USDA Natural Resources Conservation Service

Ecological site R073XY113KS
Gravelly Hills

Last updated: 8/17/2020
Accessed: 05/17/2024

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.

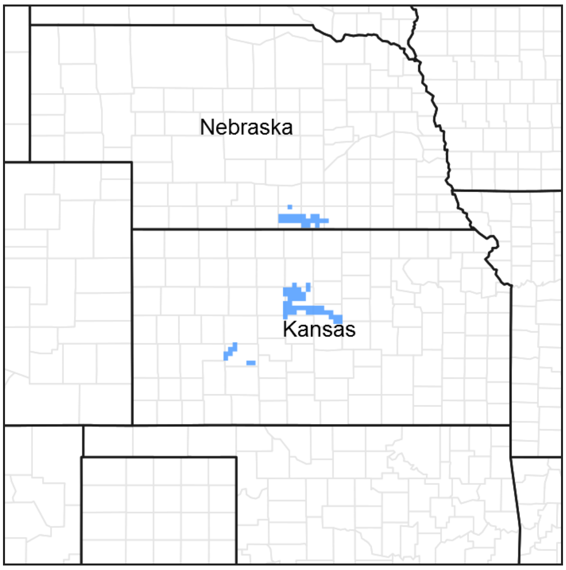


Figure 1. Mapped extent

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): 073X–Rolling Plains and Breaks

This ESD is located in the Rolling Plains and Breaks Major Land Resource Area (MLRA) 73 of the Central Great Plains Winter Wheat and Range Region of the United States. MLRA 73 is in Kansas (78 percent) and Nebraska (22 percent). It makes up about 21,485 square miles (13,750,400 acres). The towns of Hays, Great Bend, and Dodge City, Kansas, and Alma, Curtis, Holdrege, and McCook, Nebraska are in this MLRA. The MLRA is bisected by Interstate 70. The Platte River is at the northern edge of the area, and the Arkansas River is at the southern edge.

Classification relationships

Major land resource area (MLRA): 073-Rolling Plains and Breaks

Ecological site concept

The Gravelly Hills ecological site exists on a wide variety of landforms in the Rolling Plains and breaks. It mostly occurs on the uplands but can occur in low ridges, terrace breaks, alluvial fans, and foot slopes. It is generally made up of complex slopes, commonly greater than 10 percent. The site is characterized by 15-35 percent rock fragments in the surface horizon. The soils characteristic of this site formed in loamy, sandy, and gravelly soil material deposited over gravelly material on stream terraces, alluvial fans, foot slopes, and uplands.

Associated sites

R073XY100KS	**Loamy Plains** The Loamy Plains (073XY100) ecological site was formerly known as Loamy Upland (073XY015). The Loamy Plains ecological site is commonly located adjacent to or in coordination with the Loamy Plains site. The Loamy Plains ecological site occurs on relatively flat ridges, plains, and only occasionally on moderately steep side slopes. This site is located where extra moisture from drainage or overflow is not received, and therefore produces runoff to areas lower on the landscape.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

The western half of MLRA 73 and areas along the Arkansas River have remnants of the Tertiary river-laid sediments washed out onto the plains from erosion of the prehistoric Rocky Mountains in Colorado. In the valley of the Arkansas River, the wind reworked these sediments, forming a hummocky dune surface of eolian sand. A loess mantle occurs on the higher ground in the western half of the area. The Tertiary-age Ogallala and White River Formations cover Cretaceous Pierre Shale in the northern part of the area. The Ogallala Formation consists of loose to well cemented sand and gravel, and the White River Formation consists of ashy claystone and sandstone. Pierre Shale and Niobrara Chalk are at the surface in the valleys of the Republican, Smoky Hill, and Saline Rivers. Fort Hays limestone of the Niobrara Formation and Blue Hill shale of the Carlile Formation are at the surface in the valleys of the Saline and Smoky Hill Rivers. Shale can be seen exposed in the eastern half of this MLRA, in Kansas. Quaternary and more recent sand and gravel partially cover the shale in the river valleys.

The principal parent material of the Gravelly Hills ecological site formed in loamy and sandy material over gravelly sand.

This site is not extensive in MLRA 73 but can be found in the northeast parts of Franklin and Webster counties, Nebraska. Gravelly Hills can also be found along the Smokey Hill and Saline Rivers in Trego, Ellis, and Russell Counties, in Kansas. This site occurs on level to steep terraces or tertiary terrace remnants that cap ridges, crests, and upper slopes of undulating or rolling uplands. This site is dominated by loamy, sandy, and gravelly soil material deposited over gravelly material. Slopes range from 0 to 60 percent.

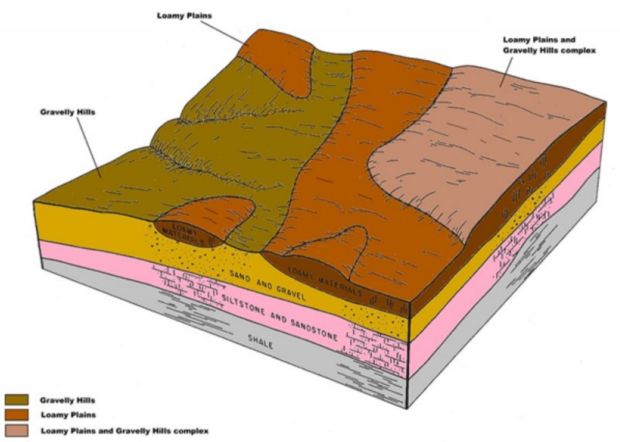


Figure 2. MLRA 73 ecological site block diagram.

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Plain (3) Terrace
Flooding frequency	None
Ponding frequency	None
Elevation	762–1,524 m
Slope	0–60%
Ponding depth	0 cm
Water table depth	0 cm

Climatic features

For MLRA 73 the average annual precipitation is 19 to 30 inches (48 to 76 centimeters). Most of the rainfall occurs as high-intensity, convective thunderstorms during the growing season. The maximum precipitation occurs from the middle of spring to the early autumn months. Precipitation in winter occurs as snow. The annual snowfall ranges from about 17 inches (45 centimeters) in the southern part of the area to 24 inches (60 centimeters) in the northern part. The average annual temperature is 48 to 56 degrees F (9 to 14 degrees C). The freeze-free period averages 180 days and ranges from 145 to 210 days, increasing in length from northwest to southeast. The following weather data originated from weather stations chosen across the geographical extent of the ecological site, and will likely vary from the data for the entire MLRA. The climate data derives from the Natural Resources Conservation Service (NRCS) National Water and Climate Center. The data-set is from 1981-2010.

Table 3. Representative climatic features

Frost-free period (average)	160 days
Freeze-free period (average)	176 days
Precipitation total (average)	660 mm

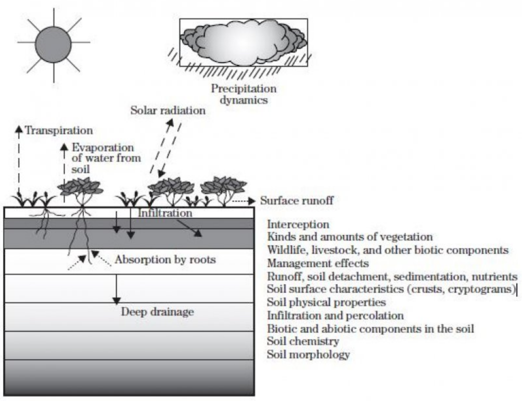
Climate stations used

- (1) RED CLOUD [USC00257070], Red Cloud, NE
- (2) RUSSELL MUNI AP [USW00093997], Russell, KS
- (3) HARLAN CO LAKE [USC00253595], Republican City, NE
- (4) FRANKLIN #2 [USC00253037], Bloomington, NE

Influencing water features

There are no water features of the Gravelly Hills ecological site or adjacent wetland/riparian regimes that influence the vegetation and/or management of the site that makes it distinctive from other ecological sites.

Figure 7–1 The hydrologic cycle with factors that affect hydrologic processes



7.1–4 (190-VI-NRPH, December 2003)

Figure 7. Fig.7-1 from National Range & Pasture Handbook.

Soil features

The soils associated with the Gravelly Hills ecological site are shallow to moderately deep over sand and gravel. These soils contain significant amounts of gravel throughout the root zone. They formed in loamy, sandy, and gravelly soil material deposited over gravelly material on stream terraces, alluvial fans, foot slopes, and uplands. The available water capacity of these soils is very low to low. The content of organic matter in these soils is low to moderate, in the surface layer.

Exposed areas of gravel are inherent to this site. The amount of bare ground varies with the amount of surface gravel. Where slopes are gentle, water flow paths should be broken, irregular in appearance, or discontinuous with numerous debris dams or vegetative barriers, and exhibit slight to no evidence of rills, wind-scoured areas, or pedestaled plants.

As slopes become steep, bare areas may increase. Expect to find evidence of water flow patterns and pedestaled plants. Sub-surface soil layers, where not affected by gravel, are non-restrictive to water movement and root penetration.

Major soil series correlated to this ecological site include Dorrance, Meadin, Schamber, and Dix.

These attributes represent 0-40 inches in depth or to the first restrictive layer.

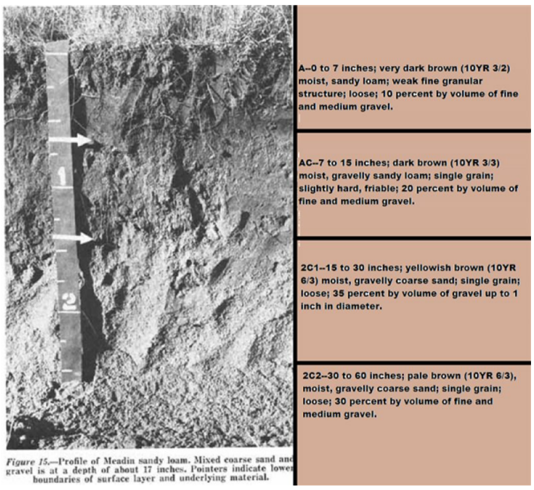


Figure 8. Meadin soil series Adams Cty., Nebraska.

Table 4. Representative soil features

Surface texture	(1) Very gravelly sandy loam (2) Loam (3) Coarse sand
Drainage class	Excessively drained
Permeability class	Very slow to slow
Soil depth	102–203 cm
Surface fragment cover <=3"	0–35%
Surface fragment cover >3"	0–15%

Available water capacity (0-101.6cm)	4.27–12.8 cm
Calcium carbonate equivalent (0-101.6cm)	0–15%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0
Soil reaction (1:1 water) (0-101.6cm)	7.5–8.3
Subsurface fragment volume <=3" (Depth not specified)	15–70%
Subsurface fragment volume >3" (Depth not specified)	5–25%

Ecological dynamics

The grasslands of Major Land Resource Area (MLRA) 73, the Rolling Plains and Breaks, located in south-central Nebraska and central Kansas, evolved under sub-humid (20-40 inch precipitation range) climates, characterized by much the same weather extremes of temperatures, rainfall, and snowfall we are familiar with today. As a result of glacial activity and other natural forces, then and later, plants have migrated from their places of origin, so that today MLRA 73 grasslands are simple-to-complex mixtures of perennial grasses and forbs, plus a few native annuals and biennials. Species composition has been modified by the introduction of Kentucky bluegrass and cool-season annual and perennial grasses, particularly Japanese brome (Launchbaugh and Owensby, 1978).

Through the ages to modern times, wildfires – many started by lightning, but most by primitive people – influenced development of fire-tolerant grasses and suppressed woody vegetation (Sauer, 1950). Certain woody plants, however, always were present as natural components of some grasslands. Browsing by animals and frequent prairie fires were largely responsible for maintaining “normal” amounts of woody species (Dyksterhuis, 1958). In primitive time, numerous large herbivores subjected herbaceous vegetation to grazing stress. After the last glacial retreat, bison emerged as the major dominant large grazer, although the prairies and plains simultaneously supported many pronghorn antelope, elk, deer, prairie dogs, rabbits, rodents, and insects. And each exerted grazing pressures on the vegetation (Launchbaugh and Owensby, 1978). There is little doubt that during and long before Spanish explorations into this area, most of the grassland was used almost continuously throughout the year by one roving herd of buffalo after another and other grazing animals (early exploration accounts reviewed by Dary in 1974; diaries of early Kansas residents cited by Choate and Fleharty in 1975). Grazing and trampling by bison and their associates were often intensive, as was uncontrolled grazing by livestock in the late 1800s after most of the wild grazers had been eliminated.

The plant communities for the Gravelly Hills ecological site are dynamic due to the complex interaction of many ecological processes. The interpretive plant community for this site is the Reference Plant Community. The Reference Community has been determined by the study of rangeland relic areas, areas protected from excessive disturbance, areas under long-term rotational grazing strategies, literature of plant communities from the early 1900s, and local expertise. Trends in plant community dynamics ranging from heavily grazed to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

This ecological site is made up of a Grassland State, a Woody State, and a Shortgrass State. The Grassland State is characterized by non-broken land (no tillage), warm-season bunchgrasses, sod-forming grasses, forbs, and shrubs. The Woody State is characterized by a community made up of primarily eastern redcedar, with few remnant native grasses making up the understory and very few forbs. The Shortgrass State is made up of a community of warm-season, short-, sod, and bunchgrasses.

Vegetation changes are expected within this ecological site and will be dependent on the site's geographical location inside Major Land Resource Area (MLRA) 73. Variation in precipitation east and west is not as affected as is temperature north and south. The northern part of MLRA 73 is characterized by cooler temperatures and a shorter growing season in respect to the southern end. As a result, cool-season bunchgrasses and sod-formers proliferate. Growth of native cool-season plants begins about April 15, and continues to about June 15. Native warm-season plants begin growth about May 15, and continue to about August 15. Green-up of cool-season plants may occur in September and October if adequate moisture is available (weather data from National Climate Data Center 1980-2010).

The Gravelly Hills ecological site developed with occasional fires as part of the ecological processes. Historically, it is believed that the fires were infrequent, randomly distributed, and started by lightning at various times throughout the season when thunderstorms were likely to occur. It is also believed that pre-European inhabitants may have used fire as a management tool for attracting herds of large migratory herbivores (bison, elk, deer, and pronghorn). The impact of fire over the past 100 years has been relatively insignificant due to the human control of wildfires and the lack of acceptance of prescribed fire as a management tool in the sub-humid, High Plains and Smoky Hills area.

The degree of herbivory (feeding on herbaceous plants) has a significant impact on the dynamics of the site. Historically, periodic grazing by herds of large, migratory herbivores was a primary influence. Secondary influences of herbivory by species such as prairie dogs, grasshoppers, gophers, and root-feeding organisms impacted the vegetation historically, and continue to this day.

The management of herbivory by humans through grazing of domestic livestock and/or manipulation of wildlife populations has been a major influence on the ecological dynamics of the site. This management, coupled with the High Plains and Smoky Hills climate, largely dictates the plant communities for the site.

Drought cycles were part of the natural range of variability within the site and historically have had a major impact upon the vegetation. The species composition changes according to the duration and severity of the drought cycle (Albertson and Weaver, 1940).

The gently rolling slopes of the Gravelly Hills site and the adjacent, more level sites are preferred by livestock, which can lead to a grazing distribution problem. Water locations, salt placement, and other aids help distribute grazing on this site. Other management techniques such as concentrated grazing and/or grazing systems also help distribute grazing more evenly.

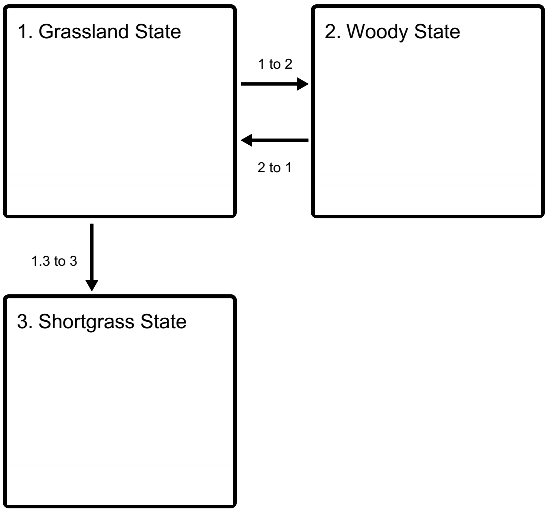
The general response of this site to long-term continuous grazing pressure is to gradually lose the vigor and reproductive potential of the tall- and midgrass species and shift the plant community toward shortgrass species.

The tall- and midgrass species generally escape excessive grazing pressure on the steeper less accessible areas. These grasses maintained on the steep area help to provide a source for these species to repopulate the site after long periods of drought and/or overgrazing. The use of grazing management that includes needed distribution tools, proper stocking, and adequate recovery periods during the growing season, helps to restore this site to its productive potential.

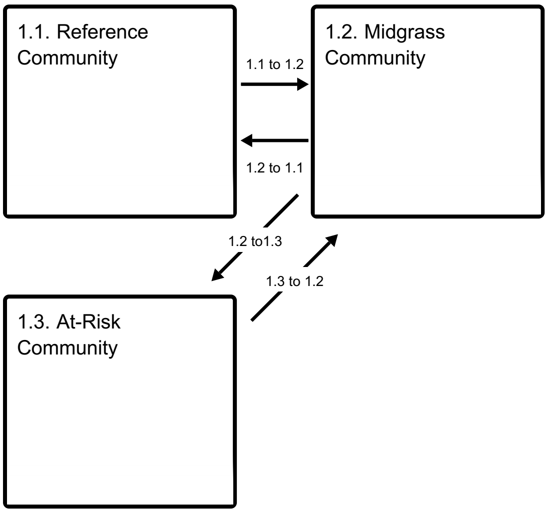
The following diagram illustrates pathways that the vegetation on this site may take from the Reference Plant Community as influencing ecological factors change. There may be other states or plant communities not shown in the diagram, as well as noticeable variations within those illustrated and described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

State and transition model

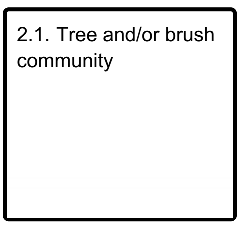
Ecosystem states



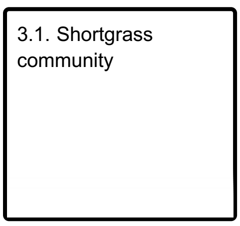
State 1 submodel, plant communities



State 2 submodel, plant communities



State 3 submodel, plant communities



State 1
Grassland State

The Grassland State is supported by empirical data, historical data, local expertise and photographs. This state is defined by three native plant communities that are a result of periodic fire, drought, and grazing. These events are part of the natural disturbance regime and climatic process. The Reference Plant Community consists of warm-season tall- and midgrasses, forbs and shrubs. Plant community 1.2 is made up primarily of sideoats grama, little bluestem with blue grama as subdominant component. The At-risk community is made blue or hairy grama, forbs, shrubs, annuals and/or woody species (mainly eastern redcedar).

Community 1.1
Reference Community

Figure 9. Gravelly Hills Franklin County, Nebraska

Figure 10. Gravelly Hills Franklin County, Nebraska

Figure 11. Gravelly Hills Franklin County, Nebraska

This plant community expresses the key vegetative characteristics of the Reference State. The Reference Plant Community is supported by empirical data, historical data, local expertise, and photographs. The potential vegetation is dominant (50%) of midgrasses, subdominant (18%) of tallgrasses, and subdominant (15%) shortgrasses. A trace component (2%) of cool-season grasses and sedge, forbs (10%), and shrubs (5%) make up the remainder of the Reference Plant Community composition by weight. Plant species in the dominant plant group include sideoats grama, little bluestem, prairie threeawn, and plains muhly. Plant species in the subdominant tallgrass group are big bluestem, switchgrass, sand dropseed, and prairie sandreed. Plant species in the shortgrass subdominant group include buffalograss, blue grama, and hairy grama. A trace of cool-season grasses include sedge, Scribner's rosette grass, needle and thread, prairie Junegrass, western wheatgrass, and thin paspalum. This plant community has a diverse forb population with the more prevalent forbs being Cuman ragweed and white heath aster. This plant community is highly productive, diverse, and resistant to short-term (<4 years) stresses, such as drought, continuous heavy stocking or non-use by grazing animals. This plant community is resilient when proper management includes adequate rest and recovery periods between grazing events and the use of prescribed fires. Total annual production ranges from 1,000 to 3,000 pounds of air-dried vegetation per acre per year and will average 2,000 pounds. These production figures are the fluctuations expected during favorable, normal, and unfavorable years due to the timing and amount of precipitation and temperature. Total annual production should not be confused with individual species productivity, which is annual production and variability by species throughout the extent of the community phase.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	1014	1905	2768
Forb	106	224	364
Shrub/Vine	–	112	230
Total	**1120**	**2241**	**3362**

Figure 13. Plant community growth curve (percent production by month).

KS7301, Big Bluestem, Little Bluestem, Sideoats Grama.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	8	25	30	25	10	2	0	0	0

Community 1.2
Midgrass Community

This plant community defines a shift in plant composition, function, and structure from that of the midgrass dominant and tallgrasses subdominant to a community of midgrasses. The tallgrass big bluestem is decreasing in composition and vigor with continuous defoliation. Little bluestem is a midgrass that is increasing in composition, production, and vigor. Big bluestem will be replaced by a dominance of sideoats grama, little bluestem, and blue grama. Forb and shrubs may also increase. If established woody species are present they will continue to increase in composition with no implementation of prescribed fire. Timing of defoliation (grazing, wildfire, hail, etc.) will have an impact on the proportions of species within the community such as western wheatgrass, needleandthread, and sedge species. Due to a decrease in plant litter, the effective precipitation is reduced, causing a decline in total annual production compared to the Reference Plant Community. The total annual production of this ranges from 700-2000 pounds per acre (air-dry weight)with an average of 1350 pounds.

Community 1.3
At-Risk Community

The At-Risk plant community is vulnerable to degradation and to exceeding the resilience limits of the Grassland State and transitioning to the Shortgrass State or Woody State. The At-Risk community phase is considered to be a stage in a transition process that is reversible if management is changed. This plant community defines a shift in plant composition, function, and structure from that of a midgrass community to a shortgrass plant community or an increase in woody vegetation. Midgrasses, such as little bluestem and sideoats grama are decreasing in composition, production, and vigor with continuous defoliation. Midgrasses will be replaced by the shortgrasses blue grama, hairy grama, buffalograss and various annuals, forbs and shrubs. Increasing grazing pressure will further reduce midgrass species shifting the plant community toward a more sod-bound blue grama and buffalograss condition. Timing of defoliation (grazing, wildfire, hail, etc.) will have an impact on the proportions of species within the community such as western wheatgrass, needleandthread, and if remnant species are present. Due to a decrease in plant litter, the effective precipitation is reduced, causing a decline in total annual production compared to the midgrass plant community. Forb diversity has drastically decreased. The shrub species present will depend upon the location within the MLRA. Dependent upon establishment and use of prescribed fire, woody species could be at infestation levels greater than 15%. The total annual production range of this site is approximately 700-1,300 pounds per acre (air-dry weight) with the average being 1,000 pounds.

Pathway 1.1 to 1.2
Community 1.1 to 1.2

The following describes the mechanisms of change from plant community 1.1 to plant community 1.2. These mechanisms include management controlled by repetitive heavy use, no rest or recovery of the key forage species, no forage and animal balance for many extended grazing seasons. This type of management for periods greater than 10 years will shift functional and structural plant group dominance towards plant community 1.2.

Pathway 1.2 to 1.1
Community 1.2 to 1.1

The following describes the mechanisms of change from plant community 1.2 to plant community 1.1. Management (10-15 years) that includes adequate rest and recovery during the growing season of the key forage species (big bluestem, little bluestem, and sideoats grama) within the Reference Plant Community. If woody species are present, prescription fires every 4-6 years will be necessary for their removal and/or maintenance.

Conservation practices

Prescribed Burning

Prescribed Grazing

Pathway 1.2 to1.3
Community 1.2 to 1.3

The following describes the mechanisms of change from plant community 1.2 to plant community 1.3. Long term (>10years) management that includes continuous, heavy use of the native vegetation. Management void of a forage and animal balance and inadequate rest and recovery of native grasses during the growing season.

Pathway 1.3 to 1.2
Community 1.3 to 1.2

The following describes the mechanisms of change from plant community 1.3 to plant community 1.2. Management (approximately 10 years) that includes adequate rest and recovery of the key forage species in the midgrass community 1.2 (little bluestem and sideoats grama). Implement prescription fires at a frequency of 6-8 years. Dependent upon the level of woody vegetation encroachment, the fire return interval might need to be adjusted to two consecutive years of prescribed fires.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 2
Woody State

This state is dominated by a tree and/or shrub plant community. The increase and spread of 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 tends to hinder the establishment of most woody species and favors forbs and grasses. However, it should be pointed out that not all unburned areas have a woody plant invasion. 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 base 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 dynamic property changes affected include biological activity, infiltration rates, and soil fertility. 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. Birds, small mammals, and livestock are instrumental in the distribution of seed and accelerating the spread of most tree 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. Conversely, the presence of trees is considered detrimental to populations of greater prairie chickens. When management for specific wildlife populations is desirable, these options should be considered in any brush management plan.

Community 2.1
Tree and/or brush community

This community is dominated by trees with a canopy cover usually greater than 15-20%. The tree species characterizing this community includes eastern redcedar. When tree encroachment occurs on areas that have been subjected to long-term continuous overgrazing, the associated grasses will usually consist of composite dropseed, purpletop tridens, purple lovegrass, Kentucky bluegrass, and Scribner’s rosette grass. Trees will also invade areas where both grazing and fire have been excluded for many years. A heavy accumulation of plant mulch and litter retarding herbage growth. This provides a favorable habitat for seed germination and establishment of many woody species. Grass yields are significantly reduced, 10 to 30 percent of the total vegetative production, due to the competition from woody species. The combination of less water entering the soil and strong ability by the trees to extract water, means that little water has a chance to drain beneath the root zone. Therefore, invasion of trees (primarily juniper) and shrubs on large areas that were once primarily grassland has strong implications for recharge of aquifers. It can be a common occurrence to have seeps and springs stop flowing in conjunction with increases in tree and shrub cover (Thurow and Hester, 1997). In this plant community, the amount of available forage is heavily dependent upon the predominant woody species cover and the kind(s) of livestock and/or wildlife utilizing the site. A prescribed burning program, mechanical brush removal, periodic rest and recovery accompanied by prescribed grazing can return the plant community to one dominated by grasses and forbs. The time frame will be dependent upon the canopy cover percentage and remnant native grass population remaining. 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. Use of labeled herbicides and mechanical removal as a brush management tool will usually be necessary to reduce fire-resistant populations like honeylocust in order to accelerate the recovery of desired vegetative cover. Some landowners rely on the browsing habits of goats to suppress the woody growth.

State 3
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. Species diversity has been reduced further. Water infiltration is reduced and runoff is increased due to the sod nature of the buffalograss and blue grama. Specific dynamic soil property 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).

Community 3.1
Shortgrass community

The potential vegetation is a short-grass prairie consisting of approximately 73 percent grasses and grass-like plants, 10 percent forbs, and 17 percent shrubs and cacti plants. Blue grama and buffalograss are the dominant grasses in this community. An increase in plains pricklypear and soapweed yucca can be observed. Forb diversity has declined. This plant community is resistant to change due to grazing and drought tolerance of both buffalograss and blue grama. A significant amount of production and diversity has been lost when compared to the Reference Plant Community. Loss of tall- and midgrass warm-season grasses, cool-season grasses, a shrub component, and nitrogen-fixing forbs have impacted the energy flow, nutrient cycling, and water cycle. Water infiltration is reduced due to the massive shallow root system, also known as a “root pan," characteristic of sod-bound blue grama and buffalograss. Soil deposition from water may be noticeable on the steeper slopes where flow paths are connected. Buffalograss and blue grama have developed a dense sod. Sideoats grama and western wheatgrass occur in trace amounts making less than 2 percent of the total annual production. During years of drought, western wheatgrass makes little or no growth and the entire site may appear to consist only of buffalograss and blue grama. Blue grama provides this site with a unique feature in that the leaves on blue grama remain semi-dormant during drought periods, but resume growing each time adequate moisture is available during the growing season. Reseeding of blue grama is unlikely because young seedlings seldom survive the extended drought periods that are common on this site. Blue grama does maintain itself by tillering. This also provides blue grama with another unique feature of being able to withstand drought and heavy grazing use. Typically blue grama is a bunchgrass but quickly forms a sod-bound condition when heavily grazed. The total average annual production of this site is approximately 700 pounds per acre (air-dry weight) with a range of 500-900 pounds.

Transition 1 to 2
State 1 to 2

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 a reduction 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, with desirable forage grasses often being 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). Tree and shrub establishment becomes increasingly greater while fine fuel loads decrease. As trees and shrubs increase at levels of greater than 20 percent canopy cover, the processes and functions that allow the Woody State to become resilient are active and dominate over the processes and systems inherent of the Grassland State. Using prescription fire as a standalone management tool is unsuccessful to eradicate the trees and shrubs due to a lack of fine fuel loads.

Transition 1.3 to 3
State 1 to 3

Long-term management (~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. Ecological processes affected are the hydrologic and nutrient cycles. Increased evaporation rate, an increase in runoff, an increase in bulk density, a decrease in infiltration, plant composition change, and functional and structural group shifts are examples of soil and vegetation properties that have compromised the resilience of the Grassland State and transitioned it to a Shortgrass State.

Restoration pathway 2 to 1
State 2 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; prescribed grazing—the controlled harvest of vegetation with grazing or browsing animals managed with the intent to achieve a specified objective. 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	**Warm-season midgrasses dominant 50%**			504–1121	
	sideoats grama	BOCU	*Bouteloua curtipendula*	224–560	–
	little bluestem	SCSC	*Schizachyrium scoparium*	224–560	–
	prairie threeawn	AROL	*Aristida oligantha*	0–28	–

	plains muhly	MUCU3	*Muhlenbergia cuspidata*	0–28	–
2	**Warm-season tallgrasses subdominant 18%**			224–398	
	big bluestem	ANGE	*Andropogon gerardii*	224–398	–
	switchgrass	PAVI2	*Panicum virgatum*	56–112	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	0–112	–
	prairie sandreed	CALO	*Calamovilfa longifolia*	0–112	–
3	**Shortgrasses subdominant 15%**			168–336	
	blue grama	BOGR2	*Bouteloua gracilis*	112–224	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	112–224	–
	buffalograss	BODA2	*Bouteloua dactyloides*	0–112	–
4	**Cool-season grasses and sedges trace component 2%**			0–50	
	sedge	CAREX	*Carex*	0–28	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	0–28	–
	needle and thread	HECOC8	*Hesperostipa comata ssp. comata*	0–28	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	0–28	–
	thin paspalum	PASE5	*Paspalum setaceum*	0–28	–
	western wheatgrass	PASM	*Pascopyrum smithii*	0–28	–
Forb					
5	**Forb minor component 10%**			112–224	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	17–56	–
	white heath aster	SYERE	*Symphyotrichum ericoides var. ericoides*	17–56	–
	whitest evening primrose	OEAL	*Oenothera albicaulis*	6–22	–
	slimflower scurfpea	PSTE5	*Psoralidium tenuiflorum*	6–22	–
	white prairie clover	DACA7	*Dalea candida*	6–22	–
	purple prairie clover	DAPU5	*Dalea purpurea*	6–22	–
	curlycup gumweed	GRSQ	*Grindelia squarrosa*	6–22	–
	hairy false goldenaster	HEVI4	*Heterotheca villosa*	6–22	–
	dotted blazing star	LIPU	*Liatris punctata*	6–22	–
	lacy tansyaster	MAPI	*Machaeranthera pinnatifida*	0–11	–
	upright prairie coneflower	RACO3	*Ratibida columnifera*	0–11	–
	milkvetch	ASTRA	*Astragalus*	0–11	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	0–11	–
Shrub/Vine					
6	**Shrubs and Cacti Minor component 5%**			22–112	
	soapweed yucca	YUGL	*Yucca glauca*	17–56	–
	skunkbush sumac	RHTR	*Rhus trilobata*	6–22	–
	common snowberry	SYAL	*Symphoricarpos albus*	0–11	–
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0–11	–
	plains pricklypear	OPPO	*Opuntia polyacantha*	0–11	–

Animal community

Wildlife Interpretations

This ecological site is on stream terraces of major streams, alluvial fans, and footslopes.

The gravelly and sandy subsurface and greater slopes make farming this site difficult, so the majority of these areas remain in native vegetation. Adjacent, more productive lands are often under cultivation or used to produce annual hay crops, resulting in these sites becoming fragmented grassland patches. These sites are sometimes quarried to produce gravel, which can dramatically alter plant community composition.

Historically, the predominance of grasses and forbs on this site supported grazers and mixed feeders such as bison, elk, deer, and pronghorn and a variety of grassland-associated birds and small mammals. Due to the heterogeneity inherent in all landscapes, some areas were not grazed uniformly by these historic large herds of grazing animals. This type of grazing, enhanced habitat for wildlife by creating a mosaic pattern, or patchiness, of vegetative structural diversity throughout the landscape. Wildlife native to the site depend on a plant community diverse in species and structure. This need is evident in the variability of known habitat requirements of grassland-associated wildlife.

Small soapweed and skunkbrush sumac may be present and locally abundant on this site. Skunkbrush sumac offers escape and thermal cover for several species of wildlife. Undisturbed sites are at risk from tree invasion from species such as eastern red cedar and cottonwood. The presence of trees makes this site generally unsuitable for prairie chickens and other ground-nesting birds that require large expanses of non-woody habitat. Trees can also increase the potential for nest parasitism by brown-headed cowbirds when adjacent to grasslands. Trees of sufficient size adjacent to drainages do offer roosting habitat for wild turkeys, and nesting and perching habitat for raptors.

The site's general close proximity to permanent or seasonal water in streams generally meets the needs of wildlife requiring open water for drinking. Seasonal pools present in these drainageways during the spring offer breeding habitat for amphibians.

Periodic events such as prolonged drought, wildfire, disease, or high insect numbers will alter plant community diversity and structure and associated wildlife species. Plant community structure is highly dependant on rainfall since the water-holding capacity of the site is very low.

Big Bluestem, Sideoats Grama, Blue Grama Reference Plant Community

The high diversity of grasses and forbs in this community provides habitat for a diverse group of insects. Areas with high forb diversity will generally support more insects such as the leaf-hoppers important to young grassland-nesting birds. Grasshoppers, associated with grasses, are a critical food source for birds in later stages of development. Plains garter snakes, western hognose snakes, six-lined racerunners and reptiles commonly found on the site. Areas with high forb and insect populations coupled with nearby roost trees offer suitable brood habitat for wild turkeys. Reference sites in good to excellent condition with taller native warm-season bunch grasses and openings at ground level offer northern bobwhite quail nesting habitat. Several species of pocket mice are common and provide prey for raptors such as red-tailed hawks and great-horned owls throughout the year, and prey for northern harriers and rough-legged hawks during the winter. Small mammals also provide prey for coyotes and other predators. Suitable thermal and escape cover for deer may be limited due to low quantities of woody plants; however, topographical variations could provide some thermal cover.

Grazing Interpretations

Historical overgrazing has been the key element that has affected the declining condition on many range sites. It is during periods of overstocking that many of the preferred species are taken out of these sites, reducing production, vigor, and diversity. Many new grazing systems are being tested and tried, utilizing stocking rates, timing, stocking density, positive animal impacts, and other factors to enhance ecological site condition.

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 desirability 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

Water is the principal factor limiting forage production on this site. Infiltration and runoff potential for this site varies from low to high. In many cases, areas with greater than 75 percent ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50 percent have the greatest potential to have reduced infiltration and higher runoff.

Recreational uses

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

Wood products

No appreciable wood products are present on the site.

Other products

None noted.

Other information

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 were used extensively to develop this ecological site description.

NRCS individuals involved in developing the Gravelly Hills ESD in 2002 include: Darrell Beougher, Jon Deege, Lorne Denetclaw, Sharla Schwien, Joel Willhoft, Dwayne Rice, and Bob Tricks from Kansas; and Nadine Bishop,

Kristin Dickinson, Kim Stine, Dana Larson, and Chuck Markley from Nebraska.

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Contributors

Chris Tecklenburg

Approval

David Kraft, 8/17/2020

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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 3/21/2017, and 8-17-2020 David Kraft, John Henry, Doug Spencer, Dwayne Rice original 2/2005
Contact for lead author	Chris Tecklenburg (chris.tecklenburg@ks.usda.gov)
Date	10/01/2019
Approved by	David Kraft
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

2. **Presence of water flow patterns:** None to minimal on gentle slopes (< 15%). Flow paths should be broken, irregular in appearance. As slope steepness increases, flow paths become more apparent and may be connected.

3. **Number and height of erosional pedestals or terracettes:** None to slight on gentle slopes. Expect some evidence of pedestalled plants when slopes exceed 15%.

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.

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

6. **Extent of wind scoured, blowouts and/or depositional areas:** None

7. **Amount of litter movement (describe size and distance expected to travel):** Expect minimal size litter to travel short distances, associated with water flow patterns following extremely high intensity storms.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of**

values): Stability class of 4-5 under canopies and in intercanopy spaces.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Typical A is 0 to 7 inches; very dark grayish brown (10YR 3/2), moist; weak fine granular structure; loose; 10 percent by volume of fine and medium gravel; neutral; gradual smooth boundary.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** High grass canopy and basal cover and small gaps between plants should reduce raindrop impact and slow overland flow, providing increased time for infiltration to occur.

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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.

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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: Warm-season midgrasses dominant 50%. Sideoats grama 200-500, little bluestem 200-500, prairie threeawn 0-25, plains muhly 0-25.

    Sub-dominant: Warm-season tallgrasses 18%. Big bluestem 200-355, switchgrass 50-100, sand dropseed 0-100, prairie sandreed 0-100.
    Shortgrasses-warm-season 15%. Blue grama 100-200, hairy grama 100-200, buffalograss 0-100

    Other: Cool-season grasses and sedge trace component 2%.
    Forb component 10% and Shrubs and Cacti 5%.

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** The majority of plants are alive and vigorous. Some mortality and decadence is expected for the site. This in part is due to drought, unexpected wildfire, or a combination of the two events. This would be expected for both dominant and sub-dominant groups.

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14. **Average percent litter cover (%) and depth (in):** Plant litter is distributed evenly throughout the site. 25-40% litter cover at 0.25 or less inch depth. Litter cover during and following extended drought can range from 10-20%.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1,000-3,000 lbs/acre. Representative value is 2000 lbs/forage/acre. Below normal precipitation during the growing season expect 1,000 lbs/forage/acre; and above normal precipitation during the growing season expect 3,000 lbs/forage/acre. If utilization has occurred, estimate the annual production removed or expected and include this amount when making the total site production estimate.

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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:** None

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17. **Perennial plant reproductive capability:** The number and distribution of tillers or rhizomes is assessed on perennial plants occupying the evaluation area. No reduction in vigor or capability to produce seed or vegetative tillers given the constraints of climate and herbivory.
