USDA Natural Resources Conservation Service

Ecological site HX076XY112
Limy Hills

Last updated: 8/12/2019
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General information

Approved. An approved ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model, enough information to identify the ecological site, and full documentation for all ecosystem states contained in the state and transition model.

MLRA notes

Major Land Resource Area (MLRA): 076X–Bluestem Hills

MLRA 76, is located in Kansas (84 percent) and Oklahoma (16 percent). It makes up about 7,555 square miles (19,585 square kilometers). The towns of Manhattan and El Dorado, Kansas, and Pawhuska, Oklahoma, are in this MLRA. The part of this area in Oklahoma lies between the towns of Ponca City and Bartlesville. Interstates 35 and 70 cross the part of the area in Kansas. The western edge of the Potawatomi Indian Reservation and the Fort Riley Military Base are in the part of the area in Kansas. Most of the Osage Indian Reservation in Oklahoma is in this area. The area is known as the “Flint Hills” in Kansas and the “Osage Hills” in Oklahoma.

Following are the various kinds of land use in this MLRA: Cropland—private, 18 percent; Grassland—private, 69 percent; Federal, 3 percent; Forest—private, 4 percent; Urban development—private, 3 percent; Water—private, 2 percent; Other—private, 1 percent.

Nearly all of this area is in farms or ranches. Nearly three fourths of the area supports native grasses grazed by beef cattle. Nearly one-fifth of the area, consisting mainly of the deeper soils in valleys and on some of the uplands, is cropland. Some winter wheat is grown as a cash crop. Other small grains, grain sorghum, alfalfa, and other kinds of hay are the major crops. These crops are also grown in small irrigated areas along the Arkansas River.

The major soil resource concerns are water erosion, surface compaction, moisture conservation, and maintenance of the
content of organic matter in the soils. Maintenance of plant health and vigor and control of noxious and invading plants are the major management concerns on grassland.

Conservation practices on cropland generally include terraces, grassed waterways, grade-control structures, conservation tillage, and nutrient and pest management. Conservation practices on rangeland generally include brush management, control of noxious weeds, nutrient management, and prescribed grazing.

Classification relationships

Land Resource Region H. Central Great Plains winter wheat and range region. Major Land Resource Area (MLRA) 76 Bluestem Hills.

Ecological site concept

The Limy Hills ecological site was formerly known as Limy Upland (R076XY012KS). This site is characterized by one soil series named Clime. This is a moderately deep, well drained soil that formed in residuum from shale. This site occurs on side slopes on uplands with slopes ranging from 1 to 60 percent. The Limy Hills ecological site is usually calcareous to the surface and always strongly calcareous within 10 inches of the soil surface.

Associated sites

HX076XY115	**Loamy Hills** The Loamy Hills ecological site sits adjacent to and in conjunction with the Limy Hills ecological site. This site is made up of moderately deep to deep, moderately well to well drained upland soils. This site has a fine-silty and loamy surface texture and is noncalcareous to the surface. Generally, the Loamy Hills ecological site is located on uplands with a slope range of 0 to 16 percent.
HX076XY128	**Shallow Hills** The Shallow Hills ecological site sits adjacent to and in conjunction with the Limy Hills site. This site is characterized by the shallow depth to limestone or shale. This site generally occurs in narrow bands or shoulders on hillslopes. Limestone at the surface is almost always present on this site. The soil series Sogn and Kipson characterize this site. It consists of shallow and very shallow, somewhat excessively drained, soils that formed in residuum weathered from limestone or shale. Slopes range from 0 to 20 percent.

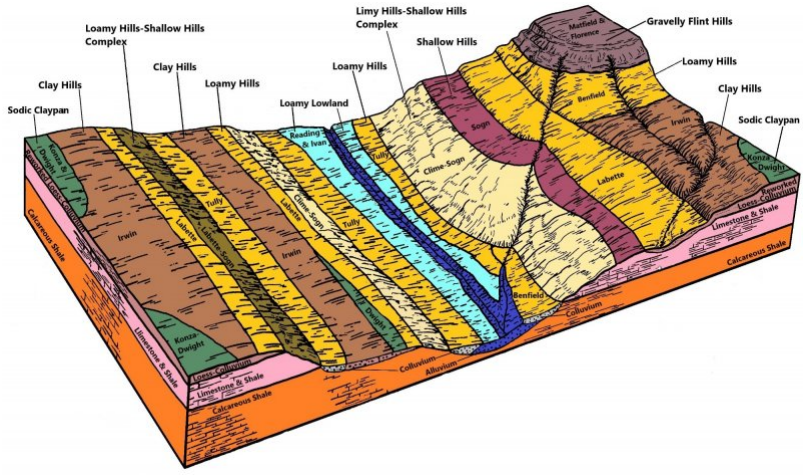


Figure 1. MLRA 76 ESD block diagram.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Andropogon gerardii* (2) *Schizachyrium scoparium*

Legacy ID

R076XY112KS

Physiographic features

Most of MLRA 76 is in the Osage Plains Section of the Central Lowland Province of the Interior Plains. The northern end of the area is in the Dissected Till Plains Section of the same province and division. The landscape consists of rolling hills and cuestas formed in dissected uplands that typically have narrow divides and narrow, steep-sided valleys where Pennsylvanian limestone bedrock is dominant. Stream valleys are less box-like (broader) where the dominant bedrock is shale. Significant flood plains occur only along a few large streams. Elevation ranges from 980 to 1,650 feet (300 to 505 meters). Local relief is generally 10 to 25 feet (3 to 8 meters), but it can be 100 to 165 feet (30 to 50 meters).

The extent of the major Hydrologic Unit Areas (identified by four-digit numbers) that make up this MLRA is as follows: Neosho-Verdigris (1107), 33 percent; Kansas (1027), 29 percent; Middle Arkansas (1103), 18 percent; Arkansas- Keystone (1106), 18 percent; and Republican (1025), 2 percent. The area has two large rivers. The Kansas River crosses the northern part of the area, and the Arkansas River runs along the southwestern edge. The smaller rivers that cross the area include the Vermillion, Mill, Neosho, Cottonwood, Fall, Verdigris, Grouse, Elk, Caney, and Bird Rivers.

The Limy Hills ecological site occurs on hillslopes of uplands that have a plane or convex surface. The slope gradient ranges from 1 to 60 percent slope.

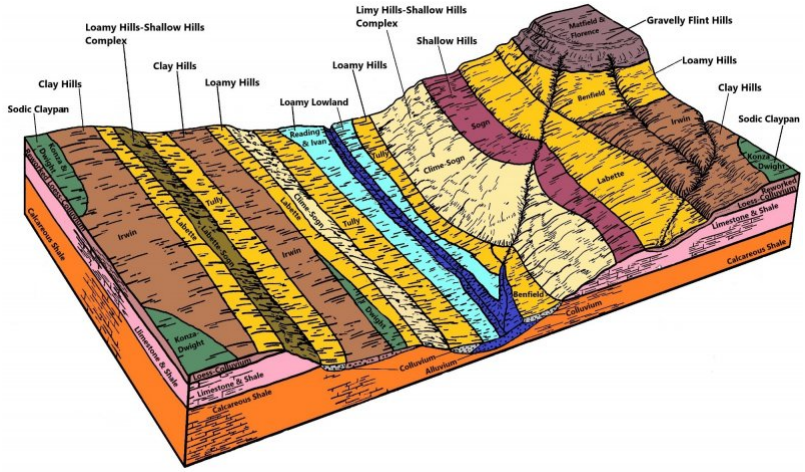


Figure 2. MLRA 76 ESD block diagram.

Table 2. Representative physiographic features

Hillslope profile	(1) Shoulder (2) Backslope
Landforms	(1) Hills > Hillslope
Runoff class	High to very high
Ponding frequency	None
Elevation	299–503 m
Slope	1–60%
Aspect	Aspect is not a significant factor

Climatic features

The climate of this area is typically continental, being in the interior of a large landmass at mid latitudes. Large daily and annual variations in temperature are common. Winters are cold because of frequent polar air masses moving into the area from the north from December into March. Summer temperatures are warm and usually prevail for about six months of the year. June typically has the most rainfall, and January is the driest. Most of the rainfall occurs as high-intensity, convective thunderstorms. The annual snowfall averages 14 to 20 inches (355 to 510 millimeters). Drought occurs on an average of 3 times in a 30-year period (1981-2010) in MLRA 76.

The climate data listed in the following tables represent minimum and maximum averages and ranges for the climate stations located throughout MLRA 76. The dates referenced are from 1981-2010 (latest 30 year average). Average annual precipitation for this MLRA ranges from 32 to 40 inches (810 to 1020 millimeters). All weather data is supported by the National Oceanic and Atmospheric Administration (NOAA) 1981-2010 Climate Normals. For the average annual precipitation of individual climate station locations and additional climate data, access the National Water and Climate Center at http://www.wcc.nrcs.usda.gov

Table 3. Representative climatic features

Frost-free period (characteristic range)	144-162 days
Freeze-free period (characteristic range)	177-192 days
Precipitation total (characteristic range)	864-991 mm
Frost-free period (actual range)	140-171 days
Freeze-free period (actual range)	167-194 days

Precipitation total (actual range)	838-1,016 mm
Frost-free period (average)	154 days
Freeze-free period (average)	185 days
Precipitation total (average)	914 mm

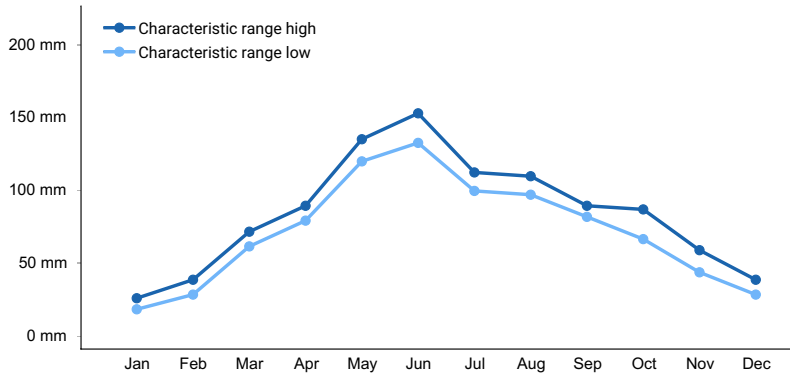


Figure 3. Monthly precipitation range

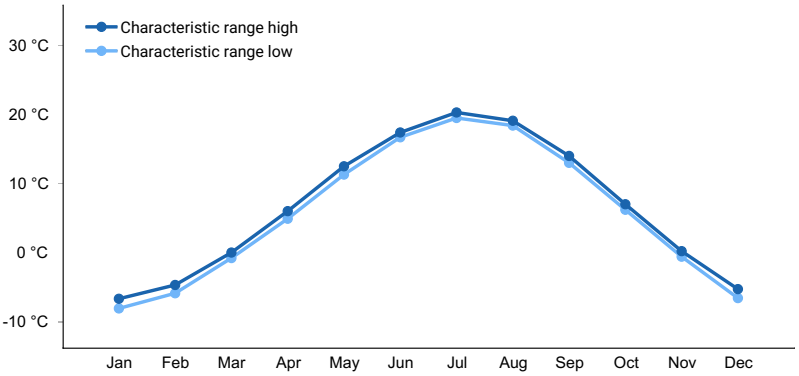


Figure 4. Monthly minimum temperature range

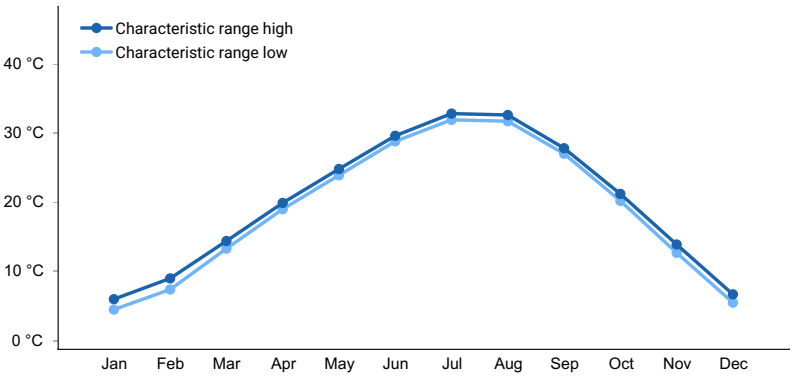


Figure 5. Monthly maximum temperature range

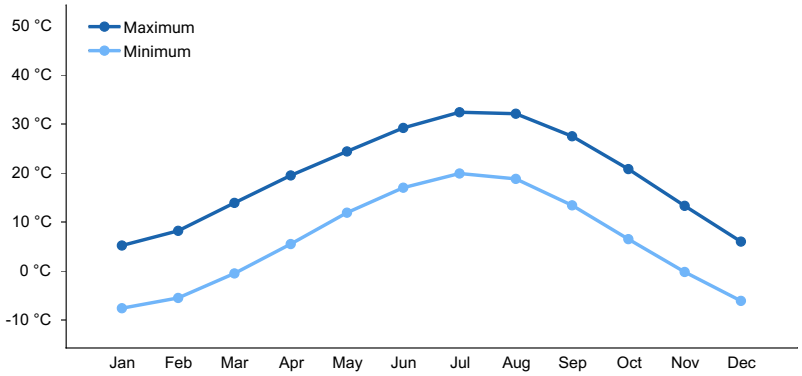


Figure 6. Monthly average minimum and maximum temperature

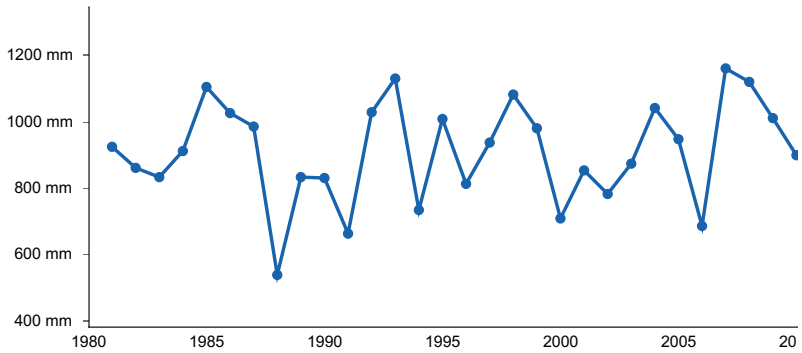


Figure 7. Annual precipitation pattern

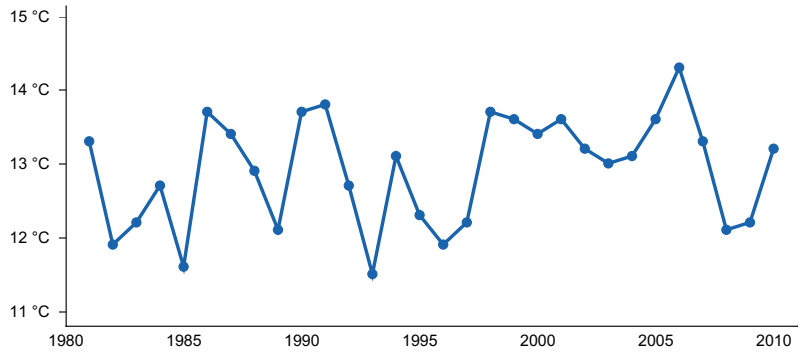


Figure 8. Annual average temperature pattern

Climate stations used

- (1) TUTTLE CREEK LAKE [USC00148259], Manhattan, KS
- (2) MANHATTAN [USC00144972], Manhattan, KS
- (3) WAMEGO 4 W [USC00148563], Wamego, KS
- (4) MANHATTAN MUNI AP [USW00003936], Manhattan, KS
- (5) MANHATTAN 6 SSW [USW00053974], Manhattan, KS
- (6) COUNCIL GROVE LAKE [USC00141867], Council Grove, KS
- (7) TALLGRASS PRAIRIE NP [USC00148061], Strong City, KS
- (8) COTTONWOOD FALLS [USC00141858], Cottonwood Falls, KS
- (9) FLORENCE [USC00142773], Florence, KS
- (10) CASSODAY 2SW [USC00141351], Cassoday, KS
- (11) EL DORADO [USC00142401], El Dorado, KS
- (12) EUREKA 1E [USC00142622], Eureka, KS
- (13) SMILEYBERG 1N [USC00147534], Douglass, KS
- (14) WINFIELD 3NE [USC00148964], Winfield, KS
- (15) HOWARD 1W [USC00143822], Howard, KS

Influencing water features

The Limy Hills ecological site is located on uplands with nearly level to moderately steep slopes. Runoff is medium to very high. Water moves down slopes into drainageways. If cover is adequate, erosion rates are still moderate on the steep terrain. If inadequate vegetative cover is present, sheet and gully erosion becomes excessive.

The soil characteristic of this ecological site is well drained with slow permeability. Available water-holding capacity ranges from low to moderate.

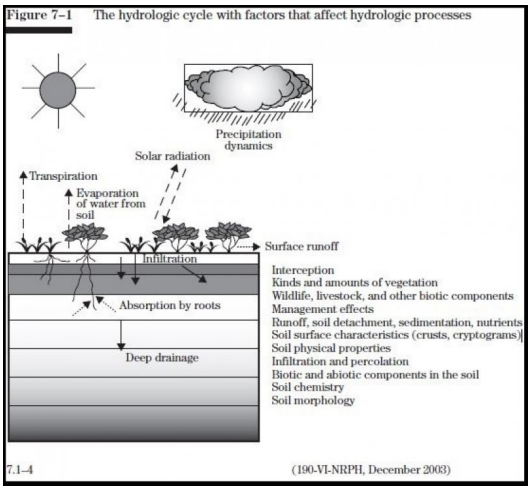


Figure 9. Fig. 7-1 from the National Range and Pasture Handbook.

Soil features

The major soil found on this site is Clime. It is characterized by being frequently calcareous to the surface and always strongly calcareous within 10 inches of the surface. The soil is considered highly erosive with gullying and sheet erosion being severe hazards.

The Clime series consists of moderately deep, well drained soils that formed in residuum from shale. Clime soils are located on side slopes on hillslopes on uplands in the Kansas Bluestem Hills, MLRA 76. Slope ranges from 1 to 60 percent. Soil surface texture range from silty clay loam to silty clay. Depth to shale ranges from 20 to 40 inches.

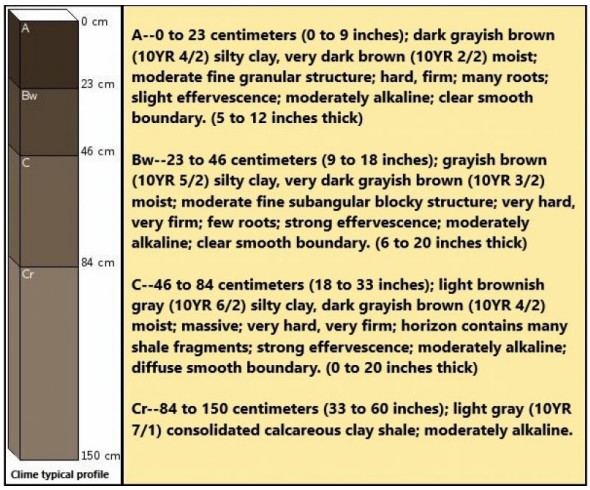


Figure 10. Clime typical soil profile in MLRA 76.

Table 4. Representative soil features

Parent material	(1) Residuum–shale
Surface texture	(1) Silty clay (2) Silty clay loam

Family particle size	(1) Clayey
Drainage class	Well drained
Permeability class	Slow
Depth to restrictive layer	51–102 cm
Soil depth	51–102 cm
Surface fragment cover >3"	0–5%
Available water capacity (0-101.6cm)	7.37–15.24 cm
Calcium carbonate equivalent (0-101.6cm)	0–25%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–25%
Subsurface fragment volume >3" (Depth not specified)	0–15%

Ecological dynamics

The Limy Hills ecological site in MLRA 76 consist of dynamic plant communities resulting from the complex interaction of many ecological factors and processes. The vegetation evolved on very deep to moderately deep soils with heavy-textured subsurface layers under a diverse, fluctuating climate. Plants were historically grazed by herds of large herbivores and periodically subjected to intense wildfires.

The original plant community developed with fires of various intensities and frequencies during different seasons of the year playing an important part in ecological processes. Historically, wildfires started by lightning often occurred in spring and early summer months when thunderstorms were prevalent, but also in late summer and fall during dry weather periods. It is also recognized that early Native Americans often used fire to attract herds of migratory herbivores, especially bison.

The dominant tallgrasses were rhizomatous, enabling them to survive the ravages of even intense wildfires and, thus, gain a competitive advantage in the plant community. In contrast, most trees and shrubs were suppressed by fire and occurred only sparsely on protected areas. Growth of perennial forbs, and especially legumes, were usually enhanced following a fire event. After an intense fire there was usually a substantial, but short-term, increase in the abundance of annual forbs as well.

Grazing history has had a major impact on the dynamics of the site. The vegetative community developed under a grazing regime that consisted primarily of periodic grazing by large herds of bison. As the herds moved through an area, grazing was probably intense. When herds moved to adjacent areas, grazed vegetation was afforded an extended period of rest and recovery during the growing season. Other grazing and feeding animals such as elk, pronghorns, deer, rabbits, insects, and numerous burrowing rodents had secondary influences on plant community development.

Variations in climate, especially a pattern of annual late summer drought and long-term drought cycles spanning several years, also had a major impact upon plant community development. Species composition fluctuated according to the duration and severity of long-term droughts. During prolonged dry cycles, many of the weaker, shallow-rooted plants died and production of deeper-rooted plants was diminished. When sufficient rainfall occurred following an extended dry period, annual forbs and annual grasses would temporarily occur in abundance. When precipitation returned to normal or above normal, the deeper-rooted grasses and forbs responded and returned to their production potentials.

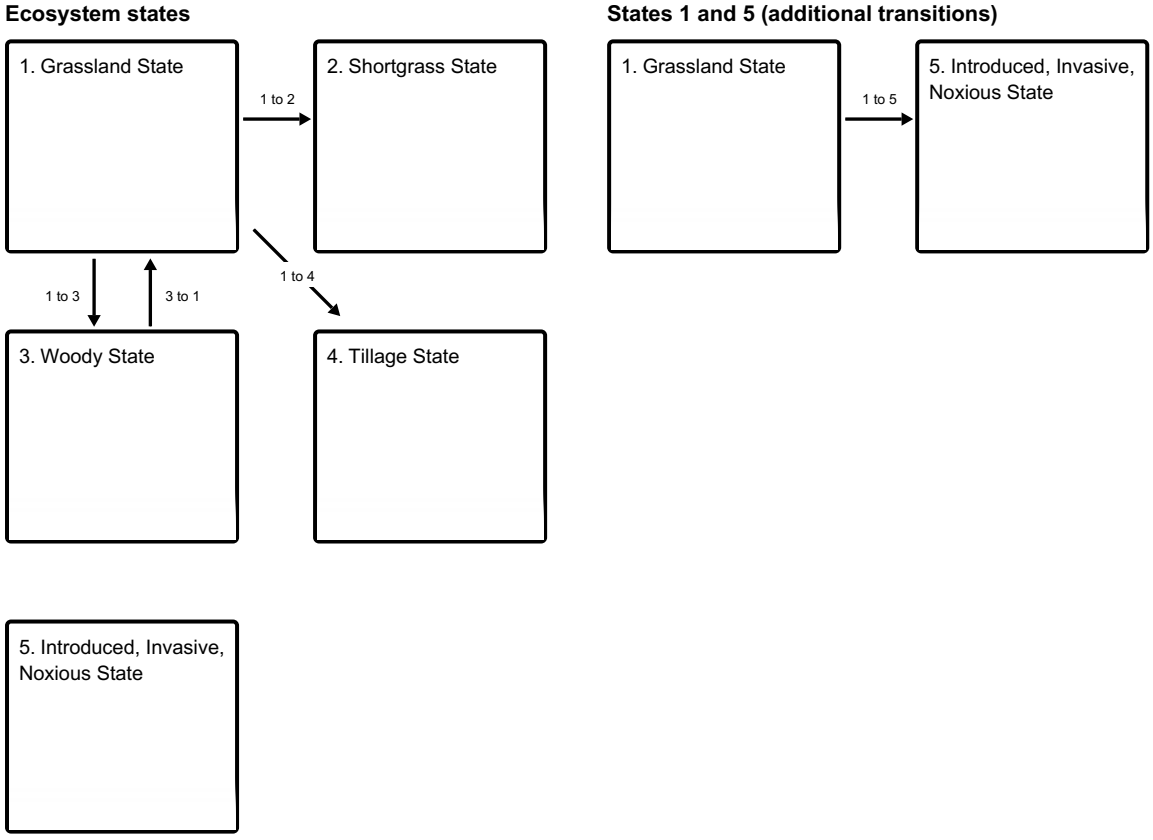
As European settlers began utilizing the site for production of domestic livestock within fenced pastures in place of roaming bison herds, its ecological dynamics and physical aspects were altered and the plant community shifted from its original composition. These changes were usually in proportion to the season and intensity of use by livestock and were accelerated by a combination of drought and overgrazing. Taller grasses and forbs more palatable to bison were similarly selected and consumed by cattle and horses. Those palatable species were repeatedly grazed throughout the growing season, thus weakening them. Over time, they were gradually replaced by the increase and spread of less palatable species. Where the history of overuse by domestic livestock was more intense, even the plants which initially increased were often replaced by less desirable and lower-producing plants. In some instances, production and plant diversity was reduced to a mixture of mid- and short-grasses, annual grasses and unpalatable forbs.

The frequency and role that fires played in maintaining the plant community was reduced with the advent of roads, cultivated fields, and fire suppression techniques developed by European settlers. Use of prescribed fire as a management tool has also diminished in some localities, especially surrounding population centers. In the absence of periodic, intense fire, there has often been a gradual increase in woody species. In some areas, shrubs and trees have encroached to the point of being the dominant influence in the plant community.

The gently rolling topography of this ecological site was attractive to European settlers who sought to create agrarian lifestyles. Some areas of this site were brought under cultivation and used to grow wheat, corn, sorghum, and other crops. Tillage and crop production caused the total destruction of the original native plant community and often major degradation of the inherent structure and fertility of the surface soil layer. Many acres that were formerly used for cultivated crops have been reseeded or allowed to re-vegetate through natural succession.

The following diagram illustrates some of the pathways that the vegetation on this site may take from the Reference Plant
Community as influencing ecological factors change. There may be other states or plant communities not shown on the diagram, as well as noticeable variations within those illustrated.

State and transition model



1 to 2 - Long-term, heavy, continuous overgrazing, no rest and recovery

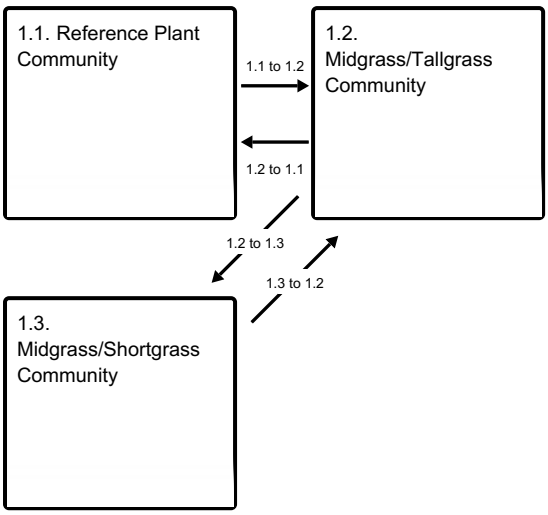
1 to 3 - Lack of fire and brush control

1 to 4 - Tillage by machinery

1 to 5 - Introduction of non-native species

3 to 1 - Prescribed grazing, brush management, and prescribed burning

State 1 submodel, plant communities



1.1 to 1.2 - Heavy, continuous grazing without adequate rest and recovery

1.2 to 1.1 - Prescribed grazing that incorporates periods of deferment during the growing season

1.2 to 1.3 - Long-term (>20 years) continuous grazing with no rest and no recovery

1.3 to 1.2 - Prescribed grazing with adequate rest and recovery period during the growing season

State 2 submodel, plant communities

2.1. Shortgrass Plant Community

State 3 submodel, plant communities

3.1. Shrub and/or Tree Community

State 4 submodel, plant communities

4.1. Reseed Plant Community

4.2. Go-back Plant Community

State 5 submodel, plant communities

5.1. Caucasian Bluestem Community

5.2. Sericea Lespedeza Community

5.3. Fescue, Brome, Bluegrass Community

State 1
Grassland State

The Grassland State defines the ecological potential and natural range of variability resulting from the natural disturbance regime of the Limy Hills ecological site. This state is supported by empirical data, historical data, local expertise, and photographs. It is defined by a suite of native plant communities that are a result of periodic fire, drought, and grazing by bison. These events are part of the natural disturbance regime and climatic process. The soil dynamic properties that can influence community phase and state changes are organic matter content, biological activity, aggregate stability, infiltration, soil fertility, and soil reaction. Other grazing and feeding animals such as elk, pronghorns, deer, rabbits, insects, and numerous burrowing rodents had secondary influences on plant community development. Today, cattle are the primary grazers on this ecological site. Within the grassland state, the woody vegetation will generally be less than 15 percent canopy cover per acre. If introduced, invasive or noxious plants are present, they should not exceed 15 percent of the total pounds of vegetation produced per acre in order to avoid crossing a threshold. Plant communities within this state function similarly in their capacity to limit soil loss, cycle water, and produce vegetative biomass. The plant community phases can vary through changes in grazing management or fluctuating climatic conditions. The variables that control the resilience of this grassland state are long-term grazing management and frequency of fire.

Characteristics and indicators. Tallgrasses and Migrasses are dominant in the Grassland State.

Resilience management. Management strategies that will sustain this state include monitoring key forage species and providing a forage and animal balance.

Community 1.1
Reference Plant Community

Figure 11. MLRA 76 Limy Hills Reference Plant Community.

The interpretive plant community for the Limy Hills ecological site is the Reference Plant Community, and represents the original plant community that existed prior to European settlement. The site is characterized as a grassland with a minor scattering of shrubs. It is dominated by tall-, warm-season grasses including big bluestem, switchgrass, and Indiangrass. The major midgrass species is little bluestem. Combined, these grasses will account for 70 to 80 percent of vegetation produced annually. Other prevalent grasses are sideoats grama, western wheatgrass, and blue grama. Scattered throughout are minor amounts of numerous mid- and shortgrasses. The site supports a wide variety of legume species which are interspersed throughout the grass sward. The most abundant are slimflower scurfpea, Nuttall's sensitive-briar, Maxmilian sunflower, prairie bundleflower, and blue wild indigo. Other important forbs include compassplant, wholeleaf rosinweed, dotted blazing star, pitcher sage, upright prairie coneflower, and Cuman ragweed. Leadplant and Jersey tea are low growing shrubs that occur over the site. Unlike most shrubs, these plants are both quite tolerant to fire. Occasional clumps of coralberry and fragrant sumac may be found on the steeper sloped exposures or in areas of rock outcrops.

Resilience management. This is a stable plant community when grazing and fire are adequately managed. A prescribed grazing program that incorporates periods of rest and recovery during the growing season benefits the tallgrasses and even the more palatable forb species. Excessive grazing and livestock trailing can quickly impact soil stability and lead to sheet and gully erosion. Because this site often occurs on shoulders and backslopes and other high elevations on the landscape, it is preferred by grazing animals during the hot days of late summer to gain relief from heat and insects. Concentrated livestock use, such as winter feeding areas, can cause compaction and stress the dominant tallgrasses.

Dominant plant species

- big bluestem (*Andropogon gerardii*), grass
- little bluestem (*Schizachyrium scoparium*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- switchgrass (*Panicum virgatum*), grass

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1793	3138	4035
Forb	336	588	757
Shrub/Vine	112	196	252
Total	**2241**	**3922**	**5044**

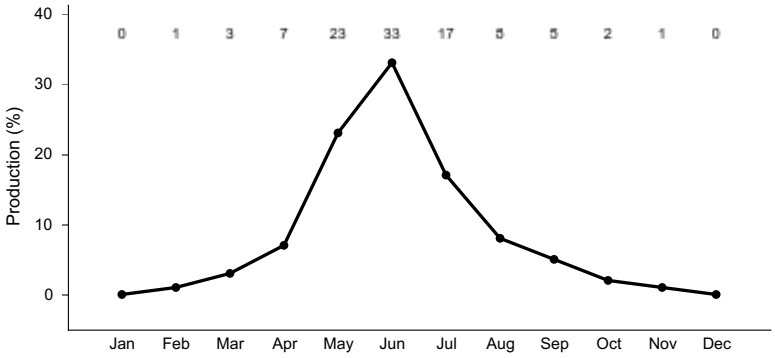


Figure 13. Plant community growth curve (percent production by month). KS7612, Limy Hills. Growth of warm season grasses on this site typically begins during the period of May 1 to May 15 and continues until mid September. Cool season grasses, sedges and rushes generally have two primary growth periods, one in the fall (September and October) and again in the spring (April, May and June). Some growth may occur in winter months during periods of unseasonably warm temperatures (Indian summers). As a general rule, 75 percent of total production is completed by mid-July. This varies only slightly from year to year depending on temperature and precipitation patterns..

Community 1.2

Midgrass/Tallgrass Community

Figure 14. MLRA 76 Midgrass/Tallgrass Plant Community.

The composition of this plant community is dominated by midgrasses and tallgrasses but is lacking in prominence of many of the productive, highly preferred forbs found in the Reference Plant Community. Additionally, eastern gamagrass is significantly reduced where it occurs on the site. This plant community developed as a result of years of overgrazing. Although tallgrasses (big bluestem, Indiangrass, and switchgrass) only make up 20 to 30 percent of total production, they tend to dominate the visual aspect of the site. Midgrasses are the primary producers of the site and make up 40 to 50 percent of the production. Dominant midgrasses include little bluestem, sideoats grama, western wheatgrass, and composite dropseed. Shortgrasses such as blue grama, hairy grama, buffalograss, tumble windmill grass, and prairie threeawn produce 5 to 10 percent of the vegetation. Forb production is variable and may range from 10 to 20 percent of the total vegetation depending on amounts and timing of rainfall events. Perennial forbs include white sagebrush, slimflower scurfpea, Missouri goldenrod, blue wild indigo, white heath aster, and Cuman ragweed. In some locations shrubs and trees such as fragrant sumac, eastern redcedar, and coralberry comprise up to 10 percent of the composition.

Resilience management. This community generally occurs as a result of long-term, heavy continuous grazing. The appearance of the site is that of the Reference Plant Community with some of its preferred forbs significantly reduced. It normally has a slightly higher percentage of grasses than the Reference Plant Community and the increasing forbs are generally not as noticeable as were those which decreased. This community is quite common on ranches which are very conscious of proper stocking but may not have a grazing system or grazing rest and recovery program to enhance the site's more fragile species. The plant community is relatively stable with moderate grazing when not adversely affected by drought or other major stress factors. With continuous overgrazing it may deteriorate to a midgrass-shortgrass community over a period of several years. Prescribed grazing with adequate rest and recovery periods during the growing season will shift this plant community to include more productive tallgrasses. Continuation of such management can shift the plant community to near the Reference Plant Community in a few years.

Dominant plant species

- fragrant sumac (*Rhus aromatica*), shrub
- little bluestem (*Schizachyrium scoparium*), grass
- sideoats grama (*Bouteloua curtipendula*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- composite dropseed (*Sporobolus compositus*), grass
- big bluestem (*Andropogon gerardii*), grass
- Indiangrass (*Sorghastrum nutans*), grass
- switchgrass (*Panicum virgatum*), grass

Community 1.3
Midgrass/Shortgrass Community

This plant community developed as a result of long-term, heavy, continuous overgrazing. Midgrasses dominate the site and comprise 40 to 55 percent of the annual production. Most abundant midgrasses include little bluestem, sideoats grama, western wheatgrass, and composite dropseed. Shortgrasses such as blue grama, hairy grama,

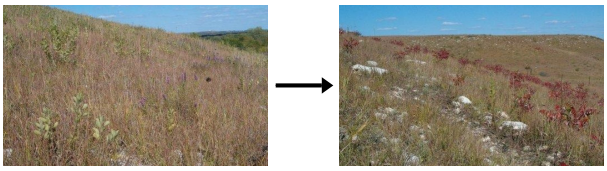
buffalograss, tumble windmill grass, and annual threeawn produce 20 to 30 percent of the vegetation. Remnant plants of big bluestem, Indiangrass, and switchgrass are commonly found only in protected locations. These plants are usually grazed repeatedly and remain in a low state of vigor. Of these remnants, big bluestem is generally the most abundant because it has rhizomes that can persist for many years in a weakened condition. When in this state, new growth consisting of three to five leaves will emerge in a prostrate rather than upright position, allowing plants to partially escape grazing. These remnants respond favorably to periods of rest from grazing and may regain vigor in two to three years. However, their numbers or the percentage of composition is so reduced it may take many years to regain a large role in the species composition. Forb production is quite variable and may range from 15 to 25 percent of the total vegetation depending on amounts and timing of rainfall events. Perennial forbs include white sagebrush, slimflower scurfpea, Missouri goldenrod, blue wild indigo, white heath aster, and Cuman ragweed. In some locations shrubs and trees such as fragrant sumac, roughleaf dogwood, eastern redcedar, and coralberry comprise up to 15 percent of the vegetation.

Resilience management. Remnant plants of big bluestem, Indiangrass, and switchgrass are commonly found only in protected locations. These plants are usually grazed repeatedly and remain in a low state of vigor. Of these remnants, big bluestem is generally the most abundant. It has rhizomes that can persist for many years in a weakened condition. When in this state of vigor, new growth consisting of three to five leaves will emerge in a prostate position rather than upright. This allows the plants to partially escape grazing. These remnant plants respond favorably to periods of rest from grazing and may regain vigor in two to three years. However, their numbers or percentage of composition is greatly reduced that it may take many years to regain a large role in the plant community. Prescribed grazing with adequate rest and recovery periods during the growing season will shift this plant community to include more productive tallgrasses. With continued management the taller grasses will gradually increase in vigor and abundance to dominate the landscape.

Dominant plant species

- little bluestem (*Schizachyrium scoparium*), grass
- sideoats grama (*Bouteloua curtipendula*), grass
- western wheatgrass (*Pascopyrum smithii*), grass
- composite dropseed (*Sporobolus compositus var. compositus*), grass
- blue grama (*Bouteloua gracilis*), grass
- buffalograss (*Bouteloua dactyloides*), grass
- hairy grama (*Bouteloua hirsuta*), grass

Pathway 1.1 to 1.2
Community 1.1 to 1.2



Reference Plant Community

Midgrass/Tallgrass Community

These mechanisms include management controlled by repetitive heavy use, no rest or recovery of the key forage species and no forage and animal balance for many extended grazing seasons. This type of management lasting for periods greater than 10 years will shift functional and structural plant group dominance towards a midgrass plant community. Annual burning or a fire frequency occurrence <2 years will cause a shift in community phases. The frequency of late spring annual burning in combination with late season rest may result in a shift in species diversity as well as fluctuations in productivity. Herbicide use every 1-3 years will remove legumes and forbs and become a grass dominated community. Drought conditions that persist >3 years with below average rainfall during the first half of the growing season in addition to inadequate rest provided for plant recovery will result in productivity changes.

Context dependence. Plant community composition shifts from Tallgrass to Midgrass dominant.

Pathway 1.2 to 1.1
Community 1.2 to 1.1

Midgrass/Tallgrass Community

Reference Plant Community

Causes of plant community shift include management (10-15 years) with adequate rest and recovery of the key forage species (big bluestem, switchgrass, Indiangrass, and little bluestem) within the Reference Plant Community . If woody species are present, prescription fires every 6-8 years will be necessary for their removal and/or maintenance.

Conservation practices

Prescribed Burning
Prescribed Grazing

Pathway 1.2 to 1.3
Community 1.2 to 1.3

These mechanisms include management controlled by repetitive heavy use, no rest or recovery of the key forage species and no forage and animal balance for many extended grazing seasons. This type of management lasting for periods greater than 20 years will shift functional and structural plant group dominance towards a Midgrass/Shortgrass Plant Community.

Pathway 1.3 to 1.2
Community 1.3 to 1.2

Causes of plant community shift include management (10-15 years) with adequate rest and recovery of the key forage species (little bluestem, sideoats grama, big bluestem, switchgrass, and Indiangrass) within the Midgrass/Tallgrass Plant Community . If woody species are present, prescription fires every 6-8 years will be necessary for their removal and/or maintenance.

Conservation practices

Prescribed Burning
Prescribed Grazing

State 2
Shortgrass State

With heavy, continuous grazing, blue grama and buffalograss will become the dominant species and have a sod-bound appearance. Unable to withstand the grazing pressure, only a remnant population of western wheatgrass remains.

Characteristics and indicators. The Shortgrass State is characterized with specific dynamic soil property changes. Changes between the Grassland State and the Shortgrass State has been documented. As plant community cover decreases from bunchgrasses to more of the sod grasses there is a decrease in infiltration and interception and an increase in surface runoff (Thurow T., 2003).

Resilience management. This is a resistant and resilient state. Grazing management practice should include a forage and animal balance.

Community 2.1
Shortgrass Plant Community

This plant community presents a distinctive shortgrass aspect on the landscape. It is dominated by blue grama and

buffalograss with notable amounts of western wheatgrass and sideoats grama present. Other grasses include annual bromes, composite dropseed, Kentucky bluegrass, prairie threeawn, and tumble windmill grass. These species commonly account for 60 to 70 percent of the annual forage production. Like the desirable grasses, palatable legumes and other forbs have been reduced by continuous grazing and competition over many years. Prevalent broadleaf species in this situation include prairie broomweed, annual ragweed, white sagebrush, Cuman ragweed, interior ironweed, wavyleaf thistle, and curlycup gumweed. Forbs may comprise 15 to 25 percent of the total vegetation. This plant community often contains 15 to 20 percent woody species as a result of fewer fires and more opportunities for their encroachment. Eastern redcedar, smooth and/or fragrant sumac, roughleaf dogwood, and coralberry are representative trees and shrubs which occur on this site. Leadplant and Jersey tea may still be found, but are generally much reduced from their prominence in the Reference Plant Community.

Resilience management. This plant community can be managed as a stable shortgrass plant community. If recovery of the tallgrasses, midgrasses, and associated forbs characteristic of the Reference Plant Community is desired, however, many years of careful management that includes prescribed grazing and extended periods of rest during the growing season will be required. More study is necessary in order to document restoration processes to the Grassland State. This site may recover faster than adjoining ones as remnant plants may be somewhat protected by the steeper slopes and occasional surface rocks. Where remnant stands of the desired species are not available on or near the site, reseeding may be necessary to advance recovery. However, seeding or interseeding may be severely limited by the steepness of slope and occasional surface rocks.

Dominant plant species

- blue grama (*Bouteloua gracilis*), grass
- buffalograss (*Bouteloua dactyloides*), grass

State 3
Woody State

This state is dominated by a shrub and/or tree plant community. The increase and spread of shrubs and trees results from an absence of fire. Woody plants can increase up to 34% from a lack of fire according to a study from 1937 to 1969, in contrast to a 1% increase on burned areas (Bragg and Hulbert, 1976). Periodic burning will hinder the establishment of most woody species and favor forbs and grasses. However, it should be pointed out that not all unburned areas have a woody plant invasion. Birds, small mammals, and livestock are instrumental in the distribution of seed and accelerating the spread of most trees and shrubs common to this site. The speed of encroachment varies considerably and can occur on both grazed and non-grazed pastures. Many species of wildlife, especially bobwhite quail, turkey, and white-tailed deer benefit from the growth of trees and shrubs for both food and cover. When management for specific wildlife populations is desirable, these options should be considered in any brush management plan.

Characteristics and indicators. Hydrologic function is affected by the amount of vegetative cover. Canopy interception loss can vary from 25.4% to 36.7% (Thurow and Hester, 1997). A small rainfall event is usually retained in the foliage and does not reach the litter layer at the base of the tree. Only when canopy storage is reached and exceeded does precipitation fall to the soil surface. Interception losses associated with the accumulation of leaves, twigs, and branches at the bases of trees are considerably higher than losses associated with the canopy. The decomposed material retains approximately 40% of the water that is not retained in the canopy (Thurow and Hester, 1997). Soil properties affected include biological activity, infiltration rates, and soil fertility.

Resilience management. Special planning will be necessary to assure that sufficient amounts of fine fuel are available to carry fires with enough intensity to control woody species. In some locations the use of chemicals as a brush management tool may be desirable to initiate and accelerate this transition.

Community 3.1
Shrub and/or Tree Community

This plant community is dominated by shrubs consisting primarily of coralberry, fragrant sumac, roughleaf dogwood, and smooth sumac which often form low, dense thickets throughout the site. Trees including eastern redcedar, honeylocust, and osage orange have invaded and become established in some areas. Shrubs and trees may produce 40 to 60 percent of the total vegetation. The spread of shrubs and trees results from the absence of fire.

Periodic burning tends to hinder the establishment of most of these woody species and favor grasses and forbs. However, not all unburned areas have a woody plant problem. The speed of woody encroachment varies considerably depending on seed availability in surrounding areas. Birds are instrumental in distributing seed and accelerating the spread of shrubs and trees. Woody encroachment may also occur on areas subjected to longtime continuous overgrazing. In these situations the associated grasses will usually consist of composite dropseed, purple lovegrass, plains lovegrass, Kentucky bluegrass, hairy grama, and Scribner's rosette grass. Shrubs also will invade and spread on areas where both grazing and fire have been excluded for many years. Heavy accumulation of plant mulch and litter retards herbage growth and provides a favorable habitat for seed germination and establishment of many woody species. The associated grasses in this situation are usually big bluestem, little bluestem, Indiangrass, switchgrass, sedges, and Canada wildrye. Grass production is significantly reduced by competition from forbs and woody species. Grass yields vary from 40 to 50 percent of the total vegetative production while forbs often produce 15 to 20 percent of the total production. Major forbs include white sagebrush, annual ragweed, Cuman ragweed, prairie broomweed, blue wild indigo, and common yarrow. Forage production on this site is heavily dependent on the predominant woody species (e.g., dense stands of eastern redcedar may have little understory vegetation). Many species of wildlife, especially bobwhite quail and white-tailed deer, benefit from the growth of shrubs for both food and cover. Their needs should be considered in any brush management plan.

Resilience management. Usually a prescribed burning program accompanied with prescribed grazing will gradually return the plant community to one dominated by grasses and forbs. Longer times will be needed where the tall- and midgrasses have been greatly reduced or eliminated. Special planning is necessary to assure that sufficient amounts of fine fuel are available to carry fires with enough intensity to control woody species. Use of labeled herbicides as a brush management tool will usually be necessary to reduce populations of fire resistant species like osage orange and honeylocust and accelerate recovery of desired vegetative cover.

Dominant plant species

- eastern redcedar (*Juniperus virginiana*), tree
- honeylocust (*Gleditsia triacanthos*), tree
- Osage-orange (*Maclura pomifera*), tree
- coralberry (*Symphoricarpos orbiculatus*), shrub
- fragrant sumac (*Rhus aromatica*), shrub
- roughleaf dogwood (*Cornus drummondii*), shrub
- smooth sumac (*Rhus glabra*), shrub

State 4
Tillage State

Extensive areas of the historic Limy Hills plant communities were plowed and converted to production of cultivated crops by the early European settlers and subsequent generations. In addition to destroying the original plant community, repeated tillage commonly resulted in major changes in soil conditions. Reductions in organic matter, mineral levels, soil structure, oxygen levels, and water holding capacity, along with increased runoff/erosion and shifts in the populations of soil-dwelling organisms, were common on these sites. The extent of these changes depended upon duration of cropping as well as crops grown and other management practices. The Tillage State consists of abandoned cropland that has been naturally revegetated (go-back) or planted/seeded to grassland. Many reseeded plant communities were planted with a local seeding mix under the Conservation Reserve Program (CRP) or were planted to a monoculture of sideoats grama. Go-back communities are difficult to define due to the variability of plant communities that can exist. Many of these communities are represented by the genus Aristida (threeawns).

Characteristics and indicators. This is an alternative state since the energy, hydrologic, and nutrient cycles are altered to that of the Reference State in its natural disturbance regime. Bulk density, aggregate stability, soil structure, and plant functional and structural groups are not fully restored to that of the Reference State. Mechanical tillage can destroy soil aggregation. Soil aggregates are an example of dynamic soil property change. Aggregate stability is critical for infiltration, root growth, and resistance to water and wind erosion (Brady and Weil, 2008).

Resilience management. This state is a result of a land use management decision.

Community 4.1

Reseed Plant Community

This plant community occurs on areas that were formerly farmed and reseeded with a mixture of native species common in the Reference Plant Community. Most seeding mixtures consisted of a blend of grasses that include sand bluestem, Indiangrass,switchgrass, little bluestem, sideoats grama, blue grama, and western wheatgrass. In some locations, seed of legumes and forbs such as prairie bundleflower and Maximilian sunflower were included in the mixture. Once these areas become fully established, production is comparable to that of the Reference Plant Community. Total annual production ranges varies according to the species planted, established plants, and years of establishment. When reseeded areas and areas supporting native rangeland exist in the same pasture, they seldom are utilized at the same intensity because domestic livestock usually prefer plants growing on the native rangeland areas. When feasible, reseeded plant communities should be managed as separate pastures or units. Some seeded areas are invaded by trees and shrubs during the establishment period of the desired plants. These invader species commonly include elm, common hackberry, eastern redcedar, and eastern cottonwood. Occasional burning is effective in controlling establishment of these woody plants.

Resilience management. Following termination of cultivation, total annual production is quite variable and full recovery of the original plant community, including forbs and legumes, may take many decades. Additions of organic matter and minerals, deferred grazing, prescribed burning, and related management practices described earlier for this ecological site can be beneficial to the rehabilitation.

Community 4.2
Go-back Plant Community

This plant community also occurs on areas that were formerly farmed. When tillage operations ceased, the areas were allowed to revegetate or “go back” naturally in contrast to artificial reseeding to a selected species or group of species. The go-back process is a slow, gradual transformation that requires many years and many successional changes or stages in the plant community. The speed and extent of revegetation depends on the size of the area, level of grazing management and the proximity of the area to existing seed sources. In the initial stages of revegetation the site is usually dominated by annual forbs such as annual ragweed, slender snakecotton, Canadian horseweed, prairie sunflower, common sunflower, Mexican fireweed, camphorweed, and annual buckwheat. Gradually these are replaced by annual grasses including prairie threeawn, mat sandbur, tumblegrass, little barley, cheatgrass, and witchgrass. As plant succession progresses the plant community gradually becomes dominated by perennials. The major grasses include sand dropseed, composite dropseed, thin paspalum, purple lovegrass, red lovegrass, Scribner’s rosette grass, Carolina crabgrass, silver beardgrass, and tumble windmillgrass. Common forbs are Cuman ragweed, white sagebrush, Carruth’s sagewort, white heath aster, Missouri goldenrod, and sand milkweed. Combinations of these plants can form a stable community. In time with prescribed grazing management, other perennial grasses and forbs common in the Reference Plant Community return to the site. Blue grama is a shortgrass that is very common to the native plant communities on this site. However, it seldom occurs in go-back communities, even after 40 to 50 years of plant succession. Some go-back areas are invaded by trees and shrubs. The more common include elm, common hackberry, eastern redcedar, eastern cottonwood, and roughleaf dogwood. Occasional burning is effective in controlling these woody plants. Total annual production varies by site. This depends on seasonal precipitation and the stage of plant succession in the plant community.

Resilience management. Following termination of cultivation, total annual production is quite variable and full recovery of the original plant community, including forbs and legumes, may take many decades. Additions of organic matter and minerals, deferred grazing, prescribed burning, and related management practices described earlier for this ecological site can be beneficial to the rehabilitation.

State 5
Introduced, Invasive, Noxious State

This state includes three community phases which are characterized by the composition of plant species and soil functions that govern the ecological processes. These three plant communities occur and function independent of one another. Species that define this state include sericea lespedeza, caucasian bluestem, tall fescue, smooth brome, and Kentucky bluegrass. These species can and will invade rangelands without proactive control measures. sericea lespedeza and caucasian bluestem community phases are partially defined by the total production exceeding 15% by weight on a per acre basis. Tall fescue, smooth brome, and Kentucky bluegrass are partially defined by the total production exceeding 40% by weight on a per acre basis.

Characteristics and indicators. Ecological processes within this state that are affected and differ from the grassland state are hydrologic cycle and nutrient cycle. Water content and infiltration rates are affected by the species.

Resilience management. The plant communities that make up this state are sustained by fertilizing species and managing as pastureland or by a lack of treatment measures for individual species control, maintenance, and/or eradication.

Community 5.1
Caucasian Bluestem Community

Caucasian bluestem is the dominant species that govern the ecological processes and uses of this community. This species can and will invade rangelands without proactive control measures.

Resilience management. Caucasian bluestem survives all control measures. There is no way of killing the Caucasian bluestem without killing the native rangeland. There have been cases where the native taller grasses appear to shade and out compete the Caucasian bluestem but there are ungrazed places on the Konza Prairie Research and biological station where it was introduced from feeding livestock contaminated hay and where it now is crowding out the native grass as its spreads. Caucasian bluestem might be the most serious threat and most aggressive of the introduced, invasive, and noxious species of this time. Soil dynamic property changes include infiltration, biological activity, and soil fertility.

Dominant plant species

- Caucasian bluestem (*Bothriochloa bladhii*), grass

Community 5.2
Sericea Lespedeza Community

Sericea lespedeza (*Lespedeza cuneata*) is the dominant species that govern the ecological processes and uses of this community. Sericea lespedeza is invasive and a statewide noxious weed in Kansas. This species will quickly invade rangelands without proactive control measures. It competes with the native grass community with sunlight, water, and nutrients. It also produces allelopathic compounds (toxic chemicals that negatively impact the germination and/or growth of other plants).

Resilience management. Control measures for sericea lespedeza involve herbicide application. Follow recommended rates and chemical use according to Kansas State University Chemical Weed Control book. Conventional management practices such as prescribed grazing and fire have been less than effective in preventing the spread of sericea lespedeza in rangelands. Some suppression of sericea lespedeza has been observed after mowing or burning followed by intensive early stocking with stocker cattle. Goats will provide some control as they do eat it much more readily than cattle.

Dominant plant species

- sericea lespedeza (*Lespedeza cuneata*), shrub

Community 5.3
Fescue, Brome, Bluegrass Community

Tall fescue, smooth brome, and Kentucky bluegrass are the dominant species that govern the ecological processes and uses of this community. Any one or combination of these species can be considered an invaded community at levels of >40% by total weight annual production. Once these levels are reached management choices can change to favor these grasses and as a result land use is transitioned from rangeland to pastureland.

Resilience management. Inputs and energy in order to return species to a grassland state are greater than what is considered to be natural. Control measures for tall fescue, smooth brome, and Kentucky bluegrass might involve herbicide application and/or consecutive prescribed burns. Follow recommended rates and chemical use according to State extension guidelines such as Kansas State University Chemical Weed Control publication. Soil dynamic property changes include biological activity and soil fertility.

Dominant plant species

- Kentucky bluegrass (*Poa pratensis*), grass
- tall fescue (*Schedonorus arundinaceus*), grass
- smooth brome (*Bromus inermis*), grass

Transition 1 to 2
State 1 to 2

Long-term management (approximately 30 years) without a forage and animal balance and heavy, continuous grazing without adequate recovery periods between grazing events will convert the Grassland State to a Shortgrass State made up of blue grama and buffalograss sod. Drought in combination with this type of management will quicken the rate at which this transition occurs.

Constraints to recovery. The ecological processes affected are the hydrologic and nutrient cycles. There is an increase in evaporation rate, runoff, and in bulk density. There is a decrease in infiltration, a change in plant composition, and the functional and structural groups have changed dominance. These are all examples of the soil and vegetation properties that have compromised the resilience of the Grassland State and therefore transitioned to a Shortgrass State.

Transition 1 to 3
State 1 to 3

Changes from a Grassland State to a Woody State lead to changes in hydrologic function, forage production, dominant functional and structural groups, and wildlife habitat. Understory plants may be negatively affected by trees and shrubs by reductions in light, soil moisture, and soil nutrients. Increases in tree and shrub density and size have the effects of reducing understory plant cover and productivity, and desirable forage grasses often are most severely reduced (Eddleman, 1983). As vegetation cover changes from grasses to trees, a greater proportion of precipitation is lost throughout interception and evaporation; therefore, less precipitation is available for producing herbaceous forage or for deep drainage or runoff (Thurow and Hester, 1997).

Constraints to recovery. Recovery is possible through management.

Transition 1 to 4
State 1 to 4

This transition is triggered by a management action as opposed to a natural event. Tillage, or breaking the ground with machinery for crop production, will move the Grassland State to a Tillage State.

Constraints to recovery. The resilience of the Reference State has been compromised by the fracturing and blending of the native virgin sod. The energy, hydrologic, and nutrient cycles are altered and vary from that of the Grassland State.

Transition 1 to 5
State 1 to 5

Changes from a Grassland State to an introduced, invasive and/or noxious state can lead to changes in hydrology/erosion, forage production, wildlife habitat, and soil dynamic properties. These changes will vary depending on dominance of species. This transition is usually triggered by an introduction of non-native species. The source from which the species originated from (i.e. adjacent crop field) can usually but not always be detected. A threshold is crossed once the species (sericea lespedeza and Caucasian bluestem) is established and increases to levels of greater than 15% total annual production per acre. For cool season grasses such as tall fescue and smooth brome that level is >40% total annual production per acre. Changes in species diversity reflect changes in soil biota activity. The introduced, invasive and noxious species are not selected and grazed and as a result become increasingly dominant. Hydrology changes begin to occur with the buildup of litter and interception rates increase as canopy increases.

Constraints to recovery. Need more documentation for recovery processes.

Restoration pathway 3 to 1
State 3 to 1

Restoration efforts will be costly, labor-intensive, and can take many years, if not decades, to return to a Grassland State. Once canopy levels reach greater than 20 percent, estimated cost to remove trees is very expensive and includes high energy inputs. The technologies needed in order to go from an invaded Woody State to a Grassland State include but are not limited to: prescribed burning— the use of fire as a tool to achieve a management objective on a predetermined area under conditions where the intensity and extent of the fire are controlled; brush management—manipulating woody plant cover to obtain desired quantities and types of woody cover and/or to reduce competition with herbaceous understory vegetation, in accordance with overall resource management objectives; and prescribed grazing—the controlled harvest of vegetation with grazing or browsing animals managed with the intent to achieve a specified objective. In addition, to grazing at an intensity that will maintain enough cover to protect the soil and maintain or improve the quantity and quality of desirable vegetation. When a juniper tree is cut and removed, the soil structure and the associated high infiltration rate may be maintained for over a decade (Hester, 1996). This explains why the area near the dripline usually has substantially greater forage production for many years after the tree has been cut. It also explains why runoff will not necessarily dramatically increase once juniper is removed. Rather, the water continues to infiltrate at high rates into soils previously ameliorated by junipers, thereby increasing deep drainage potential. In rangeland, deep drainage amounts can be 16 percent of the total rainfall amount per year (Thurow and Hester, 1997).

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

Additional community tables

Table 6. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrass**			1569–1687	
	big bluestem	ANGE	*Andropogon gerardii*	897–1177	–
	Indiangrass	SONU2	*Sorghastrum nutans*	224–392	–
	switchgrass	PAVI2	*Panicum virgatum*	168–314	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	0–45	–
2	**Midgrass**			897–1295	
	little bluestem	SCSC	*Schizachyrium scoparium*	785–1177	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	112–314	–
	purple lovegrass	ERSP	*Eragrostis spectabilis*	0–34	–
3	**Shortgrass**			34–78	
	blue grama	BOGR2	*Bouteloua gracilis*	11–22	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	11–22	–
	plains muhly	MUCU3	*Muhlenbergia cuspidata*	0–22	–
	ring muhly	MUTO2	*Muhlenbergia torreyi*	0–22	–
4	**Cool-season grasses**			0–78	
	Canada wildrye	ELCA4	*Elymus canadensis*	0–22	–
	Scribner's rosette	DIOLS	*Dichanthelium oligosanthes var.*	0–22	–

	grass		*scribnerianum*		
	fall panicgrass	PADI	*Panicum dichotomiflorum*	0–22	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0–22	–
	sedge	CAREX	*Carex*	0–22	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	0–22	–
Forb					
5	**Forbs**			280–588	
	blacksamson echinacea	ECANA	*Echinacea angustifolia var. angustifolia*	11–34	–
	pale purple coneflower	ECPA	*Echinacea pallida*	11–34	–
	pitcher sage	SAAZG	*Salvia azurea var. grandiflora*	11–34	–
	dotted blazing star	LIPU	*Liatris punctata*	11–34	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	11–34	–
	Missouri goldenrod	SOMI2	*Solidago missouriensis*	11–34	–
	white heath aster	SYER	*Symphyotrichum ericoides*	11–22	–
	Fendler's aster	SYFE	*Symphyotrichum fendleri*	0–22	–
	aromatic aster	SYOB	*Symphyotrichum oblongifolium*	0–22	–
	common yarrow	ACMI2	*Achillea millefolium*	0–22	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	0–22	–
	common milkweed	ASSY	*Asclepias syriaca*	0–22	–
	butterfly milkweed	ASTU	*Asclepias tuberosa*	0–22	–
	whorled milkweed	ASVE	*Asclepias verticillata*	0–22	–
	green antelopehorn	ASVI2	*Asclepias viridis*	0–22	–
	false boneset	BREU	*Brickellia eupatorioides*	0–22	–
	purple poppymallow	CAIN2	*Callirhoe involucrata*	0–22	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	0–22	–
	wavyleaf thistle	CIUN	*Cirsium undulatum*	0–22	–
	prairie fleabane	ERST3	*Erigeron strigosus*	0–22	–
	cutleaf evening primrose	OELA	*Oenothera laciniata*	0–22	–
	stiff goldenrod	OLRI	*Oligoneuron rigidum*	0–22	–
	upright prairie coneflower	RACO3	*Ratibida columnifera*	0–22	–
	compassplant	SILA3	*Silphium laciniatum*	0–22	–
	fringeleaf wild petunia	RUHU	*Ruellia humilis*	0–22	–
	groundplum milkvetch	ASCR2	*Astragalus crassicarpus*	0–22	–
	purple prairie clover	DAPUP	*Dalea purpurea var. purpurea*	11–22	–
	roundhead lespedeza	LECA8	*Lespedeza capitata*	0–22	–
	white prairie clover	DACA7	*Dalea candida*	0–22	–
	western silver aster	SYSE2	*Symphyotrichum sericeum*	0–22	–
	silky prairie clover	DAVIV	*Dalea villosa var. villosa*	0–22	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	0–22	–
	stiff sunflower	HEPAP2	*Helianthus pauciflorus ssp. pauciflorus*	11–22	–
	tall blazing star	LIAS	*Liatris aspera*	0–22	–

	blue wild indigo	BAAUM	*Baptisia australis var. minor*	11–22	–
	golden prairie clover	DAAU	*Dalea aurea*	0–22	–
	nineanther prairie clover	DAEN	*Dalea enneandra*	0–22	–
	Illinois bundleflower	DEIL	*Desmanthus illinoensis*	11–22	–
	Illinois ticktrefoil	DEIL2	*Desmodium illinoense*	0–22	–
	sessileleaf ticktrefoil	DESE	*Desmodium sessilifolium*	0–22	–
	button eryngo	ERYU	*Eryngium yuccifolium*	0–22	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	11–22	–
	yellow salsify	TRDU	*Tragopogon dubius*	0–11	–
	cobaea beardtongue	PECO4	*Penstemon cobaea*	0–2	–
	large Indian breadroot	PEES	*Pediomelum esculentum*	0–2	–
Shrub/Vine					
6	**Shrubs**			84–196	
	leadplant	AMCA6	*Amorpha canescens*	17–39	–
	Jersey tea	CEHE	*Ceanothus herbaceus*	11–39	–
	prairie rose	ROAR3	*Rosa arkansana*	0–39	–
	fragrant sumac	RHARS	*Rhus aromatica var. serotina*	0–28	–
	roughleaf dogwood	CODR	*Cornus drummondii*	0–28	–
	smooth sumac	RHGL	*Rhus glabra*	0–28	–

Animal community

Wildlife

The Limy Hills ecological site is a preferred tallgrass prairie habitat for many wildlife species. There is a great diversity of forbs and grasses that attracts grazing animals such as white-tailed deer, pronghorn, and, historically, bison. This same plant diversity also attracts smaller burrowing animals such as gophers, badgers, and the thirteen-lined ground squirrel. Deer mice and prairie voles forage on the diverse plant foods available along with numerous insects that are attracted to plants during the growing season. These small mammals attract many different predators such as coyotes and badgers which often prey on burrowing creatures. Many avian predators are common including the red-tail hawk and great horned owl.

Greater prairie chicken commonly use this site for feeding, nesting, and loafing cover as does the western meadowlark, the state bird of Kansas. Bobwhite quail, the eastern cottontail, and a variety of songbirds are more common in those areas that include some shrub growth.

With good grazing management to maintain plant vigor, productivity, and diversity, this site will be preferred upland habitat.

Some animals are important because of their threatened and endangered status and require special consideration. Please check the Kansas Department of Wildlife and Parks and Tourism (KDWP&T) website at www.ksoutdoors.com for the most current listing for your county.

Grazing Interpretations

Calculating Safe Stocking Rates: Proper stocking rates should be incorporated into a grazing management strategy that protects the resource, maintains or improves rangeland health, and is consistent with management objectives. In addition to usable forage, safe stocking rates should consider ecological condition, trend of the site, past grazing use history, season of use, stock density, kind and class of livestock, forage digestibility, forage nutritional value, variation of harvest efficiency based on preference of plant species, and/or grazing system, and site grazeability

factors (such as steep slopes, site inaccessibility, or distance to drinking water).

Often the current plant community does not entirely match any particular Community Phase as described in this Ecological Site Description. Because of this, a resource inventory is necessary to document plant composition and production. Proper interpretation of inventory data will permit the establishment of a safe initial stocking rate.

No two years have exactly the same weather conditions. For this reason, year-to-year and season-to-season fluctuations in forage production are to be expected on grazing lands. Livestock producers must make timely adjustments in the numbers of animals or in the length of grazing periods to avoid overuse of forage plants when production is unfavorable, and to make advantageous adjustments when forage supplies are above average.

Initial stocking rates should be improved through the use of vegetation monitoring and actual use records that include number and type of livestock, the timing and duration of grazing, and utilization levels. Actual use records over time will assist in making stocking rate adjustments based on the variability factors. Average annual production must be measured or estimated to properly assess useable forage production and stocking rates.

Hydrological functions

Following are the estimated withdrawals of freshwater by use in MLRA 76: Public supply—surface water, 12.9%; ground water, 10.2% Livestock—surface water, 15.8%; ground water, 4.5% Irrigation—surface water, 53.9%; ground water, 2.7%
Other—surface water, 0.0%; ground water, 0.0%

The total withdrawals average 35 million gallons per day (130 million liters per day). About 17 percent is from ground water sources, and 83 percent is from surface water sources. The moderate precipitation provides water for pastures and crops. Much of the water for livestock is stored in small reservoirs and ponds. A small area is irrigated with water from the Arkansas River in Oklahoma. The surface water is generally of good quality and is suitable for most uses.

The Clime soil characteristic of this site is a hydrologic group C soil. It is moderately well drained and has slow permeability. Please refer to the NRCS National Engineering Handbook Section 4 (NEH-4) for runoff quantities and hydrologic curves when making hydrology determinations.

Recreational uses

This site provides opportunities for a variety of outdoor activities which might include bird watching, hiking, outdoor/wildlife photography, and hunting. A wide variety of plants is in bloom throughout the growing season, especially in those years with average and above rainfall, providing much aesthetic appeal to the landscape. This site is subject to both wind and water erosion when mismanaged. Vehicular traffic can lead to gully formation on steeper sites. This site is often an excellent location for deer and quail hunting.

Wood products

This site generally does not produce trees of sufficient size for commercial harvest.

Other products

None

Other information

The subsoil material from this site may be used for road-base material.

Site Development and Testing Plan

This site went through the approval process.

Inventory data references

Information presented here has been derived from NRCS clipping data, numerous ocular estimates and other inventory data. Field observations from experienced range-trained personnel was used extensively to develop this ecological site description.

NRCS contracted the development of MLRA 79 ESDs in 2005. Extensive review and improvements were made to those foundational ESDs in 2017-2018 which provided an approved product.

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Approval

David Kraft, 8/12/2019

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem condition based on benchmark characteristics described in the Reference Sheet. A suite of 17 (or more) indicators are typically considered in an assessment. The ecological site(s) representative of an assessment location must be known prior to applying the protocol and must be verified based on soils and climate. Current plant community cannot be used to identify the ecological site.

Author(s)/participant(s)	Chris Tecklenburg/Revision 1-07-2019 David Kraft, John Henry, Doug Spencer and Dwayne Rice/original authors 1-15-2005.
Contact for lead author	State Rangeland Management Specialist for Kansas.
Date	01/07/2019
Approved by	

Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** No natural rill formation common or part of the Limy Hills ecological site.

2. **Presence of water flow patterns:** There are no water flow patterns evidenced by litter, soil, or gravel redistribution, or pedestalling of vegetation or stones that break the flow of water as a result of overland flow.

3. **Number and height of erosional pedestals or terracettes:** There is no evidence of pedestals or terracettes that would indicate the movement of soil by water and/or by wind on this site.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Less than 5% bare ground is found on this site. It is the remaining ground cover after accounting for ground surface covered by vegetation (basal and canopy [foliar] cover), litter, standing dead vegetation, gravel/rock, and visible biological crust (e.g., lichen, mosses, algae).

5. **Number of gullies and erosion associated with gullies:** No evidence of accelerated water flow resulting in downcutting of the soil.

6. **Extent of wind scoured, blowouts and/or depositional areas:** No wind-scoured or blowout areas where the finer particles of the topsoil have blown away, sometimes leaving residual gravel, rock, or exposed roots on the soil surface. Also, there are no areas of redeposited soil onto this site from another site due to the wind, i.e., depositional areas.

7. **Amount of litter movement (describe size and distance expected to travel):** No evidence of litter movement (i.e., dead plant material that is in contact with the soil surface).

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surfaces may be stabilized by soil organic matter which has been fully incorporated into aggregates at the soil surface, adhesion of decomposing organic matter to the soil surface, and biological crusts. A soil stability kit will score a range from 5-6.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Clime OSD:

   A--0 to 23 centimeters (0 to 9 inches); dark grayish brown (10YR 4/2) silty clay, very dark brown (10YR 2/2) moist; moderate fine granular structure; hard, firm; many roots; slight effervescence; moderately alkaline; clear smooth boundary. (5 to 12 inches thick)

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Functional and structural groups are that of the Reference Plant Community (see functional and structural group worksheet). Note changes to plant communities if different than that of the functional and structural group worksheet.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** There is no evidence of a compacted soil layer less than 6 inches from the soil surface. Soil structure is similar to that described in Indicator 9. Compacted physical features will include platy, blocky, dense soil structure over less dense soil layers, horizontal root growth, and increase bulk density (measured by weighing a known volume of oven-dry soil).

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: Group 1 Tallgrass dominant 43% 1505 lbs. big bluestem 800-1050, switchgrass 150-280, Indiangrass 200-350, composite dropseed 0-40.

    Sub-dominant: Group 2 Midgrass subdominant 33% 1155 lbs. little bluestem 700-1050, sideoats grama 100-280, purple lovegrass 0-30.

    Other: Group 3 Shortgrass trace 2% 70 lbs. buffalograss 10-20, blue grama 10-20, hairy grama 10-20, plains muhly 0-20 lbs, ring muhly 0-20 lbs.
    Group 4 Cool-season grass Trace 2% 70 lbs.

    Additional: Group 5 forbs subdominant 15% 525 lbs. see Reference Plant community for entire list
    Group 6 shrub Minor 5% 175 lbs.

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Recruitment of plants is occurring and there is a mixture of many age classes of plants. The majority of the plants are alive and vigorous. Some mortality and decadence is expected for the site, due to drought, unexpected wildfire, or a combination of the two events. This would be expected for both dominant and subdominant groups.

14. **Average percent litter cover (%) and depth (in):** Plant litter is distributed evenly throughout the site. There is no restriction to plant regeneration due to depth of litter. When prescribed burning is practiced, there will be little litter the first half of the growing season.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** All species (e.g., native, seeded, and weeds) alive in the year of the evaluation, are included in the determination of total above ground production. Site potential (total annual production) ranges from 2,000 lbs in a below-average rainfall year and 4,500 lbs in an above-average rainfall year. The representative value for this site is 3,500 lbs production per year.

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: There are no noxious weeds present. Invasive plants make up a small percentage of plant community, and invasive brush species are < 5% canopy.

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17. **Perennial plant reproductive capability:** Plants on site exhibit the required vigor and growth to be able to reproduce vegetatively or by seed. Current management activities do not adversely effect the capability of plants to reproduce.
