USDA Natural Resources Conservation Service

Ecological site R081AY290TX
Clay Flat 14-19 PZ

Last updated: 9/19/2023
Accessed: 05/12/2025

General information

Provisional. A provisional ecological site description has undergone quality control and quality assurance review. It contains a working state and transition model and enough information to identify the ecological site.

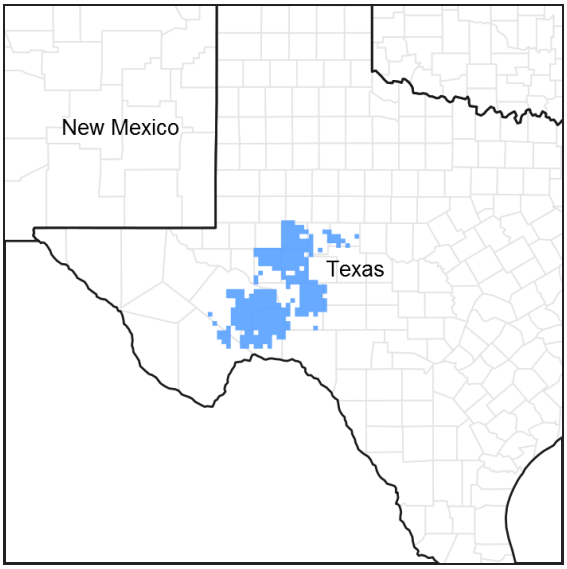


Figure 1. Mapped extent

Areas shown in blue indicate the maximum mapped extent of this ecological site. Other ecological sites likely occur within the highlighted areas. It is also possible for this ecological site to occur outside of highlighted areas if detailed soil survey has not been completed or recently updated.

MLRA notes

Major Land Resource Area (MLRA): 081A–Edwards Plateau, Western Part

This area is entirely in Texas. It makes up about 16,550 square miles (42,885 square kilometers). The cities of San Angelo and Fort Stockton and the towns of Big Lake, McCamey, Ozona, and Sheffield are in this MLRA. Interstate 20 crosses the northern part of the area, and Interstate 10 crosses the middle of the area. The eastern part of Amistad National Recreation Area is in this MLRA.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 81A

Ecological site concept

The Clay Flat is characterized by heavy clay soils on nearly level slopes. Sites are productive, but can be droughty due to their high clay content and available moisture to plants. The depression areas can be occasionally ponded with excess precipitation for up to a month.

Associated sites

R081AY566TX	**Limestone Hill 14-19 PZ** The Limestone Hill ecological site has shallow soils over a lithic contact and is less productive.
R081AY291TX	**Clay Loam 14-19 PZ** The Clay Loam ecological site has less clay content and does not pond water.
R081AY311TX	**Shallow 14-19 PZ** The Shallow ecological site has shallow soils and is less productive.

Similar sites

R081AY291TX	**Clay Loam 14-19 PZ** The Clay Loam ecological site has deep soils with less clay.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	(1) *Pleuraphis mutica* (2) *Panicum obtusum*

Physiographic features

These nearly level to very gently sloping soils are on basin floors and shallow depressions of uplands. Slopes range from 0 to 3 percent. Soils can be occasionally ponded throughout the year depending on amount of precipitation and current soil moisture.

Table 2. Representative physiographic features

Landforms	(1) Plains > Closed depression
Runoff class	Negligible
Ponding duration	Long (7 to 30 days)
Ponding frequency	Occasional
Elevation	457–914 m
Slope	0–1%
Ponding depth	0–25 cm
Water table depth	203–254 cm
Aspect	Aspect is not a significant factor

Table 3. Representative physiographic features (actual ranges)

Runoff class	Negligible to low
Ponding duration	Brief (2 to 7 days) to long (7 to 30 days)
Ponding frequency	None to occasional
Elevation	366–1,067 m
Slope	0–3%
Ponding depth	0–71 cm
Water table depth	0–254 cm

Climatic features

The climate is semiarid and is characterized by hot summers and dry, relatively mild winters. The average relative humidity in mid-afternoon ranges from 25 to 50 percent. Humidity is higher at night, and the average at dawn is around 70 to 80 percent. The sun shines 80 percent of the time during the summer and 60 percent in winter. The prevailing wind is from the south-southwest. Approximately two-thirds of annual rainfall occurs during the May to October period. Rainfall during this period generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. The climate is one of extremes, which exert much more influence on plant communities than averages. Timing and amount of rainfall are critical. High temperatures and dry westerly winds have a tremendously negative impact on precipitation effectiveness, as well as length of time since the last rain. Records since the mid-1900's, as well as geological and archaeological findings, indicate wet and dry cycles going back many thousands of years and lasting for various lengths of time with enormous influence on the flora and fauna of the area.

Table 4. Representative climatic features

Frost-free period (characteristic range)	210-240 days
Freeze-free period (characteristic range)	240-280 days
Precipitation total (characteristic range)	356-483 mm
Frost-free period (actual range)	210-240 days
Freeze-free period (actual range)	240-280 days
Precipitation total (actual range)	356-584 mm
Frost-free period (average)	225 days
Freeze-free period (average)	255 days
Precipitation total (average)	457 mm

Climate stations used

- (1) PANDALE 1 N [USC00416780], Comstock, TX
- (2) PANDALE 11 NE [USC00416781], Comstock, TX
- (3) BAKERSFIELD [USC00410482], Iraan, TX
- (4) BIG LAKE 2 [USC00410779], Big Lake, TX
- (5) COPE RCH [USC00411974], Big Lake, TX
- (6) GARDEN CITY [USC00413445], Garden City, TX
- (7) MCCAMEY [USC00415707], Mc Camey, TX
- (8) PAINT ROCK [USC00416747], Paint Rock, TX
- (9) SANDERSON [USC00418022], Dryden, TX
- (10) SHEFFIELD [USC00418252], Sheffield, TX

Influencing water features

Due to the high clay content and low slope, sites can be ponded. This only occurs occasionally, 1 in 10 years, but the water can be up to 10 inches deep for 1 month on average. Ponded water depth may range up to 28 inches for shorter periods of time.

Wetland description

An onsite investigation is required to determine if areas meet wetland definition.

Soil features

The soils are very deep, well drained, very slowly permeable that formed in calcareous clayey alluvium. Soil series correlated to this site include: Dalby, Irion, and Tobosa.

Table 5. Representative soil features

Parent material	(1) Alluvium–limestone
Surface texture	(1) Clay (2) Silty clay
Family particle size	(1) Fine
Drainage class	Well drained
Permeability class	Very slow
Depth to restrictive layer	152–203 cm
Soil depth	152–203 cm
Surface fragment cover <=3"	0–5%
Surface fragment cover >3"	0–2%
Available water capacity (0-101.6cm)	10.67–18.03 cm
Calcium carbonate equivalent (0-101.6cm)	0–10%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–8
Soil reaction (1:1 water) (0-101.6cm)	7.4–8.4
Subsurface fragment volume <=3" (30.5-101.6cm)	0–4%
Subsurface fragment volume >3" (30.5-101.6cm)	0–2%

Table 6. Representative soil features (actual values)

Drainage class	Not specified
Permeability class	Not specified
Depth to restrictive layer	Not specified
Soil depth	Not specified
Surface fragment cover <=3"	Not specified
Surface fragment cover >3"	Not specified
Available water capacity (0-101.6cm)	3.3–18.03 cm
Calcium carbonate equivalent (0-101.6cm)	0–40%
Electrical conductivity (0-101.6cm)	0–16 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–25
Soil reaction (1:1 water) (0-101.6cm)	7.4–8.4
Subsurface fragment volume <=3" (30.5-101.6cm)	0–10%
Subsurface fragment volume >3" (30.5-101.6cm)	0–20%

Ecological dynamics

The plant communities are dynamic entities. In pre-settlement times, the site would most likely be a savannah dotted with mesquite trees, occasional shrubs and, in some areas, live oaks. The surface would be mostly covered by mid-size bunch grasses and perennial forbs. This reference plant community was greatly influenced by grazing, climate (including periodic extended periods of drought) and, to a lesser degree, fire. Reference community plants developed ways to withstand periods of drought. The midgrasses and forbs shaded the ground, reduced soil temperature, improved infiltration of what little moisture might fall and maintained soil moisture longer. Their roots reached deeper into the soil, utilizing deep soil moisture no longer available to short-rooted plants. In extreme cases many species could go virtually dormant, preserving the energy stored in underground roots, crowns and stems until wetter weather arrived. Their seeds could stay viable in the soil for long periods, sprouting when conditions improved.

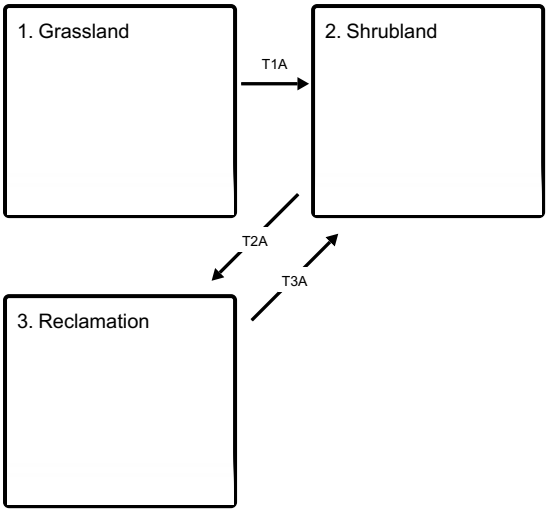
Extensive herds of pronghorns, large towns of black-tailed prairie dogs, as well as smaller populations of elk, white-tailed deer, and desert mule deer were present and had an impact on the plant community. Bison, a migratory herd animal, would come into an area, graze on the move, and not come back for many months or even years. This long deferment period allowed the plants to recover from the heavy grazing. Bison grazing on this site was probably intermittent, occurring during wetter periods. Very few bison were reported in the area after 1830. There were no recorded sightings after 1860. Fire has an influence on plant community structure and was probably a factor in maintaining the original savannah vegetation. Mesquite were present on the site, but not at the level seen today. Periodic fires may have helped keep mesquite as a scattered savannah and other woody species a small part of the composition. Grazing patterns by native herbivores and prairie dog activities were probably more significant factors in maintaining a well-balanced plant community.

While grazing is a natural component of this ecosystem, overstocking and thus overgrazing by domesticated animals has had a tremendous impact on the site. Early settlers, accustomed to farming and ranching in more temperate zones of the eastern United States or even Europe, misjudged the capacity of the site for sustainable production and expected more than could be delivered. Moreover, there was a gap of time between the extirpation of bison and the introduction of domestic livestock which resulted in an accumulation of plant material. This may have given the illusion of higher production than was actually being produced. Overgrazing and fire suppression disrupted ecological processes that took hundreds or thousands of years to develop. Instead of grazing and moving on, domestic livestock were present on the site most of the time, particularly after the practice of fencing arrived. Another influence on grazing patterns was the advent of wells and windmills. They opened up large areas that were previously unused by livestock due to lack of natural surface water. The more palatable plants were selected repeatedly and eventually began to disappear from the ecosystem to be replaced by lower successional, less palatable species. As overgrazing continued, overall production of grasses and forbs declined, more bare ground appeared, soil erosion increased, and woody and succulent increasers began to multiply. The elimination of fire due to the lack of fine fuel or by human interference assisted the rapid encroachment of mesquite and other woody increasers and a concurrent reduction of usable forage.

Extremes in climate exerted tremendous influence on the site long before European man arrived. Geologic formations, archeological findings, and rainfall records since the mid-1900’s show wide variations in precipitation with cycles of long, dry periods going back thousands of years with corresponding variations in kind and amount of flora and fauna species. The mineral content and reaction of the soils enable the site to produce diverse, highly nutritious forage. Loss of cover and soil robs the site the site of this capability and promotes rapid water shed, erosion and crusting. Pedestalling, terracetes, and water flow patterns are range health indicators that will be present if the site begins to deteriorate.

State and transition model

Ecosystem states

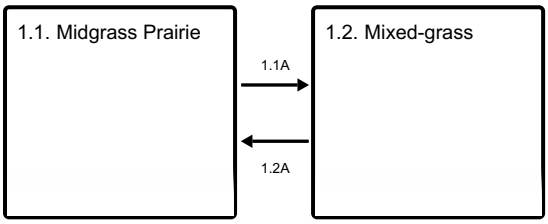


T1A - Absence of disturbance and natural regeneration over time

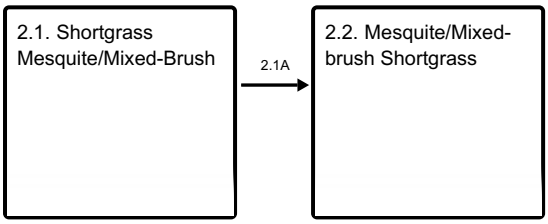
T2A - Removal of woody canopy and reintroduction of natural disturbance regimes

T3A - Absence of disturbance and natural regeneration over time

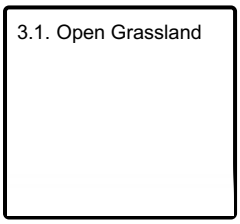
State 1 submodel, plant communities



State 2 submodel, plant communities



State 3 submodel, plant communities



State 1
Grassland

Dominant plant species

- sideoats grama (*Bouteloua curtipendula*), grass
- Arizona cottontop (*Digitaria californica*), grass

Community 1.1
Midgrass Prairie

The reference community for this site is a fire-dependent midgrass prairie. Woody species make up less than five

percent of the total herbage production. Tobosa, being tolerant of repeated fires, made up as much as 20 percent. Sideoats grama, feathery bluestems, vine mesquitegrass, Arizona cottontop (*Digitaria californica*), Texas cupgrass (*Eriochloa sericea*), and plain bristlegrass contribute 30 to 60 percent. Buffalograss and curlymesquite were common shortgrasses. Texas wintergrass (*Nassella leucotricha*), wildrye (Elymus spp.), and western wheatgrass (*Pascopyrum smithii*) were important parts of the cool-season grass component. Forbs include Engelmann's daisy (*Engelmannia peristenia*), ruellia (Ruellia spp.), sida (Sida spp.), verbena, groundcherry (Physalis spp.), and bundleflower (Desmanthus spp.). Shrubs are scarce but include fire-resistant species as sumac (Rhus spp.), pricklypear (Opuntia spp.), and condalia (Condalia spp.). Oaks (Quercus spp.) and mesquite (Prosopis spp.) are also present but are usually scattered multi-stemmed shrubs created by repeated wildfires. Annual yields decline from east to west due to precipitation differences. Grasses and forbs contribute up to 95 percent of the total annual production. The midgrasses aid in the infiltration of rainfall into the moderately permeable soil and reduced runoff. Litter and organic matter buildup are limited by the dry climate.

Community 1.2
Mixed-grass

The Mixed-grass Savannah Community (1.2) is being encroached by woody species that have been held at low densities by repeated fires and competition from a vigorous grass component. Brushy species, including pricklypear and mesquite, increase in density because abusive heavy grazing by livestock reduces grass cover, causes reduction of soil cover, and reduces fine fuel necessary to care fires. Due to selective grazing and differential response of plants to defoliation, heavy grazing also causes changes in composition of the reference community. The more palatable midgrasses and forbs are replaced by less palatable, or more grazing resistant, species. The encroaching woody species are generally less than five feet tall and subject to control by prescribed burning. The woody canopy varies between 5 and 15 percent depending on length and severity of overgrazing, frequency and duration of fires, and seed sources by invading species. Typically, mesquite and/or or pricklypear are early and persistent increasers. Condalia (Condalia spp.), algerita (*Mahonia trifoliolata*), broom snakeweed, and acacia (Acacia spp.) are also common. The prairie grassland becomes a grassland-shrub savannah being encroached by suppressed woody species. The preferred midgrasses are being replaced by the more grazing-resistant tobosa, although sideoats grama, vine mesquite, Texas cupgrass, and feathery bluestems still persist in this phase. Most of the perennial forbs found in the reference community remain, although in lesser amounts. Annual primary production is reduced slightly relative to the reference community. Grasses remain the dominant producers of forage. Heavy abusive grazing reduces plant cover, litter and mulch, and increases bare ground which exposes the soil to erosion. There could be some mulch and litter movement during rainstorms but due to gentle slopes, little soil movement takes place in this vegetation phase.

Pathway 1.1A
Community 1.1 to 1.2

The reference community can be maintained with prescribed grazing and prescribed burning. Stocking rates must consider the kind of livestock and balance their numbers with current annual forage production while considering competition from other herbivores. With heavy abusive grazing, decrease in intensity and frequency of fires, and no brush management, this plant community transitions very quickly to the Mixed-grass Savannah Community (1.2).

Pathway 1.2A
Community 1.2 to 1.1

Prescribed grazing, return of fire, and brush management will be necessary to transition back to the reference community (1.1).

State 2
Shrubland

Dominant plant species

- buffalograss (*Bouteloua dactyloides*), grass

Community 2.1

Shortgrass Mesquite/Mixed-Brush

The Shortgrass Mesquite/Mixed-Brush Community (2.1) presents a 15 to 35 percent woody canopy cover dominated by mesquite with mixed-brush and a shortgrass understory. This community is the result of selective heavy grazing by livestock, suppression of fire, and the differential response of plants due to defoliation. The diversity of the grassland component declines while woody plants and unpalatable forbs increase. Primary production decreases due to decline in soil structure and organic matter and is primarily from the woody component instead of the grass-like component. All, except the more palatable woody species, have increased in size and density. Mesquite typically dominates the overstory and pricklypear dominates the understory. Algerita, acacia, condalia, and broom snakeweed may also be present in this community. Remnants of reference community may occupy interspaces between trees and shrubs, but more often they are unpalatable invader species. Tobosa remains dominant, but as regression progresses under heavy grazing pressure, tobosa gives way to buffalograss (Buchloe dactyloides), curlymesquite (Hilaria belangeii), and other less palatable shortgrasses. Mexican sagewort (Artemesia ludoviciana), Texas nightshade (Solanum spp.), queen's delight (*Stillingia sylvatica*), prairie coneflower (*Ratibida columnifera*), Texas grama (*Bouteloua rigidiseta* var. rigidiseta), and red grama (*Bouteloua trifida*) are commonly found in this community. Cool-season grasses such as Texas wintergrass can be found under and around woody plants. In wet cycles, bromes (Bromus spp.) and other annual species such as broomweed (Gutierrezia spp.) are abundant. Herbage production is balanced between the grassland component and woody species. As the grassland component declines, more soil is exposed to crusting and wind erosion. During the middle and end of this plant community phase, considerable soil becomes exposed further. Water erosion is not a serious problem because of the shallow slopes on the site but wind erosion can be rather high. High interception losses by the increasing woody canopy combined with evaporation losses can reduce the effectiveness of rainfall. Litter, soil organic matter and structure decline in the interspaces reducing water infiltration but hydrologic conditions improve under the woody plant cover.

Community 2.2
Mesquite/Mixed-brush Shortgrass

The Mesquite/Mixed-Brush Shortgrass Community (2.2) is dominated by mesquite and shrubs with few shortgrasses present. Remnants of the grassland vegetation, mostly shortgrasses and shade-tolerant forbs, occupy the shrub interspaces. This community is the result of selective heavy grazing by livestock and wildlife, absence of natural fires and the differential response of plants due to defoliation on the shrubland site. The typical woody canopy is mesquite with pricklypear in the understory. Algerita, acacia, condalia, and snakeweed are also common in this community. Tobosa remains dominant initially; but under heavy grazing pressure, tobosa gives way to buffalograss, curlymesquite, and other less palatable species. Mexican sagewort, Texas nightshade, queen's delight, prairie coneflower, Texas grama, and red grama become common. Cool-season grasses such as Texas wintergrass can be found under and around woody plants. During wet periods, bromes and other annual species such as broomweed are abundant. Because of grazing pressure and competition for nutrients and water from the woody plants, the grassland component shows lack of plant vigor and productivity. As the grassland component declines, more soil is exposed to crusting and wind erosion. During the beginning and middle of this plant community phase, considerable soil becomes exposed. Water erosion is not a serious problem because of the shallow slopes, but wind erosion can be rather high. High interception losses by the increasing woody canopy combined with evaporation losses can reduce the effectiveness of rainfall. Litter, soil organic matter and structure decline in the interspaces reducing water infiltration in the interspaces, but hydrologic conditions improve under the woody plant cover. Browsing animals can find fair quality food sources if deer and goat browsing have not been excessive. Forage quantity and quality for cattle in this plant community is low. Livestock stocking decisions should consider the forage species composition, quantity of available forage, and rangeland health conditions to determine the proper annual carrying capacity. Unless brush management and prescribed grazing management are applied, the transition toward dense shrubland will continue. Brush control practices are required to reverse the continuing trend of brush canopy enclosure. To restore livestock or deer production, brush management is required to remove undesirable brush species, range planting of native species to return vegetation, and establish prescribed grazing and prescribed fire conservation practices to maintain the health of the desired plant community. Caution should be applied in choosing brush control and seeding methods. Broadcast herbicides are often ineffective and mechanical treatments that expose soil leave the site open which can lead infestation of weeds that often can persist for several years.

Pathway 2.1A

Community 2.1 to 2.2

When the shrub canopy cover nears 35 percent and the herbaceous component contributes less than 50 percent of the herbage production, the plant community crosses the threshold and becomes a Mesquite/Mixed-Brush Shortgrass Community (2.2).

State 3
Reclamation

Community 3.1
Open Grassland

This community is the product of endeavors to reclaim the Shrubland State (2) back to a grassland. Depending on the goals of the land user, reclamation efforts might involve the whole site or only part of it. A land manager involved primarily with livestock might prefer more open, grassy areas, whereas one interested mostly in wildlife would probably want to leave substantial brushy areas. Through brush management, reseeding of native species (both grasses and forbs) in areas of adequate rainfall, prescribed grazing, and re-introduction of fire where appropriate, one can possibly manipulate this site successfully towards a reference community appearance, but it will never be able to mirror the original site. However, utilizing natives as the reseeding source will greatly benefit wildlife species such as deer, turkey, quail, and other birds. This Open Grassland Community may also be comprised of seeded species which are non-native and which may occur as a monoculture community. This type may contain less cover or food for wildlife, often practically devoid of native grasses and forbs. The site’s capacity to produce must be determined over time under careful management. Maintenance through prescribed grazing, prescribed burning and individual plant treatment with appropriate chemicals can preserve the site’s sustained production indefinitely. Without these measures, the site will experience renewed encroachment of mesquite and other increasers/invaders.

Transition T1A
State 1 to 2

The changes in species composition are small initially, but unless proper grazing and prescribed burning are initiated, the invading species continue to increase in size and density. When the canopy of the woody plants becomes dense enough (15 percent) or tall enough (greater than five feet) to suppress grass growth and resist fire damage, a threshold in ecological succession is crossed. This threshold can also occur when the fine fuel load provided by grasses is too low to control brush effectively with fire. The Mixed-grass Savannah Community (1.2) then becomes the Shortgrass Mesquite/Mixed-Brush Community (2.1). In this plant community, normal range management practices, such as prescribed grazing, cannot reverse the trend to woody plant dominance.

Transition T2A
State 2 to 3

Brush management is the primary driver for this transition. Once the woody species have been removed, range planting, return of natural fire intervals, and prescribed grazing are needed.

Transition T3A
State 3 to 2

Without brush management, prescribed fire, and prescribed grazing, the reclamation efforts will become covered in brushy species.

Additional community tables

Animal community

This site is suitable for the production of domestic livestock and to provide habitat for native wildlife. Cow-calf, stocker cattle, sheep, and goats can utilize this site. Carrying capacity has declined drastically over the past 100 years due to deterioration of the reference plant community. An assessment of vegetation is needed to determine the site’s current carrying capacity. Calculations used to determine livestock stocking rate should be based on

forage production remaining after determining use by resident wildlife, then refined by frequent and careful observation of the plant community's response to animal foraging.

A large diversity of wildlife is native to this site. In the historic plant community, migrating bison, grazing primarily during wetter periods, resident pronghorns, and smaller populations of white-tailed deer, desert mule deer, quail and prairie chickens were the more predominant species. With the subsequent transformation of the plant community, due primarily to the influence of man and climate change, the kind and proportion of wildlife species have been altered.

With the eradication of the screwworm fly, increase in woody vegetation, and man-suppressed natural predation, deer numbers have increased and are often in excess of carrying capacity. Where deer numbers are excessive, overbrowsing and overuse of preferred forbs causes deterioration of the plant community. Progressive management of deer populations through hunting can keep populations in balance and provide an economically important ranching enterprise. Achieving a balance between brushy cover and more open plant communities on this and adjacent sites is important to deer management. Competition among deer, sheep, and goats must be a consideration in livestock and wildlife management to prevent damage to preferred vegetation.

Smaller mammals include many kinds of rodents, jackrabbit, cottontail rabbit, raccoon, skunks, possum and armadillo. Mammalian predators include coyote, red fox, gray fox, bobcat, and mountain lion. Wolves were common in earlier times, bears resided in some areas and an occasional jaguar was encountered. Many species of snakes and lizards are native to the site.

Many species of birds are found on this site including game birds, songbirds and birds of prey. Major game birds that are economically important are bobwhite quail, scaled (blue) quail and mourning dove. Quail prefer a combination of low shrubs, bunch grass (critical for nesting cover), bare ground and low successional forbs. Turkeys visit the site to feed. The different species of songbirds vary in their habitat preferences. Habitat on this site that provides a large diversity of grasses, forbs and shrubs will support a good variety and abundance of songbirds. Birds of prey are important to keep the numbers of rodents, rabbits and snakes in balance.

Inventory data references

Information provided here has been derived from limited NRCS clipping data, and from field observations of range trained personnel.

Other references

Archer, S. 1994. Woody plant encroachment into southwestern grasslands and savannas: Rates, patterns, and proximate causes. Ecological implications of livestock herbivory in the West, 13-68.

Archer, S. and F. E. Smeins. 1991. Ecosystem-level processes. Grazing Management: An Ecological Perspective. Edited by R.K. Heischmidt and J.W. Stuth. Timber Press, Portland, OR.

Bestelmeyer, B. T., J. R. Brown, K. M. Havstad, R. Alexander, G. Chavez, and J. E. Herrick. 2003. Development and use of state-and-transition models for rangelands. Journal of Range Management, 56(2):114-126.

Bracht, V. 1931. Texas in 1848. German-Texan Heritage Society, Department of Modern Languages, Southwest Texas State University, San Marcos, TX.

Bray, W. L. 1904. The timber of the Edwards Plateau of Texas: Its relations to climate, water supply, and soil. No. 49. US Department of Agriculture, Bureau of Forestry.

Briske, D. D., S. D. Fuhlendorf, and F. E. Smeins. 2005. State-and-transition models, thresholds, and rangeland health: A synthesis of ecological concepts and perspectives. Rangeland Ecology and Management, 58(1):1-10.

Brothers, A., M. E. Ray Jr., and C. McTee. 1998. Producing quality whitetails, revised edition. Texas Wildlife Association, San Antonio, TX.

Brown, J. K. and J. K. Smith. 2000. Wildland fire in ecosystems, effects of fire on flora. Gen. Tech. Rep. RMRS-

GTR-42-vol. 2. Ogden, UT: US Department of Agriculture, Forest Service, Rocky Mountain Research Station, 257:42.

Davis, W. B. 1974. The Mammals of Texas. Texas Parks and Wildlife Department, 41.

Foster, J. H. 1917. The spread of timbered areas in central Texas. Journal of Forestry 15(4):442-445.

Frost, C. C. 1998. Presettlement fire frequency regimes of the United States: A first approximation. Fire in ecosystem management: Shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings, 20:70-81.

Gould, F. W. 1975. The grasses of Texas. The Texas Agricultural Experiment Station, Texas A&M University Press, College Station, TX.

Hatch, S. L. and J. Pluhar. 1993. Texas Range Plants. Texas A&M University Press, College Station, TX.

Hamilton, W. and D. Ueckert. 2005. Rangeland woody plant control--past, present, and future. Texas A&M University Press. College Station, TX.

Hart, C. R., A. McGinty, and B. B. Carpenter. 1998. Toxic plants handbook: Integrated management strategies for West Texas. Texas Agricultural Extension Service, The Texas A&M University, College Station, TX.

Heitschmidt, R. K. and J. W. Stuth. 1991. Grazing management: An ecological perspective. Timberline Press, Portland, OR.

Loughmiller, C. and L. Loughmiller. 1984. Texas wildflowers. University of Texas Press, Austin, TX.

Milchunas, D. G. 2006. Responses of plant communities to grazing in the southwestern United States. Gen. Tech. Rep RMRS-GTR-169. Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station, 126:169.

Niehaus, T. F. 1998. A field guide to Southwestern and Texas wildflowers (Vol. 31). Houghton Mifflin Harcourt, Boston, MA.

Ramsey, C. W. 1970. Texotics. Texas Parks and Wildlife Department, Austin, TX.

Roemer, F. translated by O. Mueller. 1995. Roemer’s Texas, 1845 to 1847. Texas Wildlife Association, San Antonio, TX.

Scifres, C. J. and W. T. Hamilton. 1993. Prescribed burning for brushland management: The South Texas example. Texas A&M Press, College Station, TX.

Smeins, F. E., S. Fuhlendorf, and C. Taylor, Jr. 1997. Environmental and land use changes: A long term perspective. Juniper Symposium, 1-21.

Taylor, C. A. and F. E. Smeins. 1994. A history of land use of the Edwards Plateau and its effect on the native vegetation. Juniper Symposium, 94:2.

Thurow, T. L. 1991. Hydrology and erosion. Grazing Management: An Ecological Perspective. Edited by R.K. Heitschmidt and J.W. Stuth. Timber Press, Portland, OR.

Tull, D. and G. O. Miller. 1991. A field guide to wildflowers, trees and shrubs of Texas. Texas Monthly Publishing, Houston, TX.

USDA-NRCS. 1997. National range and pasture handbook. Washington, DC: United States Department of Agriculture. Natural Resources Conservation Service, Grazing Lands Technology Institute.

Weniger, D. 1997. The explorers’ Texas: The animals they found. Eakin Press, Austin, TX.

Weniger, D. 1984. The explorers' Texas: The lands and waters. Eakin Press, Austin, TX.

Vines, R. A. 1984. Trees of Central Texas. University of Texas Press, Austin, TX.

Vines, R. A. 1960. Trees, shrubs and vines of the Southwest. University of Texas Press, Austin, TX.

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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)	
Contact for lead author	
Date	05/12/2025
Approved by	Bryan Christensen
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:**

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2. **Presence of water flow patterns:**

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3. **Number and height of erosional pedestals or terracettes:**

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):**

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5. **Number of gullies and erosion associated with gullies:**

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6. **Extent of wind scoured, blowouts and/or depositional areas:**

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

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

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

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:**

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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):**

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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:

    Sub-dominant:

    Other:

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):**

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14. **Average percent litter cover (%) and depth (in):**

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):**

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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:

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17. **Perennial plant reproductive capability:**
