115–230	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	115–230	–
	thin paspalum	PASE5	*Paspalum setaceum*	0–78	–
	Grass, perennial	2GP	*Grass, perennial*	0–78	–
	sandhill muhly	MUPU2	*Muhlenbergia pungens*	0–46	–
4	**Native Cool-Season Grass**			230–345	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	115–230	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	115–230	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–115	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	0–115	–
	Grass, perennial	2GP	*Grass, perennial*	0–46	–
5	**Grass-like**			23–115	
	sedge	CAREX	*Carex*	23–115	–

Forb					
6	**Forb**			115–345	
	white sagebrush	ARLU	*Artemisia ludoviciana*	0–92	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–92	–
	field sagewort	ARCA12	*Artemisia campestris*	0–92	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–92	–
	Forb, perennial	2FP	*Forb, perennial*	0–92	–
	Forb, annual	2FA	*Forb, annual*	0–92	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–69	–
	Carolina puccoon	LICA13	*Lithospermum caroliniense*	0–69	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–69	–
	dotted blazing star	LIPU	*Liatris punctata*	0–69	–
	lemon scurfpea	PSLA3	*Psoralidium lanceolatum*	0–69	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–69	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	0–46	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–46	–
	aromatic aster	SYOB	*Symphyotrichum oblongifolium*	0–46	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–46	–
	beardtongue	PENST	*Penstemon*	0–46	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–46	–
Shrub/Vine					
7	**Shrub**			115–230	
	leadplant	AMCA6	*Amorpha canescens*	46–115	–
	western sandcherry	PRPUB	*Prunus pumila var. besseyi*	46–115	–
	rose	ROSA5	*Rosa*	46–115	–
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	46–115	–

Table 11. Community 1.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm-Season Tallgrass**			720–1200	
	sand bluestem	ANHA	*Andropogon hallii*	360–840	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	240–480	–
	switchgrass	PAVI2	*Panicum virgatum*	120–360	–
	Indiangrass	SONU2	*Sorghastrum nutans*	0–120	–
	Grass, perennial	2GP	*Grass, perennial*	0–72	–
2	**Warm-Season Midgrass**			360–600	
	little bluestem	SCSC	*Schizachyrium scoparium*	240–480	–
	sand lovegrass	ERTR3	*Eragrostis trichodes*	120–240	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–120	–
	Grass, perennial	2GP	*Grass, perennial*	0–48	–
3	**Warm-Season Shortgrass**			0–120	
	blue grama	BOGR2	*Bouteloua gracilis*	0–120	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	0–120	

	hairy grama	BOHI2	*Bouteloua hirsuta*	0–120	–
	thin paspalum	PASE5	*Paspalum setaceum*	0–120	–
	Grass, perennial	2GP	*Grass, perennial*	0–48	–
4	**Native Cool-Season Grass**			480–840	
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	240–480	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	240–480	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	48–192	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	48–192	–
	Grass, perennial	2GP	*Grass, perennial*	0–48	–
5	**Grass-like**			24–48	
	sedge	CAREX	*Carex*	24–48	–
8	**Non-Native Cool-Season Grass**			0–120	
	cheatgrass	BRTE	*Bromus tectorum*	0–120	–
	field brome	BRAR5	*Bromus arvensis*	0–120	–
	Kentucky bluegrass	POPR	*Poa pratensis*	0–120	–
Forb					
6	**Forb**			48–120	
	Forb, perennial	2FP	*Forb, perennial*	0–120	–
	Forb, annual	2FA	*Forb, annual*	0–120	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–120	–
	spiny phlox	PHHO	*Phlox hoodii*	0–120	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–72	–
	beardtongue	PENST	*Penstemon*	0–48	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	0–48	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–48	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–48	–
	thistle	CIRSI	*Cirsium*	0–48	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–48	–
	field sagewort	ARCA12	*Artemisia campestris*	0–48	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–48	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–48	–
	dotted blazing star	LIPU	*Liatris punctata*	0–48	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–48	–
Shrub/Vine					
7	**Shrub**			48–120	
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	48–120	–
	leadplant	AMCA6	*Amorpha canescens*	0–72	–
	western sandcherry	PRPUB	*Prunus pumila var. besseyi*	0–72	–
	rose	ROSA5	*Rosa*	0–72	–

Table 12. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					

1	**Warm-Season Tallgrass**			340–680	
	prairie sandreed	CALO	*Calamovilfa longifolia*	340–510	–
	switchgrass	PAVI2	*Panicum virgatum*	0–170	–
	sand bluestem	ANHA	*Andropogon hallii*	0–85	–
	Grass, perennial	2GP	*Grass, perennial*	0–34	–
2	**Warm-Season Midgrass**			170–340	
	sand dropseed	SPCR	*Sporobolus cryptandrus*	85–255	–
	little bluestem	SCSC	*Schizachyrium scoparium*	0–170	–
	purple lovegrass	ERSP	*Eragrostis spectabilis*	0–85	–
	Grass, perennial	2GP	*Grass, perennial*	0–34	–
3	**Warm-Season Shortgrass**			85–170	
	hairy grama	BOHI2	*Bouteloua hirsuta*	85–170	–
	blue grama	BOGR2	*Bouteloua gracilis*	85–170	–
	thin paspalum	PASE5	*Paspalum setaceum*	0–85	–
	sandhill muhly	MUPU2	*Muhlenbergia pungens*	0–34	–
	Grass, perennial	2GP	*Grass, perennial*	0–34	–
4	**Cool-Season Grass**			85–255	
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	85–170	–
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	0–85	–
	porcupinegrass	HESP11	*Hesperostipa spartea*	0–85	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–85	–
	Grass, perennial	2GP	*Grass, perennial*	0–34	–
5	**Grass-like**			17–85	
	sedge	CAREX	*Carex*	17–85	–
8	**Non-Native Cool-Season Grass**			340–680	
	Kentucky bluegrass	POPR	*Poa pratensis*	340–680	–
	smooth brome	BRIN2	*Bromus inermis*	0–170	–
	field brome	BRAR5	*Bromus arvensis*	0–85	–
	cheatgrass	BRTE	*Bromus tectorum*	0–85	–
Forb					
6	**Forbs**			170–425	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	170–340	–
	tarragon	ARDR4	*Artemisia dracunculus*	0–170	–
	thistle	CIRSI	*Cirsium*	0–85	–
	stiff sunflower	HEPA19	*Helianthus pauciflorus*	0–85	–
	rush skeletonplant	LYJU	*Lygodesmia juncea*	0–85	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	0–85	–
	lemon scurfpea	PSLA3	*Psoralidium lanceolatum*	0–85	–
	silverleaf Indian breadroot	PEAR6	*Pediomelum argophyllum*	0–85	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	0–85	–
	stiff goldenrod	OLRI	*Oligoneuron rigidum*	0–85	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–85	–
	Forb, annual	2FA	*Forb, annual*	0–85	

	Forb, annual	2FA	*Forb, annual*	0–85	–
	Forb, perennial	2FP	*Forb, perennial*	0–85	–
	dotted blazing star	LIPU	*Liatris punctata*	0–68	–
	scaly blazing star	LISQ	*Liatris squarrosa*	0–68	–
	white heath aster	SYER	*Symphyotrichum ericoides*	0–51	–
Shrub/Vine					
7	**Shrubs**			85–255	
	Shrub (>.5m)	2SHRUB	*Shrub (>.5m)*	34–136	–
	rose	ROSA5	*Rosa*	34–85	–
	leadplant	AMCA6	*Amorpha canescens*	0–34	–
	western sandcherry	PRPUB	*Prunus pumila var. besseyi*	0–34	–

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): 2,600 Stocking Rate (AUM/acre): 0.71
►At-Risk Community (1.2)
Average Production (lb./acre, air-dry): 2,300 Stocking Rate (AUM/acre): 0.63
►Excessive Litter Community (1.3)
Average Production (lb./acre, air-dry): 2,400 Stocking Rate (AUM/acre): 0.66
►Native/Non-Native Grass Community (3.1)
Average Production (lb./acre, air-dry): 1,700 Stocking Rate (AUM/acre): 0.47

*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 Sans 22-25" PZ ecological site. Normal rainfall is 22 to 25 inches per year. Valentine soils on this site are in Hydrologic Soil Group A (low runoff and high infiltration even when thoroughly wetted). Water transmission through Group A soils is normally greater than 0.30 inches per hour. Runoff is expected to occur only during the most intense storms (refer to Section 4, NRCS National Engineering Handbook for runoff quantities and hydrologic curves).

For the interpretive plant community, rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses such as little bluestem. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present but only cover 1 to 2 percent of the soil surface. Overall, this site has the appearance of being very stable and productive.

Recreational uses

This site provides hunting opportunities for upland game species. The wide variety of plants which bloom from spring to fall have an aesthetic value that appeals to visitors.

Wood products

No appreciable wood products are present on the site.

Other products

Seed harvest of native plant species can provide additional income on this site.

Other information

Revision Notes: “This PROVISIONAL ecological site concept has been through the Quality Control and Quality Assurance process 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.

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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.

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Contributors

Dana Larsen
Doug Whisenhunt
Nadine Bishop

Approval

Suzanne Mayne-Kinney, 2/04/2025

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.

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

3. **Number and height of erosional pedestals or terracettes:** Typically, none. Bunch grasses may be slightly pedestalled (0.5 inch/1.25 cm) with no exposed roots; occurrence of pedestalled plants will be rare. Pedestals will typically occur on north and west aspects of slopes exceeding 10 percent and where bunchgrasses are more common. Drought or wildfire can contribute to increased incidences of pedestalled plants.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Bare ground is typically 15 percent or less. Bare ground patches are not connected and are less than 6 inches (15 cm) across, unless associated with disturbance such as burrowing animals. Multi-year drought can increase bare ground to 25 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).

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** Typically, none. Occasional areas associated with concentrated animal activity (livestock trailing and burrowing animals) may exhibit wind scoured areas with accompanying deposition. These areas are typically less than 10 feet (3 meters) across and comprise less than 1 percent of the site.

7. **Amount of litter movement (describe size and distance expected to travel):** Litter should fall in place. Fine litter movement should be less than 6 inches (15 cm). Coarse litter is not expected to move.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** This site has low organic matter in the surface horizon and the structure is single grain sand. Soil stability will be difficult to measure on these soils. Soil stability ratings of less than 2 are expected.

   Surface erosion by water rarely occurs due to rapid infiltration, but the surface is 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.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** The A-horizon should be 2 to 4 inches (5-10 cm) thick. Soils have little organic matter in the A-horizon and soil color is grayish brown (values of 4 to 6) when dry and dark grayish brown colors (values of 3 to 5) when moist. Structure ranges from fine granular to single grained in the A-horizon.

   Valentine 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 (mid & tall rhizomatous and tufted perennial cool season grasses) with fine and coarse roots positively influences infiltration. Woody encroachment may adversely impact infiltration on this site.

    The expected composition of the plant community is 85 to 90 percent grasses and grass-likes, 5-10 percent forbs, and 1to 5 percent shrubs. The perennial grass component is made up of warm-season tallgrass (50-60%), warm-season midgrass (20-30%), warm-season shortgrass (1-10%), and cool-season grass (15-20%).

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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, 1300-1560 #/ac, 50-60%, 4 species minimum: sand bluestem, prairie sandreed, switchgrass, Indiangrass.
    2. Native, perennial, warm-season midgrass, 520-780 #/ac, 20-30%, 2 species minimum: little bluestem, sand lovegrass, sand dropseed.

    Phase 1.2
    1.Native, perennial, warm-season tallgrass, 805-1265 #/ac, 35-55%, 3 species minimum: sand bluestem, prairie sandreed, switchgrass, Indiangrass.
    2. Native, perennial, warm-season midgrass, 345-690 #/ac, 15-30%, 1 species minimum: little bluestem, sand lovegrass, sand dropseed, blowout grass, purple lovegrass.

    Phase 1.3
    1. Native, perennial, warm-season tallgrass, 720-1260 #/ac, 30-50%, 3 species minimum: sand bluestem, prairie sandreed, switchgrass, Indiangrass.
    2. Native, perennial, cool-season grass, 480-840 #/ac, 20-35%, 4 species minimum: needle and thread, porcupinegrass, Scribner's rosette grass, prairie Junegrass.

    Sub-dominant: Phase 1.1
    1. Native, perennial, cool-season grass, 390-520 #/ac, 15-20%, 4 species minimum: needle and thread, porcupinegrass, Scribner's rosette grass, prairie Junegrass.

    Phase 1.2

1. Native, perennial, cool-season grass, 230-345 #/ac, 10-15%, 2 species minimum: needle and thread, porcupinegrass, Scribner's rosette grass, prairie Junegrass.
2. Native, perennial, warm-season shortgrass, 230-345 #/ac, 10-15%, 2 species minimum: blue grama, hairy grama, thin paspalum, sandhill muhly.
3. Native forb, 230-345 #/ac, 10-15%, 3 species minimum: forbs present vary from location to location.

Phase 1.3
1. Native, perennial, warm-season midgrass, 360-600 #/ac, 15-25%, 2 species minimum: little bluestem, sand lovegrass, sand dropseed.

Other: Minor - Phase 1.1
1. Native forb, 130-260 #/ac, 5-10%: forbs present vary from location to location.
2. Native, perennial, warm-season shortgrass, 26-260 #/ac, 1-10%: blue grama, hairy grama, thin paspalum.
3. Grass-like, 26-130 #/ac, 1-5%: sedge
4. Native shrub, 26-130 #/ac, 1-5%: leadplant, western sandcherry, rose.

Minor - Phase 1.2
1. Native shrub, 115-230 #/ac, 5-10%: leadplant, western sandcherry, rose.
2. Grass-like, 23-115 #/ac, 1-5%: sedge

Minor - Phase 1.3
1. Native forb, 48-120 #/ac, 2-5%: forbs present vary from location to location.
2. Native shrub, 48-120 #/ac, 2-5%: leadplant, western sandcherry, rose.
3. Native, perennial, warm-season shortgrass, 0-120 #/ac, 0-5%: blue grama, hairy grama, thin paspalum, sandhill muhly.
4. Non-native, cool-season grass, 0-120 #/ac, 0-5%: Kentucky bluegrass, field brome, cheatgrass.

Trace - Phase 1.3
1. Grass-like, 24-48 #/ac, 1-2%: sedge

Additional: The Reference Community (1.1) includes seven F/S groups. These groups are, in order of relative abundance, native, perennial, C4 tallgrass; native, perennial, C4 midgrass; native, perennial, C3 grass; native forb, native, perennial, C4 shortgrass; grass-like=shrub.

The At-Risk Community (1.2) includes seven F/S groups which are in order of relative abundance native, perennial, C4 tallgrass, native, perennial, C4 midgrass; native, perennial, C3 grass=native, perennial C4 shortgrass=native forb; shrub; grass-like.

The Excessive Litter Community (1.3) includes eight F/S groups which are native, perennial, C4 tallgrass; native, perennial, C3 grass; native, perennial, C4 midgrass; forb=shrub; native, perennial, C4 shortgrass=non-native C3 grass; grass-like.

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Bunch grasses have strong, healthy centers with few (less than 3 percent) dead centers. Shrubs may show some dead branches (less than 5 percent) as plants age.

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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 60 to 90 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 30 to 50 percent.

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 2,600 pounds per acre on an air dry weight basis. Low and high production years should yield 1,900 and 3,200 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:** No non-native invasive species are present. Annual bromes (cheatgrass and Japanese/field), leafy spurge, absinth wormwood, eastern red cedar, and Kentucky bluegrass 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.

    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.
