Climate Vulnerability Analysis and Land Management Strategies

Volume 3 – Appendices

City of Austin, Parks and Recreation Department

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Appendix 1 - Management Complexes

Management complex / tract name		area included (acres)			
		total		BCP	
Barton Creek complex		2,088.8			
Barton Creek Greenbelt	3753 S Capital of Texas Hwy., Austin, Texas 78746		838.8	814.6	*
Barton Creek Wilderness Park	3918 S Mopac Expy Svrd SB, Austin, Texas 78746		1,120.3	1,075.2	*
Gaines Greenbelt	4800 S Mopac Expy., Austin, Texas 78735		121.0		
Gaines Park at Barton Creek Greenbelt	3918 S Mopac Expy Svrd., Austin, Texas 78746		8.7		
Decker complex		2,140.9			
Decker Tallgrass Prairie Preserve	8001 Decker Ln., Austin, Texas 78724		348.0		
Louis Rene Barrera Indiangrass Wildlife Sanctuary	9138 Blue Bluff Rd., Austin, Texas 78724		290.6		
Walter E. Long Metro Park	6620 Blue Bluff Rd., Austin, Texas 78724		1,502.2		
East Boggy + Red Bluff complex		124.1			
East Boggy Creek Greenbelt	5609 Stuart Cir., Austin, Texas 78721		75.0		
Red Bluff Nature Preserve	5607 Harold Ct., Austin, Texas 78721		49.1		
Guerrero + Co River Preserve complex		309.8			
Colorado River Park WIldlife Sanctuary	5827 Levander Loop, Austin, Texas 78702		42.5		
Roy Guerrero Metro Park	400 Grove Blvd., Austin, Texas 78741		267.3		
Onion Creek - Old San Antonio complex		110.0			
Old San Antonio District Park	12110 Old San Antonio Rd., Austin, Texas 78652		58.1		
Old San Antonio Greenbelt	11705 Old San Antonio Rd., Austin, Texas 78748		28.4		
Wunneburger Neighborhood Park	11901 Old San Antonio Rd., Austin, Texas 78652		23.5		
Onion Creek Metro complex		843.1			
Jimmy Clay Golf Course	5400 Jimmy Clay Dr, Austin, TX 78744		50.1		
Marble Creek Greenbelt	6605 E William Cannon Dr., Austin, Texas 78744		75.8		
Marble Creek Neighborhood Park	6704 Zequiel Dr., Austin, Texas 78744		8.7		
Onion Creek Greenbelt	7004 Onion Creek Dr., Austin, Texas 78744		174.2		
Onion Creek Metro Park	8652 Nuckols Crossing Rd., Austin, Texas 78744		459.3		
Onion Creek Soccer Complex	5600 E William Cannon Dr., Austin, Texas 78744		65.5		
Salt Springs Neighborhood Park	6401 E William Cannon Dr., Austin, Texas 78744		9.5		
Slaughter Creek Metro complex		598.6			
Circle C Ranch on Slaughter Creek	6301 W Slaughter Ln., Austin, Texas 78739		532.0		*
Hielscher Tract Greenbelt	6801 La Crosse Ave., Austin, Texas 78739		66.5		
Trevino + Walnut complex		400.9			
Colorado/Walnut Greenbelt	8001 Delwau Ln., Austin, Texas 78725		100.2		
John Trevino Jr. Metro Park at Morrison Ranch	9501 FM 969 Rd., Austin, Texas 78725		300.7		
Isolated tracts					
Barrow Nature Preserve	7515 Step Down Cv., Austin, Texas 78731		7.0	7.0	
Bauerle Ranch at Slaughter Creek Greenbelt	2715 Lynnbrook Dr., Austin, Texas 78748		319.4		
Blunn Creek Nature Preserve	1200 St. Edwards Dr., Austin, Texas 78704		38.8		
Big Walnut Creek Nature Preserve	9221 E US 290 Hwy EB, Austin, Texas 78724		43.7		
Bull Creek District Park	6701 Lakewood Dr., Austin, Texas 78731		47.9	28.0	
Commons Ford Ranch Metro Park	614 N Commons Ford Rd., Austin, Texas 78733		211.8	115.0	
Deer Park at Maple Run Preserve	4929 Davis Ln., Austin, Texas 78749		24.3		*
Dick Nichols District Park	8011 Beckett Rd., Austin, Texas 78749		85.9		
Emma Long Metro Park	1600 City Park Rd., Austin, Texas 78730		950.0	950.0	
Goat Cave Karst Nature Preserve	3900 Deer Ln., Austin, Texas 78749		14.1		*
Little Walnut Creek Greenbelt	5100 E 51st St., Austin, Texas 78723		205.9		
Mary Moore Searight Metro Park	907 W Slaughter Ln., Austin, Texas 78748		291.8		
Mayfield Preserve	3805 W 35th St., Austin, Texas 78703		19.9		
Onion Creek Wildlife Sanctuary	4435 E SH 71, Austin, Texas 78617		178.5		
Southern Walnut Creek Greenbelt	6013 Loyola Ln, Austin, Texas 78724		538.1		
St. Edwards Greenbelt	7301 Spicewood Springs Rd., Austin, Texas 78750		79.3	50.0	
Stephenson Nature Preserve	7501 Longview Rd., Austin, Texas 78745		147.1		
Stillhouse Hollow Nature Preserve	7810 Sterling Dr., Austin, Texas 78731		20.3	20.3	*
Walnut Creek Metro Park	12138 N Lamar Blvd, Austin, Texas 78758		240.1		
William H. Russell Karst Preserve	3705 Deer Ln., Austin, Texas, 78749		190.1		*
Zilker Nature Preserve	301 Nature Center Dr., Austin, Texas 78746		77.4		
	BCP			3,060.1	
	Total		10,347.4		
*Contains BCP-protected caves.					

Appendix 2 - Methods

A. – Geospatial Methods for Climate Hazards and Vulnerability

This appendix describes the geospatial analysis methods for climate hazards and indices with a focus on processing steps applied to the data. Data evaluation, considerations, and summary and interpretation of results are included in 5.7 Geospatial Analysis in the Climate Vulnerability Analysis and Land Management Strategies document. Data sources and scoring are provided in Table 1 attached.

General

1. All GIS analysis was conducted in ArcPro 3.0.3.
2. Study Area files:
   2.1. Study area park boundaries in vector format= "Boundaries_LMP_SOW."
   2.2. Study area park boundaries in raster format= "Boundaries_LMP_SOW_30ft_Val1" with study area set to Value 1.
3. All climate analysis was executed in raster format with the following Environments settings matching file "Boundaries_LMP_SOW_30ft_Val1":
   - Workspace: Set to current working gdb.
   - Output Coordinate System: NAD 1983 StatePlane Texas Central FIPS 4203 (US Feet)
   - Processing Extent: Same as Layer "Boundaries_LMP_SOW_30ft_Val1."
   - Cell size: 30
   - Defaults for all other settings.
4. Clipping to Study Area
   4.1. Raster Calculator was applied to clip raster data to the study area.
      4.1.1. Raster Calculator Formula= "Boundaries_LMP_SOW_30ft_Val1" * <Input Data to be Clipped>
5. Condition Polygon-level Analysis
   5.1. File preparation for condition polygon-level analysis
      5.1.1. Each polygon from the Condition Assessment was assigned a unique integer value in Field "BIO_ID."
      5.1.2. Polygon to Raster was applied using Value Field= "BIO_ID."
      5.1.3. Output= "Condition_Polygon_Bio_Ras_REV1_SA"
   5.2. Condition polygon-level analysis general process
      5.2.1. Data for each hazard was compiled and scored as noted in the Hazards section below.
      5.2.2. An area weighted average of the hazard scoring was generated to summarize each hazard at the unit of each individual condition polygon. The greater the spatial area covered by a particular score in a polygon, the greater influence that score had on the polygon scoring. To do so, Zonal Statistics was applied with the following settings:
         - Input Raster= "Condition_Polygon_Bio_Ras_REV1_SA"
         - Input Value Raster= Hazards as noted below
         - Statistics Type= Mean
         - Ignore NoData in Calculations= Checked
      5.2.3. Polygon-level analysis results were classified into five classes with the Jenks Natural Breaks method (Natural Breaks) and assigned a score of 1 (lowest hazard) to 5 (highest hazard).

Hazards

6. Wildfire
   6.1. Wildfire Inputs
      6.1.1. Crown Fire= FlamMap output "FlamMap_Output_N30_crownfireactivity_N30"

6.1.2. Burn probability= FlamMap output “FlamMap_Output_N30_burnprob_N30”

6.2. Wildfire Process

6.2.1. To identify areas of modeled crown fire “FlamMap_Output_N30_crownfireactivity_N30” was reclassified to contain only areas of “Active Crown Fire” from the FlamMap modeling with an output Value 1. Output= “CrownFire.”

6.2.2. Burn Probability File Preparation

6.2.2.1. Burn probability was normalized by the highest probability in the FlamMap output at the scale of the full FlamMap study area. For the full FlamMap study area the normalized output ranges from 0 to 1. Raster Calculator Formula= “FlamMap_Output_N30_burnprob_N30” / 0.0036899999249726534 (Max value of FlamMap_Output_N30_burnprob_N30”).

6.2.2.2. The result of the previous step was clipped to only areas of “CrownFire.” Output= “FlamMap_CrownFire_Burnprob_Norm_2_SA.”

6.2.2.3. “FlamMap_CrownFire_Burnprob_Norm_2_SA” was reclassified to a 1 to 5 scoring as noted in Table 1 for “Crown Fire Probability Weighting.” This created a crown fire layer that is weighted by the burn probability, with areas of higher probability weighted higher for hazard. Output= “Crownfire_Scored.”

6.2.3. Crown Fire Percentage was calculated for each condition assessment polygon using the weighted crown fire area of “Crownfire_Scored” present in each polygon, and the full area of each assessment polygon in “Condition_Polygon_Bio_Ras_REV1_SA”. (E.g., a condition assessment polygon that is 50% covered by “Crownfire_Score” area that all has a score of 1 would have a Crown Fire Percentage of 50%. A condition assessment polygon that is 25% covered by “Crownfire_Score” area that all has a score of 2 would also have a Crown Fire Percentage of 50%.) This results in a percentage of crown fire area in each condition assessment polygon that is weighted by the burn probability.

6.2.4. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

6.3. Wildfire Output

6.3.1. Crown Fire Probability= “CrownFire_Prob_3_Poly_RC”

7. Extreme Heat

7.1. Extreme Heat Input

7.1.1. Daytime Land Surface Temp= “Austin_DayLST”

7.2. Extreme Heat Process

7.2.1. “Austin_DayLST” was reclassified to a 1 to 5 scoring based on standard deviations from the mean for temperatures within the study area, as noted in Table 1 for “Heat Intensity.”

7.2.2. An area weighted average of the result of the previous step was calculated for each condition assessment polygon with steps noted in 5.2.2.

7.2.3. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

7.3. Extreme Heat Output

7.3.1. Heat Intensity= “Heat_Poly_2_RC”

8. Drought

8.1. Drought Input

8.1.1. NRCS SSURGO Soil Data= “SSURGO_Box_SA_1000mBuff”

8.2. Drought Process

8.2.1. Soil Water Availability was indicated in “SSURGO_Box_SA_1000mBuff” as SSURGO Field Name “aws0100wta” with Alias “Available Water Storage 0-100 cm - Weighted Average.”

8.2.2. Polygon to Raster was applied using Value Field= “aws0100wta.”

8.2.3. The result of the previous step was reclassified to a 1 to 5 scoring based on standard deviations from the mean, as noted in Table 1 for “Soil Water Availability.” Low Soil Water Availability equates to higher hazard, and high Soil Water Availability equates to lower hazard.
8.2.4. An area weighted average of the result of the previous step was calculated for each condition assessment polygon with steps noted in 5.2.2.
8.2.5. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

8.3. Drought Output
8.3.1. Soil Water Availability = “SoilWaterAvailability_Poly_2_RC”

9. Flooding
9.1. Flooding Inputs
9.1.1. 500-Year Floodplain, FEMA= “FLOOD_S_FLD_HAZ_AR_500YR”
9.1.2. 100-Year Floodplain, Austin= “Greater_Austin_Fully_Developed_Floodplain”

9.2. Flooding Process
9.2.1. The 500 Year Floodplain and 100 Year Floodplain were converted from vector to raster format and assigned scoring as noted in Table 1 for “Flooding.” “Boundaries_LMP_SOW_30ft_Val1” was used as a data source for areas outside of the 500- and 100-Year Floodplains but within the study area with a score of 1.
9.2.2. The three files in the previous step were combined using Cell Statistics with the following settings:
- Input Rasters= <three scored rasters for 500-Year, 100-Year, and study area background>.
- Statistics Type= Max
- Ignore NoData in Calculations= Checked

9.2.3. An area weighted average of the result of the previous step was calculated for each condition assessment polygon with steps noted in 5.2.2.
9.2.4. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

9.3. Flooding Output
9.3.1. Flooding= “Flood_Poly_2_RC”

<u>Indices</u>

10. Environmental Vulnerability Index (EVI)
10.1. EVI Inputs
10.1.1. Crown Fire Probability= “CrownFire_Prob_3_Poly_RC”
10.1.2. Soil Water Availability = “SoilWaterAvailability_Poly_2_RC”
10.1.3. Condition= “Condition_Polygon_REV_230406”

10.2. EVI Process
10.2.1. Polygon to Raster was applied to the Condition scoring using Value Field= “Condition” to convert the vector input to raster format.
10.2.2. The 1 to 5 Condition values were inverted to match the scoring as noted in Table 1 for “Condition.” A low Condition value equates to a higher vulnerability score, and high Condition value equates to a lower vulnerability score. Output= “Condition_Polygon_REV_230406_Ras_2_RC_Invert.”
10.2.3. Crown Fire Probability, Soil Water Availability, and Condition were combined with even weighting using Cell Statistics with the following settings:
- Input Rasters= “CrownFire_Prob_3_Poly_RC,” “SoilWaterAvailability_Poly_2_RC,” and “Condition_Polygon_REV_230406_Ras_2_RC_Invert”
- Statistics Type= Sum

- Ignore NoData in Calculations= Checked

10.2.4. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

10.3. EVI Output

10.3.1. Environmental Vulnerability Index= “EVI_2_RC”

11. Social Vulnerability Index (SVI)

11.1. SVI Input

11.1.1. CDC/ ATSDR Social Vulnerability Index, 2020= “SVI2020_SA”

11.2. SVI Process

11.2.1. “SVI2020_SA” values were scored in vector format in new Field= “SVI_SCR” as noted in Table 1 for “SVI” using the overall summary ranking variable Field= “RPL_THEMES.”

11.2.2. The census tract borders of the input SVI data are sometimes very coarsely drawn. In some areas a waterway acts as the border for the census tract, but the coarse SVI line does not match the waterway very accurately. In some cases, a very small amount of an SVI polygon intersects a condition polygon because of this inaccuracy at waterways. To account for these situations, a manual desktop review with manual adjustments was conducted of census tract borders at waterways in the study area.

11.2.2.1. The SVI borders at the following condition polygons were manually adjusted: BIO_ID 40, 53, 54, 55, 57, 59, 191, 197, 337, 469, 774.

11.2.2.2. Output= “SVI2020_SA_Clip_2_CleanUp”

11.2.3. Polygon to Raster was applied using Value Field= “SVI_SCR.” Output= “SVI2020_SA_Clip_3_CleanUp_RasScr”

11.2.4. Condition polygons were assigned an SVI value based on the maximum SVI score that intersected the polygon. Zonal Statistics was applied with the following settings:

- Input Raster= “Condition_Polygon_Bio_Ras_REV1_SA”
- Input Value Raster= “SVI2020_SA_Clip_3_CleanUp_RasScr”
- Statistics Type= Max
- Ignore NoData in Calculations= Checked

11.2.5. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

11.3. SVI Output

11.3.1. Social Vulnerability Index= “Poly_SVI_Max_RC_REV1”

12. Park Climate Vulnerability Index

12.1. Park Climate Vulnerability Index Inputs

12.1.1. Environmental Vulnerability Index= “EVI_2_RC”

12.1.2. Social Vulnerability Index= “Poly_SVI_Max_RC_REV1”

12.2. Park Climate Vulnerability Index Process

12.2.1. The EVI and SVI were combined with even weighting using Cell Statistics:

- Input Rasters= “EVI_2_RC” and “Poly_SVI_Max_RC_REV1.”
- Statistics Type= Sum
- Ignore NoData in Calculations= Checked

12.2.2. The result of the previous step was classified into five Natural Breaks classes as described in 5.2.3.

12.3. Park Climate Vulnerability Index Output

12.3.1. Park Vulnerability Index= “PCVI_2_RC”

13. Park Climate Vulnerability Index Summary by Park

13.1. Park Climate Vulnerability Index Summary by Park Inputs

13.1.1. Park Vulnerability Index= “PCVI_2_RC”

13.1.2. Park Boundaries in raster format= "Boundaries_LMP_SOW_Bio_ID"

13.2. Park Climate Vulnerability Index Summary by Park Process

13.2.1. File Preparation for Park Boundary Calculations

13.2.1.1. Each park boundary from "Boundaries_LMP_SOW" was assigned a unique integer value in Field "BIO_ID."

13.2.1.2. Polygon to Raster was applied using Value Field= "BIO_ID."

13.2.1.3. Output= "Boundaries_LMP_SOW_Bio_ID"

13.2.2. Park Boundary-level Calculations Process

13.2.2.1. The calculation process summarizes Park Climate Vulnerability Index scores of condition polygons, at the scale of each individual park, on an area-weighted basis. To do so, Zonal Statistics was applied with the following settings:

- Input Raster= "Boundaries_LMP_SOW_Bio_ID"
- Input Value Raster= "PCVI_2_RC"
- Statistics Type= Mean
- Ignore NoData in Calculations= Checked

13.3. Park Climate Vulnerability Index Summary by Park Output

13.3.1. Park Climate Vulnerability Index Summary by Park= Park_PCVI_1_ZSMean

Table 1. Climate Hazard and Vulnerability Scoring

Crown Fire Probability

Indicator	**1 Lowest Hazard**	**2**	**3**	**4**	**5 Highest Hazard**	**Data Notes**	**Data Source**
Crown Fire Probability Weighting	0 to 0.6	> 0.6 to 0.12	>0.12 to 0.18	>0.18 to 0.24	>0.24 to 0.30	Crown fire probability normalized by highest probability in the model output. This metric used to weight the crownfire area.	Austin Fire Department Wildfire Division
Weighted Crown Fire Percentage	Natural Breaks 1	Natural Breaks 2	Natural Breaks 3	Natural Breaks 4	Natural Breaks 5	Percentage of area modeled to have crown fire, weighted by crown fire probability.	Austin Fire Department Wildfire Division

Environmental Vulnerability Index (EVI)

Indicator	**1 Lowest Vulnerability**	**2**	**3**	**4**	**5 Highest Vulnerability**	**Data Notes**	**Data Source**
Crown Fire Probability	Natural Breaks 1	Natural Breaks 2	Natural Breaks 3	Natural Breaks 4	Natural Breaks 5	Percentage of area modeled to have crown fire, weighted by fire probability. See Crownfire above for additional details.	Austin Fire Department Wildfire Division
Soil Water Availability	>1/2 SD Highest Soil Water Availability	>Mean to 1/2 SD	-1/2 SD to Mean	<-1 SD to -1/2 SD	<-1 SD Lowest Soil Water Availability	Available Water Storage (AWS) 0 to 100cm Available water storage (AWS). The volume of water that the soil, to a depth of 100 centimeters, can store that is available to plants. It is reported as the weighted average of all components in the map unit, and is expressed as centimeters of water. AWS is calculated from AWC (available water capacity) which is commonly estimated as the difference between the water contents at 1/10 or 1/3 bar (field capacity) and 15 bars (permanent wilting point) tension, and adjusted for salinity and rock fragments.	NRCS SSURGO https://nrcs.app.box.com/v/soils/
Condition	5	4	3	2	1	Summary condition score from field work and site observations.	Blackland and RES

Park Climate Vulnerability Index

Indicator	**1 Lowest Vulnerability**	**2**	**3**	**4**	**5 Highest Vulnerability**	**Data Notes**	**Data Source**
Crown Fire Probability and Percentage + AWS + Condition	Natural Breaks 1	Natural Breaks 2	Natural Breaks 3	Natural Breaks 4	Natural Breaks 5	Percentage of area modeled to have crown fire, weighted by fire probability.	Austin Fire Department Wildfire Division, NRCS SSURGO, Blackland and RES
SVI	0 to 0.2	>0.2 to 0.4	>0.4 to 0.6	>0.6 to 0.8	>0.8 to 1	Overall summary ranking variable.	CDC/ ATSDR, 2020 https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

Other Hazards

Indicator	**1 Lowest Hazard**	**2**	**3**	**4**	**5 Highest Hazard**	**Data Notes**	**Data Source**
Heat Intensity	<-1/2 SD	-1/2 SD to Mean	Mean to 1/2 SD	1/2 SD to 1 SD	>1 SD	Daytime Land Surface Temp Process by NASA Develop: Earth observation products from Landsat 8 Operational Land Imager and Thermal Infrared Sensors. All available images without cloud coverage were selected from April 1st to September 30th, which constitutes the summer and its shoulder months which are times where heat exposure is most hazardous to vulnerable communities. The study used data from the years 2015-2020. 61 Landsat images images were used.	Landsat via NASA Develop Report: Austin Health & Air Quality Identifying Communities Most Susceptible to Heat Exposure in Austin, Texas using NASA Earth Observations, April 2, 2021
Flooding	Outside 500-year	500-year FEMA (New Austin regulatory 100-year)	-	Fully Developed Austin 100-year (New Regulatory 25-year)		With future updates by Watershed Protecton Dept. to Atlas 14 Data, flood frequencies will shift. (100-yr becomes ~25-yr, etc.) Score 5 was originally 25-yr (new 10-yr), but that data was not consistently available across the full study area, so 25-yr was omitted.	City of Austin Watershed Protection Department 500-Yr: https://msc.fema.gov/portal/home 100-Yr: https://data.austintexas.gov/Public-Safety/Greater-Austin-Fully-Developed-Floodplain/2xn4-j3u2

B - On-the-Ground Assessment Scoring Methodology

A subset of data gathered was used to assign condition scores to the points. The following algorithm was used to assign numerical scores with higher numbers representing better condition. The scores were then broken into 5 categories using the Natural Breaks function within GIS and reclassed on a 5 point scale to indicate condition.

- 1 Very poor
- 2 Poor
- 3 Moderate
- 4 Good
- 5 Very good

The algorithm used to develop the scores was as follows:

Condition= structural diversity + compositional diversity + soil condition – invasive cover – potential impacts + adaptive capacity.

A general score was calculated for all communities and then parameters specific to community type were added in a community specific score.

Condition = General score (all communities) + Community specific store (bottomland/riparian, woodland, grassland)

The data classes put into the algorithm are as follows. Soil parameters were overrepresented in the formula, so a decreaser (0.5) factor was used. The spreadsheet containing the calculations will be provided.

General score

General score=((Erosion class-Erosion extent)*0.5)+(0.5*(-% cover bare ground))-% cover invasive species+species richness all layers+rare species+surface condition-drought-invasion potential-% cover adaptive trees+%cover adaptive grasses+Microtopography+Pollinator plants+seed source+management access

Community specific scores

- Grassland=General Score+% cover decreaser grass+forb cover+Microtopography
- Woodland =General Score-Fire risk-fuel condition+# of layers present+woody age diversity
- Bottomland/riparian =General Score+Fuel condition+Stabilizer species present+Structural diversity+riparian buffer-floodplain connectivity

Community condition polygons were hand drawn in GIS using the point scores, the vegetation fuel map layer created for the Austin Fire Department wildfire risk model, ecological site types, FEMA 100 and 500 year floodplain, National Hydrology Dataset drainage features (rivers and lakes) and community boundaries visible in aerial imagery and site photos taken during the assessment. An attempt was made to preserve the “special” fuel type areas within the Austin Fire Department raster vegetation fuel map layer for use in later calculations. These areas were confirmed on the ground to represent patches of standing dead vegetation. In situations in which a polygon had multiple points, the lowest score was taken. In situations in which a polygon had no points its score was extrapolated from a nearby polygon sharing its ecological site, visual community type, and vegetation fuel map layer condition.

The condition score provides a summary of condition. However, individual parameters should be considered when evaluating specific management strategies. Parameters of particular interest include Overall diversity and Fuel model (Timber, shrub, grass).

Soil Condition

Character	Class 1	Class 2	Class 3	Class 4	Class 5
Soil movement	Subsoil exposed on much of the area; may have embryonic dunes an/or wind scoured depressions	Soil and debris deposited against minor obstructions	Moderate movement of soil particles has occurred	Some movement of soil particles has occurred	No visual evidence of soil movement
Surface rock and/or litter	Very little remaining; if present, surface rock or fragments exhibit some movement and accumulation of smaller fragments behind obstacles	Extreme movement; many large deposits against obstacles; surface rocks exhibit movement; smaller fragments accumulate behind obstacles	Moderate movement; fragments deposited against obstacles, fragments have a poorly developed distribution pattern	May show slight movement; if present, coarse fragments have truncated appearance or spotty distribution caused by wind or water	Accumulation in place; if present, the distribution of fragments shows no movement caused by wind or water
Pedestaling	Most rocks and plants pedestaled and roots are exposed	Many rocks and plants pedestaled and roots are exposed	Rocks and plants pedestaled in flow patterns	Slight pedestalling in flow patterns	No visual evidence of pedestaling
Flow patterns	Flow patterns numerous, readily noticeable; may have large barren fan deposits	Flow patterns contain silt, sand deposits and alluvial fans	Well defined, small and few with intermittent deposits	Deposition of particles may be in evidence	No visual evidence of flow patterns
Rills and gullies	May be present at depths of 8--15 cm and at intervals of less than 13 cm; sharply incised gullies cover most of the area, with 50% actively eroding	Rills 1-15 cm deep at 150 cm intervals; gullies numerous and well developed; active erosion on 10-50% of their lengths or a few well-developed gullies with active erosion along more than 50% of their length	Rills 1-15 cm deep in exposed places at about 300 cm intervals; gullies well developed, with active erosion along less than 10% of their length with vegetation present	Few infrequent rills in evidence at distances of over 300 cm; evidence of gullies with little bed or slope erosion; some vegetation is present on slopes	No visual evidence of rills; may be present in stable condition, but with vegetation on channel bed and side slopes

C - On-the-ground assessment raw data key

Raw data collected from Survey 123 will be provided to the City of Austin as an accompanying spreadsheet. Reports generated for each point are found in Appendix 8. The following key allows interpretation of outputs.

Key Name	Value	Label
drought	1	Class 1: Prevalence spp. capable of dormancy
drought	2	Class 2:
drought	3	Class 3:
drought	4	Class 4:
drought	5	Class 5: Evidence of plant mortality
erosionClass	1	Class 1 - Severe: subsoil exposed, most rocks/plants pedestaled and roots exposed
erosionClass	2	Class 2
erosionClass	3	Class 3 - Moderate: movement of soil, surface rock, or litter, pedestalling in flow patterns
erosionClass	4	Class 4
erosionClass	5	Class 5 - no visual evidence of soil movement
fireRisk	1	Class 1: Recent burn/low fuel/mesic vegetation/lifted canopy/low ladder fuel/breaks in continous canopy
fireRisk	2	Class 2:
fireRisk	3	Class 3:
fireRisk	4	Class 4:
fireRisk	5	Class 5: High/continuous fuel
fuelCondition	1	1 - Low. Raised canopy, low ladder fuel, crown separation, low dead/live fuel ratio
fuelCondition	2	2 - High. low canopy base height, high ladder fuel, high dead to live fuel ratio, close crown spacing
fuelType	1	1 - Timber Mature canopy, midstory <25%, easy to walk
fuelType	2	2 - Shrub Immature canopy or aggrading woodland, midstory >25% harder to walk through
fuelType	3	3 - Grass
fuelType	4	4 - Slash
fuelType	5	5 - Special - high dead - drought/freeze damage
invasion	1	Class 1:

Key Name	Value	Label
invasion	2	Class 2:
invasion	3	Class 3:
invasion	4	Class 4:
invasion	5	Class 5: High edge/disturbed soil/adjacent sources
invasives	1	Ailanthus altissima (Tree of Heaven)
invasives	2	Arundo donax (Giant reed)
invasives	3	Bothriochloa ischaemum (King ranch bluestem)
invasives	4	Broussonetia papyrifera (Paper mulberry)
invasives	5	Centaurea melitensis (Yellow star-thistle)
invasives	6	Colocasia esculenta (Elephant ears)
invasives	7	Cyrtomium falcatum (Japanese netvein hollyfern)
invasives	8	Cynodon dactylon (Bermudagrass)
invasives	9	Eichhornia crassipes (Water hyacinth)
invasives	10	Firmiana simplex (Chinese parasoltree)
invasives	11	Hydrilla verticillata (Hydrilla)
invasives	12	Ligustrum spp. (Ligustrum spp.)
invasives	13	Lonicera japonica (Japanese honeysuckle)
invasives	14	Macfadyena unguis-cati (Cats claw creeper)
invasives	15	Melia azedarach (Chinaberry)
invasives	16	Nandina domestica (Nandina)
invasives	17	Phyllostachys aurea (Bamboo)
invasives	18	Pistacia chinensis (Chinese pistache)
invasives	19	Pueraria montana (Kudzu)
invasives	20	Pyracantha angustifolia (Narrowleaf firethorn)
invasives	21	Rapistrum rugosum (Bastard cabbage)
invasives	22	Sorghum halepense (Johnsongrass)
invasives	23	Tamarix ramosissima (Saltcedar)
invasives	24	Triadica sebifera (Chinese tallow)
invasives	25	Other
lowHigh	1	Class 1: Very Low
lowHigh	2	Class 2: Low
lowHigh	3	Class 3: Moderate
lowHigh	4	Class 4: High
lowHigh	5	Class 5: Very High
mitFuelType	1	Type 1: Timber litter. Surface fuel leaf litter. Overstory 75% deciduous, Midstory <25% of area. Walk w/o stooping

Key Name	Value	Label
mitFuelType	2	Type 2: Shrub. Overstory at least 75% coniferous. surface fuel light- duff. Walk with some stooping
mitFuelType	3	Type 3: Grass. Woody < 50%
mitFuelType	4	Type 4: Slash
mitFuelType	5	Type 5: Special - Drought/Freeze stress. High proportion of dead fuel or dense live fuel
percCover	1	Class 1: 0 - trace
percCover	2	Class 2: 1 - 25%
percCover	3	Class 3: 26 - 50%
percCover	4	Class 4: 51 - 75%
percCover	5	Class 5: 75 - 100%
rankSmall	0	0: Absent
rankSmall	1	1: Low
rankSmall	2	2: High
rareSpecies	1	Present
rareSpecies	2	Absent
structureLayer	1	1
structureLayer	2	2
structureLayer	3	3
surfaceCondition	1	Class 1 - Low: thin, damaged, rocky, construction. Debris present.
surfaceCondition	2	Class 2
surfaceCondition	3	Class 3 - Medium
surfaceCondition	4	Class 4
surfaceCondition	5	Class 5 - High: developed organic layer, good structure, low/no disturbance
usefulSpecies	1	Cercis canadensis (Eastern redbud)
usefulSpecies	2	Diaspyros texana (Texas persimmon)
usefulSpecies	3	Platanus mexicana (Mexican sycamore)
usefulSpecies	4	Prosopis glandulosa (Mesquite)
usefulSpecies	5	Rhus aromatica, r. lanceolata, R. virens (Sumac)
usefulSpecies	6	Zanthoxylum hirsutulm (Tickle-tongue)
usefulSpecies	7	Ziziphus obtusifolia (lotebush)
usefulSpecies	8	Ulmus americana (American elm)

Key Name	Value	Label
usefulSpecies	9	Carya texana (Black hickory)
usefulSpecies	10	Acer negundo (Green ash)
usefulSpecies	11	Celtis occidentalis (Hackberry)
usefulSpecies	12	Live oak (Quercus virginiana)
usefulSpecies	13	Maclura pomifera (Osage-orange)
usefulSpecies	14	Quercus nigra (Water oak)
usefulSpecies	15	Ulmus alata (Winged elm)
usefulSpecies	16	Quercus marilandica (Blackjack oak)
usefulSpecies	17	Carya illinoinensis (Pecan)
usefulSpecies	18	Celtis laevigata (Hackberry)
usefulSpecies	19	Panicum virgatum (Switchgrass)
usefulSpecies	20	Tripsacum dactyloides (Eastern gammagrass)
usefulSpecies	21	Andropogon glomeratus (Bushy bluestem)
usefulSpecies	22	Taxodium distichum (Bald cypress)
usefulSpecies	23	Carex emoryi (Emory sedge)
usefulSpecies	24	Populus deltoides (Eastern cottonwood)
usefulSpecies	25	Cephalanthus occidentalis (Buttonbush)
usefulSpecies	26	Amorpha fruticosa (Indigobush amorpha)
usefulSpecies	27	Salix nigra (Black willow)
usefulSpecies	28	Carex species (Sedges)
usefulSpecies	29	Schizachyrium scoparium (Little bluestem)
usefulSpecies	30	Sorghastrum nutans (Indiangrass)
usefulSpecies	31	Andropogon gerardii (Big bluestem)
woodAge	1	Class 1: Single age
woodAge	2	Class 2
woodAge	3	Class 3
woodAge	4	Class 4
woodAge	5	Class 5: All ages present
eco_site_species_list.csv		See additional tab in this excel file

Appendix 3 - Condition Matrix

Plant community	Parameter	Condition				
		Very good	Good	Fair	Poor	Very Poor
Oak-Juniper woodland. (Canopy cover >70%. Juniper cover > 50%)	Hardwood cover	>30%	>30%	15-30%	1-15%	0%
	Species Diversity	High	Moderate	Moderate	Low	Very low
	Age class distribution	Good	Good	Moderate	Poor	Poor
	Bare ground	<5%	<5%	<5%	5-30%	>30%
	Erosion severity/extent	Low/Low	Low/Low	Low/Low	Mod/Mod	High/High
	Fuel model	Timber	Timber	Shrub	Shrub	Shrub
Mixed woodland. (Canopy cover > 70%. Juniper cover <50%.)	Canopy species	4+	<4	<3	<3	<3
	Species Diversity	High	High	Moderate	Low	Low
	Age class distribution	Good	Good	Moderate	Poor	Poor
	Herbaceous cover	>50%	25-50%	5-25%	<5%	<5%
	Invasive sp cover	<5%	<25%	<25%	25-50%	>75%
	Bare ground	<5%	<5%	<5%	<5%	>5%
	Erosion severity/extent	Low/Low	Low/Low	Low/Low	Low/Low	Mod/Mod
	Fuel model	Timber	Timber	Shrub	Shrub	Shrub
Grassland - Savanna, prairie. Woody cover <30%.	Canopy cover	<10%	10-30%	30-50%	>50%	>50%
	Species Diversity	High. Conservative sp present	High/Mod. Conservative sp present, native increasers dominate.	Moderate. Conservative sp absent. Native grasses primarily increasers.	Low. Conservative species absent.	Low. Conservative species absent.
	Forb cover/diversity	>50%/High	26-50%/Moderate	<20%/Moderate	<20%/Low	<20%/Low
	Invasive sp cover	<10%	10-25%	25-50%	50-75%	>75%
	Microtopography	Present	Absent	Absent	Absent	Absent
	Bare ground	Appropriate to ecosite	Appropriate to ecosite	Appropriate to ecosite	Higher than ecosite	Higher than ecosite
	Erosion severity/extent	Absent/Absent	Absent/Absent	Low/Low	Mod/Mod	High/High
	Fuel model	Grass	Grass	Grass	Shrub	Shrub
Bottomland woodland/ riparian	Canopy cover	>50%	>50%	>50%	>50%	>50%
	Herbaceous cover	>75%	50-75%	Variable	Variable	Variable
	Species Diversity	High	High	Moderate	Low	Low
	Invasive sp cover	<25%	25-50%	50-75%	>75%	>75%
	Riparian buffer	300+ft	300+ft	25+ft	25+ft	<25 ft
	Erosion severity/extent	Low/<25%	Low/<25%	Low/25-50%	Moderate/50-75%	High/>75%
	Channel-floodplain connectivity	Connected	Connected	Connected	Connected	Disconnected
Bottomland grassland/ riparian	Canopy cover	<30%	<30%	<30%	<30%	<30%
	Herbaceous cover	>75%	>75%	50-75%	Variable	Variable
	Species Diversity	High	High	Moderate	Low	Low
	Invasive sp cover	<25%	25-50%	50-75%	>75%	>75%
	Riparian buffer	300+ft	300+ft	25+ft	25+ft	<25 ft
	Erosion severity/extent	Low/<25%	Low/<25%	Low/25-50%	Moderate/50-75%	High/>75%
	Channel-floodplain connectivity	Connected	Connected	Connected	Connected	Disconnected

Appendix 4 - Invasive Management

Follow all appropriate City of Austin policies and procedures. Refer to the PARD Integrated Pest Management Plan and the City of Austin Invasive Management Plan.

Invasive species impact function in a variety of ways, but the primary impact of concern is reduction in diversity of desired species, which would reduce the efficiency of ecosystem processes. Invasive species are defined here as non-native (or alien) to the local ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (National Invasive Species Council 1999). We recommend focusing on species likely to interfere with revegetation efforts. Note that non-native is not synonymous with invasive. Many invasive species are non-native and are invasive here because there is no natural control for them. However, many non-native species are not invasive. Alternatively, native species can be problematic and need to be controlled, such as native woody species which will encroach upon grasslands without periodic fire or mechanical/chemical control. Invasive species can be particularly problematic for restoration efforts because they reduce the diversity that the land manager is working to build and, in some cases, alter ecological processes.

Managers should use integrated pest management (IPM) principles to control problematic vegetation. IPM calls for the use of a combination of control methods (mechanical, chemical, cultural) so that the least toxic, yet effective, treatment is selected. The land manager should research the life history of the species to be controlled as well as control methods so that control efforts are targeted and more effective. For example, Johnsongrass stores carbohydrate in rhizomes (underground stems) which can be quite large. Therefore, mechanically cutting, and often pulling, the plant is ineffective alone and can worsen the problem because any part of the rhizome left in the soil can re-sprout. The plant can be weakened; however, by repeated cuttings which force it to draw on its carbohydrate reserves. Also, carbohydrate reserves are lowest in the fall. Thus, an effective treatment regime should be repeated mowing followed by a fall application of glyphosate, which has been shown effective against the plant.

Items to be researched include:

Plant Life History

- Ability to Re-sprout and/or Spread Vegetatively - Plants that can re-sprout from roots or crowns generally cannot be controlled by mechanical methods alone and herbicide often needs to be integrated into treatment. Young plants are an exception, and can frequently be hand pulled or weed wrenched from the ground.
- Timing of Seed Maturation - Ideally treatment will occur prior to seed maturation
- Growing Season - Generally plants must be actively growing if post emergent herbicide is to be used. Treatment will be ineffective if plants are dormant or drought stressed.

- Carbohydrate Reserves - When are the plant's reserves lowest—when is it most vulnerable?

Control Methods

- Mechanical
  - Effectiveness for particular species
  - Cost and practicality for area
  - Potential for soil damage
- Chemical
  - Effectiveness of particular chemical against target species
  - Toxicity of chemical and persistence time
  - Mobility
  - Soil/water activity
  - Cost

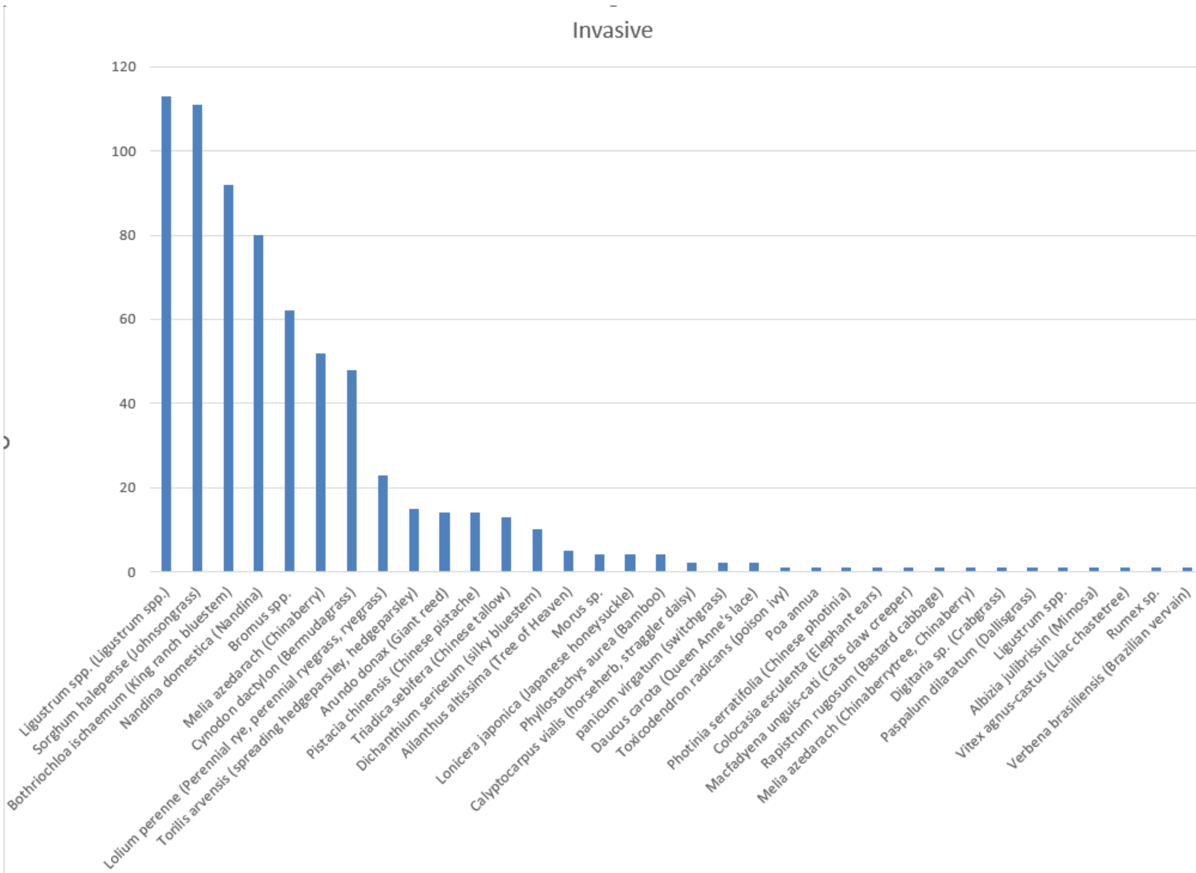
Species of particular concern for this project are warm and cool season grasses which can directly interfere with restoration efforts. Warm season grasses of concern are bermudagrass, King Ranch bluestem and Johnsongrass. Cool season grasses of concern are perennial rye and brome species. Bastard cabbage and Malta star thistle will invade particularly aggressively following soil distrubances. Invasive species documented within project boundaries are found in Table 1. The 6 most common are Ligustrum species *(Ligustrum japonicum*, *L. sinense*), Johnsongrass (*Sorghum halepense*), King Ranch bluestem (*Bothriochloa ischaemum*), Nandina (*Nandina domestica*) Chinaberry (*Melia azedarach*), and bermudagrass (*Cynodon dactylon*).

Most species can be identified early in their life cycle (before seed maturity) and must be removed prior to seed set. As a general rule, species can be treated with herbicide or physically removed before flowering. However, once they flower, the plant must be killed and the entire above ground portion of the plant must be removed from the site to eliminate reseeding.

When employing herbicide always follow all label directions and read the material safety data sheets (MSDS). Do not apply herbicide when rain is expected within 48 hours. Use directed, rather than broadcast, application methods.

Several steps can be taken to prevent infestation. The most important of which is the limitation of soil disturbance. Many invasive species are colonizer species which thrive in disturbed soils. When soil is disturbed, repair and revegetate it quickly to reduce colonization. After establishment of plantings, limit applications of fertilizer and water. Many invasive species thrive on high nutrient conditions while most native prairie species prefer low nutrient conditions and are well adapted to low water situations. Finally, purchase seed from reputable dealers that limit the amount of weed seed in their mixes.

Table 1. Invasive species documented during site assessment (04/2022-02/2023).



Appendix 5 - Site Hygiene

Maintenance begins when construction activities commence. When soil is disturbed or uncovered it is more vulnerable to colonization by invasive species. Frequently, soil must be disturbed during construction and it is important to be vigilant about invasive management during this particularly vulnerable time. Some invasive seed is already present in the seed bank and will take advantage of the temporary absence of competition and the flush of nutrients that accompanies soil disturbance. Some seed will be transported into the site by wind, water and fauna, or will be carried into the site on equipment and shoes. These new infestations must be taken care of quickly while they are still manageable. Responsible managers should practice good site hygiene to reduce new infestations and quickly manage existing ones. Simple steps can be followed to maintain site hygiene:

- Define vegetation and soil protection zones (VSPZs) and plan construction roads and laydown areas with soil protection in mind.
- Wash down equipment to remove weed seed before bringing it to a new site
- Frequently monitor disturbed or high use areas for new infestations of invasive species
- Protect healthy soil by minimizing or eliminating vehicular traffic through healthy soil areas
- When soil must be disturbed, restore it quickly by addressing soil compaction and adding appropriate seed, and monitor it for invasive species. If possible, use salvaged soil from on-site when soil addition is needed
- Purchase seed from reputable dealers that take reasonable precautions to limit weed seed contamination of their products
- Source seed as locally as possible and from vendors who have good records of seed provenance

Appendix 6 - Recommended Species

Species identified during surveys were crosswalked with the species vulnerability scores developed as part of the Vulnerability Assessment of Austin's Urban Forest and Natural Lands[1]. Species found on the survey with moderate or low vulnerability scores are recommended for encouragement.

Name	Count	Vulnerability	
Juniperus ashei (Ashee juniper)	334	Moderate	3
Ulmus (elm)	230	Moderate	3
Quercus virginiana (live oak)	121	Low-Moderate	2
Celtis (hackberry)	108	Moderate	3
Quercus fusiformis (Texas live oak)	85	Moderate	3
Carya illinoinensis (pecan)	69	Moderate-High	4
Quercus buckleyi (Texas red oak)	36	High	5
Populus deltoides (eastern cottonwood)	31	Moderate-High	4
Celtis occidentalis (common hackberry)	28	Moderate	3
Platanus occidentalis (American sycamore)	20	Moderate-High	4
Quercus stellata (post oak)	16	Moderate-High	4
Salix nigra (black willow)	15	High	5
Fraxinus (ash)	15	NA	
Acer negundo (boxelder)	13	Moderate	3
Prosopis glandulosa (mesquite (or honey mesquite))	9	Low	1
Malvaviscus arboreus (Turkscap)	8	NA	
Quercus (oak)	7	NA	
Diospyros texana (Texas persimmon)	6	Low	1
Juglans nigra (black walnut)	5	Moderate-High	4
Morus sp.	5	NA	
Pistacia chinensis (Chinese pistache)	4	Moderate	3
Triadica sebifera (Chinese tallow)	4	Moderate	3
Quercus texana (Nuttall oak)	4	NA	
Quercus sinuata (Durand oak)	3	High	5

[1] Brandt, L. A., C. Rottler, W. S. Gordon, S. L. Clark, L. O'Donnell, A. Rose, A. Rutledge, and E. King. 2020. Vulnerability of Austin's urban forest and natural areas: A report from the Urban Forestry Climate Change Response Framework. USDA

Name	Count	Vulnerability	
Quercus havardii (shin oak)	3	NA	
Morus rubra (red mulberry)	2	Moderate-High	4
Ilex vomitoria (Yaupon holly)	1	Moderate	3
Prunus serotina (Black cherry)	1	Moderate	3
Quercus marilandica (blackjack oak)	1	Moderate	3
Vachellia farnesiana (huisache)	1	Moderate	3
Fraxinus albicans (Texas ash)	1	Moderate-High	4
Sideroxylon lanuginosum (elbowbush)	1	Moderate-High	4
Taxodium distichum (bald cypress)	1	Moderate-High	4
Hilaria belangeri (curly-mesquite)	1	NA	
Mahonia trifoliolata (agarita)	1	NA	
Yucca rupicola (twistleaf yucca, spanish dagger,)	1	NA	

General species recommendation woodland

	Common Name	Scientific Name
Canopy	American elm	*Ulmus americana*
	bur oak	*Quercus macrocarpa*
	cedar elm	*Ulmus crassifolia*
	chinkapin oak	*Quercus muehlenbergii*
	coastal live oak	*Quercus virginiana*
	live oak	*Quercus fusiformis*
	Monterey white oak	*Quercus polymorpha*
Understory	agarita	*Mahonia trifoliolata*
	American beautyberry	*Callicarpa americana*
	American smoketree	*Cotinus obovatus*
	black dalea	*Dalea frutescans*
	coralberry	*Symphoricarpos orbiculatus*
	desert willow	*Chilopsis linearis*
	elbowbush	*Forestiera pubescens*
	evergreen sumac	*Rhus virens*
	flame leaf sumac	*Rhus lanceolata*
	gum bully	*Sideroxylon lanuginosum*
	honey mesquite	*Prosopis glandulosa*
	huisache	*Acacia farnesiana*
	Lacey oak	*Quercus laceyi*
	Lindheimer's silktassel	*Garrya ovata ssp. lindheimeri*
	Mexican Palo Verde	*Parkinsonia aculeata*
	Mexican plum	*Prunus mexicana*
	skunkbush sumac	*Rhus trilobata var trilobata*
	Texas persimmon	*Diospyros texana*
	Texas redbud	*Cercis canadensis L. var. texensis*
	turk's cap	*Malvaviscus arboreus var. drummondii*
	western soapberry	*Sapindus saponaria var. drummondii*
Ground	black-eyed Susan	*Rudbeckia hirta var pulcherrima*
	bluets/diamondflowers	*Stenaria nigricans*
	buffalograss	*Buchloe dactyloides*
	butterfly milkweed	*Asclepias tuberosa ssp interior*
	Canada wildrye	*Elymus canadensis*
	creek oats/inland sea oats	*Chasmanthium latifolium*
	dotted gayfeather	*Liatris punctata*
	Drummond's wild petunia	*Ruellia drummondiana*
	eastern gamagrass	*Tripsacum dactyloides*
	Illinois bundleflower	*Desmanthus illinoensis*
	little bluestem	*Schizachyrium scoparium*
	Mexican hat	*Ratibida columnifera*
	partridge pea	*Chamaecrista fasciculata*
	poverty dropseed	*Sporobolus vaginiflorus*
	showy evening primrose	*Oenothera speciosa*
	sideoats grama	*Bouteloua curtipendula*

	spiderwort	*Tradescantia*
	Texas bluebonnet	*Lupinus texensis*
	Texas paintbrush	*Castilleja indivisa*
	Texas sedge	*Carex texensis*
	Texas wintergrass	*Stipa leucotricha*
	twistleaf yucca	*Yucca rupicola*
Vines	climbing dogbane	*Trachelospermum difforme*
	crossvine	*Bignonia capreolata*
	mustang grape	*Vitis mustangensis*
	pitcher leatherflower/bluebill	*Clematis pitcheri var pitcheri*
	scarlet clematis/scarlet leatherflower	*Clematis texensis*
	trumpet creeper	*Campsis radicans*
	Virginia creeper	*Parthenocissus quinquefolia*

General Species recommendations Edwards Plateau grassland

	Common Name	Scientific Name
Forbs	butterfly weed	*Asclepias tuberosa*
	winecup	*Callirhoe involucrata*
	partridge pea	*Cassia fasciculata*
	Indian paintbrush	*Castilleja indivisa*
	American basketflower	*Centaurea americana*
	golden-wave	*Coreopsis basalis*
	plains coreopsis	*Coreopsis tinctoria*
	scrambled eggs	*Corydalis curvisiliqua*
	Illinois bundle flower	*Desmanthus illinoensis*
	purple coneflower	*Echinacea purpurea*
	Engleman daisy	*Engelmannia pinnatifida*
	Indian blanket	*Gaillardia pulchella*
	prairie verbena	*Glandularia (Verbena) bipinnatifida*
	Maximillian sunflower	*Helianthus maximiliani*
	standing cypress	*Ipomopsis rubra*
	gayfeather	*Liatris mucronata*
	Texas Yellow Star	*Lindheimera texana*
	Texas bluebonnet	*Lupinus texensis*
	horsemint	*Monarda citriodora*
	Missouri primrose	*Oenothera missouriensis*
	pink evening primrose	*Oenothera speciosa*
	foxglove	*Penstemon cobaea*
	white prairie clover	*Petalostemum candidum*
	purple prairie clover	*Petalostemum purpurea*
	clasping coneflower	*Rudbeckia amplexicaulis*
	black-eyed Susan	*Rudbeckia hirta*
	tall goldenrod	*Solidago altissima*
	greenthread	*Thelesperma filifolium*
Grasses	big bluestem	*Andropogon geradii*
	purple three awn	*Aristida purpurea*
	silver bluestem	*Bothriochloa laguroides* var. torreyana
	sideoats grama	*Bouteloua curtipendula*
	buffalograss	*Buchloe dactyloides*
	Canadian wildrye	*Elymus canadensis*
	sand lovegrass	*Eragrostis trichodes*
	green sprangletop	*Leptochloa dubia*
	Texas wintergrass	*Nassella leucotricha*
	switchgrass	*Panicum virgatum*
	little bluestem	*Schizacyrium scoparium*
	Indiangrass	*Sorghastrum nutans*
	white tridens	*Triden albescens*
	eastern gamagrass	*Tripsacum dactyloides*

General species recommendation Blackland Prairie grassland

	Common Name	Scientific Name
Forbs	American basketflower	Centaurea americana
	annual winecup	Callirhoe leiocarpa
	black-eyed Susan	Rudbeckia hirta
	bush sunflower	Simsia calva
	butterfly weed	Asclepias tuberosa
	Clasping coneflower	Rudbeckia amplexicaulis
	Engleman daisy	Engelmannia pinnatifida
	Foxglove	Penstemon cobaea
	Gayfeather	Liatris mucronata
	golden-wave	Coreopsis basalis
	greenthread	Thelesperma filifolium
	horsemint	Monarda citriodora
	Illinois bundle flower	Desmanthus illinoensis
	Indian blanket	Gailardia pulchella
	Indian Paintbrush	Castelleja indivisa
	lanceleaf coreopsis	Coreopsis lanceolata
	Maximillian sunflower	Helianthus maximiliani
	mealy blue sage	Salvia farinacea
	Missouri primrose	Oenothera missouriensis
	Obedient plant	Physostegia intermedia
	partridge pea	Cassia fasciculata
	pink evening primrose	Oenothera speciosa
	pitcher sage	Salvia azurea
	plains coreopsis	Coreopsis tinctoria
	prairie verbena	Verbena bipinnatifida
	purple coneflower	Echinacea purpurea
	purple conflower	Echinacea angustifolia
	purple prairie clover	Petalostemum purpurea
	scarlet sage	Salvia coccinea
	scrambled eggs	Corydalis curvisiliqua
	standing cypress	Ipomopsis rubra
	tall Goldenrod	Solidago altissima
	Texas bluebonnet	Lupinus texensis
	Texas Yellow Star	Lindheimera texana
	white prairie clover	Petalostemum candidum
	winecup	Callirhoe involucrata
Grasses	big bluestem	Andropogon geradii
	blue grama	Bouteloua gracilis
	buffalograss	Buchloe dactyloides
	Bushy bluestem	Andropogon glomeratus
	Canadian wildrye	Elymus canadensis
	eastern gamagrass	Tripsacum dactyloides
	green sprangletop	Leptochloa dubia
	Indiangrass	Sorghastrum nutans
	inland sea oats	Chasmanthium latifolium
	little bluestem	Schizacyrium scoparium

	Prairie Wildrye	Elymus canadensis
	purple three awn	Aristida purpurea
	sand lovegrass	Eragrostis trichodes
	sideoats grama	Bouteloua curtipendula
	silver bluestem	Bothriochloa laguroides varr. Torreyana
	switchgrass	Panicum virgatum
	Texas wintergrass	Nassella leucotricha

General species recommendations Riparian

	Wetland Indicator Status	Common Name	Scientific Name	Stability Rating
Trees and Shrubs	OBL	bald cypress	*Taxodium distichum*	9
	OBL	buttonbush	*Cephalanthus occidentalis*	8
	OBL	rose-mallow	*Hibiscus laevis*	
	FACW	American black elderberry	*Sambucus nigra ssp canadensis*	
	FACW	arroyo willow	*Salix exigua*	7
	FACW	black willow	*Salix nigra*	7
	FACW	dwarf palmetto/sabal palm	*Sabal minor*	
	FACW	green ash	*Fraxinus pennsylvanica*	
	FACW	indigobush	*Amorpha fruticosa*	7
	FACW	northern spicebush	*Lindera benzoin*	
	FACW	possumhaw	*Ilex decidua*	6
	FACW	retama	*Parkinsonia aculeata*	6
	FAC	American elm	*Ulmus americana*	
	FAC	cedar elm	*Ulmus crassifolia*	6
	FAC	eastern baccharis	*Baccharis halimifolia*	
	FAC	eastern cottonwood	*Populus deltoides*	7
	FAC	flame-leaf sumac	*Rhus lanceolata*	
	FAC	little walnut	*Juglans microcarpa*	6-7
	FAC	pecan	*Carya illinoinensis*	6
	FAC	Roosevelt weed	*Baccharis neglecta*	6
	FAC	roughleaf dogwood	*Cornus drummondii*	6
	FAC	sugar hackberry	*Celtis laevigata*	5-6
	FAC	sycamore	*Platanus occidentalis*	6
	FAC	Turkscap	*malvaviscus arboreus*	
	FAC	yaupon	*Ilex vomitoria*	
	FACU	black walnut	*Juglans nigra*	6
	FACU	desert willow	*Chilopsis linearis*	6
	UPL	brickellbush	*Brickellia sp.*	4
	UPL	rusty blackhaw	*Viburnum rufidulum*	
Forbs	OBL	swamp smartweed	*Polygonum hydropiperoides*	
	OBL	water willow	*Justicia americana*	
	OBL/FACW	water primrose	*Ludwigia sp.*	3-4
	FACW	cardinal flower	*Lobelia cardinalis*	5
	FACW	frogfruit	*Phyla nodiflora*	4
	FACW	obedient plant	*Physostegia virginiana*	
	FACW	spiny aster	*Aster spinosa*	8
	FACW	tall goldenrod	*Solidago altissima*	6-7
	UPL	Lindheimer senna	*Senna lindheimeriana*	6-7
	UPL	Maximilian sunflower	*Helianthus maximiliani*	
	UPL	plateau goldeneye	*Viguiera dentata*	5
	NA	Drummonds's wild petunia	*Ruellia drummondiana*	
	NA	Gregs mistflower	*Conoclinium greggii*	
	OBL	common rush	*Juncus effusus*	

Graminoids	OBL	emory sedge	*Carex emoryi*	9
	OBL	sawgrass	*Cladium mariscus*	9
	OBL	spikerush	*Eleocharis sp.*	6
	FACW	bushy bluestem	*Andropogon glomeratus*	5
	FACW	Cherokee sedge	*Carex cherokeensis*	
	FACW	flat sedge	*Cyperus sp.*	5
	FACW	knotgrass	*Paspalum distichum*	6
	FACW	white top sedge	*Rynchospora colorata*	6
	FAC	eastern gamagrass	*Tripsacum dactyloides*	9
	FAC	inland seaoats	*Chasmanthium latifolium*	5
	FAC	Lindheimer muhly	*Muhlenbergia linheimeri*	7
	FAC	rustyseed paspalum	*Paspalum langei*	5-6
	FAC	switchgrass	*Panicum virgatum*	8-9
	FAC	Virginia wildrye	*Elymus virginicus*	
Ferns	OBL	horsetail	*Equisetum laevigatum*	6
	FACW	maidenhair fern	*Adiantum capillus-veneris*	5
	FAC	river fern	*Thlypteris ovata*	6
Vines	FACW	climbing dogbane	*Trachelospermum difforme*	
	FAC	crossvine	*Bignonia capreolata*	
	FAC	trumpet creeper	*Campsis radicans*	
	FACU	pitcher leatherflower/bluebill	*Clematis pitcheri var pitcheri*	
	FACU	Virginia creeper	*Parthenocissus quinquefolia*	
	NA	mustang grape	*Vitis mustangensis*	
	NA	scarlet clematis/scarlet leatherflower	*Clematis texensis*	

Edwards Plateau species tolerances

This EPA Level III ecoregion encompasses all or part of 42 Texas counties. Lying entirely within the state, it is commonly referred to as the Texas Hill Country. This ecoregion covers approximately the same land area as the Texas Parks & Wildlife Department's Edwards Plateau vegetative region.

Scientific Name	Common Name	Duration	Habit	Location	Light Requiremen	Soil Moisture	Water Use	Duration	Size notes	Drought Tolerant	Cold Tolerant	Heat Tolerant	/ulnerability in Natural Areas	Climate Change Effect	Count	Notes
Cercis canadensis var. mexica	Mexican Redbud	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low , Medium	Perennial	10-15 ft normally, but can reach 25 ft	High	Yes	Yes	Low	Drought tolerant but flood intolerant and air		
Cercis canadensis var. texensi	Texas Redbud	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low, Medium	Perennial	up to ~ 20ft.	Medium-High	Yes	Yes	Low-Moderate	No Effect		
Diospyros texana	Texas Persimmon, Mexican Persimmon, Black Persimmon, Chapote, Chapote Prieto	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low	Perennial	but can reach up to 45 ft, or more, in the	High		Yes	Low	No Effect	2,014,199	as large in clay soil but won't suffer there either.
Pistacia mexicana	Mexican Pistachio, Texas Pistachio, American Pistachio, Copal Pistachio, Wild Pistachio, Lentisco,	Perennial	Tree	Upland	Sun	Dry		Perennial	shrub or multi-trunked small tree,				Low-Moderate	No Effect		
Rhus lanceolata	Prairie Flameleaf Sumac, Flameleaf Sumac, Prairie Sumac, Lance-leaf Sumac, Lance-leaved Sumac,	Perennial	Tree	Upland	Sun	Dry	Low, Medium	Perennial	up to ~ 30 ft. usually much shorter	High	Yes	Yes	Low	No Effect		
Senegalia roemeriana	Roemer Acacia, Roemer's Acacia, Roundflower Catclaw, Round-flowered Catclaw, Catclaw Acacia,	Perennial	Shrub, Tree	Upland	Sun	Dry	Low	Perennial	tall when growing as a tree. Much shorter			Yes	Low-Moderate			
Sophora secundiflora	Texas Mountain Laurel, Mountain Laurel, Mescal Bean, Mescal Bean Sophora, Frijolillo, Frijolito	Perennial	Shrub, Tree	Upland	Sun, Part-shade	Moist, Dry	Low, Medium	Perennial	up to ~ 30 ft. usually much shorter	High	Yes	Yes				
Ungnadia speciosa	Mexican Buckeye, Monilla	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low	Perennial	up to ~30 ft		Yes		Moderate			drought resistant
Vachellia farnesiana	Huisache, Texas Huisache, Sweet Acacia, Perfume Acacia, Mealy Acacia, Mealy Wattle, Cassie	Perennial	Tree	Upland	Sun	Dry	Low	Perennial	Height 15-25 feet	High		Yes				
Zanthoxylum hirsutum	Texas Hercules' Club, Texas Prickly Ash, Limetone Prickly Ash, Toothache Tree, Tickle-tongue, Tingle-	Perennial	Tree	Upland	Part-shade	Dry	Low	Perennial	up to ~15ft tall				Low			
Quercus fusiformis	Escarpment Live Oak, Plateau Live Oak, Hill Country Live Oak, Texas Live Oak, Scrub Live Oak, Plateau	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low	Perennial	20-40 ft tall	High	Yes	Yes	Moderate	No Effect	101,848	
Chilopsis linearis	Desert Willow, Flowering Willow, Willow-leaved Catalpa, Willowleaf Catalpa, Bow Willow, Flor De	Perennial	Tree	Bottomland	Sun	Moist, Dry	Low	Perennial	twigged, small tree or large shrub	High	Yes	Yes	Low-Moderate	Positive		
Crataegus opaca	Mayhaw, Western Mayhaw, May Hawthorn, Riverflat Hawthorn, Applehaw	Perennial	Tree	Bottomland	Part-shade	Wet			Up to about 30 feet tall.							Low, wet woods, creeks and river bottoms
Parkinsonia aculeata	Retama, Paloverde, Mexican Paloverde, Jerusalem Thorn, Horsebean, Lluvia De Oro	Perennial	Tree	Bottomland	Sun	Moist, Dry	Low, Medium	Perennial	up to ~ 40 ft usually much shorter	Medium		Yes	Low-Moderate	Positive		north winds in cold regions, as it can be
Quercus polymorpha	Mexican White Oak, Netleaf White Oak, Monterrey Oak	Perennial	Tree	Bottomland	Sun, Part-shade	Moist	Medium	Perennial	Up to about 80 feet tall.				Low-Moderate	Positive	84,000	

Blackland Prairie species tolerances

Texas Blackland Prairies																
Scientific Name	Common Name	Duration	Habit	Location	Light Requirement	Soil Moisture	Water Use	Duration	Size notes	Drought Tolerant	Cold Tolerant	Heat Tolerant	Vulnerability in Natu	Climate Change	Count	Notes
Cercis canadensis var. texensis	Texas Redbud	Perennial	Tree		Sun, Part-shade	Dry	Low, Medium	Perennial	up to ~ 20ft.	Medium-High	Yes	Yes	Low- Moderate	No Effect		
Condalia hookeri	Bluewood Condalia, Brasil, Brasilwood, Bluewood, Logwood, Purple Haw, Capul Negro	Perennial	Shrub, Tree	Upland	Part-shade	Dry	Low	Perennial	Up to about 20 feet tall when growing as a				Low- Moderate	No Effect		
Diospyros texana	Texas Persimmon, Mexican Persimmon, Black Persimmon, Chapote, Chapote Prieto	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low	Perennial	Normally 10-15 ft tall but can reach up to 45 ft, or more, in the	High		Yes	Low	No Effect	2,014,199	in clay soil but won't suffer there either. Can be drought-deciduous in some regions. Can survive
Rhus lanceolata	Prairie Flameleaf Sumac, Flameleaf Sumac, Prairie Sumac, Lance-leaf Sumac, Lance-leaved Sumac, Texas Sumac, Tree Sumac, Limestone Sumac,	Perennial	Tree	Upland	Sun	Dry	Low, Medium	Perennial	up to ~ 30 ft. usually much shorter	High	Yes	Yes	Low	No Effect		
Schaefferia cuneifolia	Desert Yaupon	Perennial	Tree	Upland	Part-shade	Dry	Low	Perennial	Up to about 6 feet tall.							
Zanthoxylum hirsutum	Texas Hercules' Club, Texas Prickly Ash, Limetone Prickly Ash, Toothache Tree, Tickle-tongue, Tingle-tongue	Perennial	Tree	Upland	Part-shade	Dry	Low	Perennial	up to ~15ft tall				Low	No Effect		
Quercus fusiformis	Escarpment Live Oak, Plateau Live Oak, Hill Country Live Oak, Texas Live Oak, Scrub Live Oak, Plateau Oak, Encino Molino, Tesmoli	Perennial	Tree	Upland	Sun, Part-shade	Dry	Low	Perennial	20-40 ft tall	High	Yes	Yes	Moderate	No Effect	101,848	
Chilopsis linearis	Desert Willow, Flowering Willow, Willow-leaved Catalpa, Willowleaf Catalpa, Bow Willow, Flor De Mimbre, Mimbre	Perennial	Tree	Bottomland	Sun	Moist, Dry	Low	Perennial	Up to about 40 feet tall.	High	Yes	Yes	Low-Moderate	Positive		
Parkinsonia aculeata	Retama, Paloverde, Mexican Paloverde, Jerusalem Thorn, Horsebean, Lluvia De Oro	Perennial	Tree	Bottomland	Sun	Moist, Dry	Low, Medium	Perennial	up to ~ 40 ft usually much shorter	Medium		Yes	Low-Moderate	Positive		Give protection from north winds in cold regions, as it can be damaged by frost.
Cephalanthus occidentalis	Common Buttonbush, Buttonbush, Button Willow, H	Perennial	Shrub	Bottomland	Shade, Part-shade	Wet, Moist	High	Perennial	Up to about 12 feet tall		Yes					

Appendix 7– Ecological Site Descriptions

Ecosite name	Communities						
Adobe	Grassland savanna. 10% canopy oaks tall midgrass	Savanna shrubland community. Midgrasses sccattered live oak, juniper 5-25% canopy <15%	Oak/Juniper woodland. Junipwer>25%>20' high	2.2 Oak/juniper woodland/remnant herbaceous remnant herbaceous. >25% canopy, >20' height, remnat herbaceous plants			
Clay Loam	Tallgrass savanna <5% woody	Mid/tallgrass Savanna 5-15% woody	Short/midgrass Savanna 15-30% woody, few remnant climaxes	Woodland/Shortgrass >25% woody cover			
Deep Redland 29-35 PZ	Oak savanna. tallgrass scattered QUST	Oak/juniper grassland JUAS<6' tall <5% canopy	Oak/juniper Grassland community Juniper 8-12' tall 10-30+% canopy	Oak/Juniper state			
Loamy bottomland	Tallgrass savanna <20% canopy tallgrassed dominate understory	Midgrass savanna 20-50% midgrasses dominate understory	Dense woodland community. cool season grasses and shade tolerant spp dominante understory >50% cover				
Low Stony Hill	Grassland savanna 10-20% canopy tall midgrass	savanna shrubland midgrasses 10-20% canopy, <6' tall	Oak Juniper grassland Oak 20-25% canopy, juniper 10-20%, 6-15' h	Oak/juniper/mesquite woodland Juniper >25% canopy>20' h	Woodland community		
Shallow	Mid and tallgrass prairie	Midgrass/oak savanna 10-15% canopy	Oak/mixed-brush shortgrass. >25% woody cover	Oak/Juniper/Mesquite woodland grass/forb<25%		converted land	abandoned land
Southern Blackland	Tallgrass prairie <10% woody. tallgrasses 50%	Midgrass prairie 10-35% cover <3' tall Midgrasses 50%	Mixed-grass/Mixed-brush 35-50% woody	Mixed-brush >50% woody	Woodland	Converted state	
Southern Eroded Blackland	Tallgrass prairie <5% woody	Midgrass prairie Shrubs<3' tall 5-25% cover	Midgrass/mixed-brush community. 25-50% shrub	Mixed-brush/Midgrass Shrubland . >50% canopy	converted state		
Clayey Bottomland	Tallgrass savanna <20% woody	Midgrass savanna 20-50% midgrasses dominate understory	Dense woodland community. cool season grasses and shade tolerant spp dominante understory >50% cover	Coverted state			
Gravelly	Tallgrass/oak savanna <20% woody post oak and blackjack	Oak scrub/Shrubland 20-50% overstory more shade spp	Post oak/blackjack oak woodland. 50-80% cover oaks, elms and understory	Converted land			
Redland	Oak savanna. tallgrass scattered QUST	Oak/juniper grassland JUAS<6' tall <5% canopy	Oak savanna shortgrass. Oak with shortgrasses, no understory	Oak/Juniper grassland. JUAS >8-12' tall, 10-30%+ canop, 5-20 years old	open grassland state - native or exotic		
Sandy	Tallgrass/oak savanna <20% woody post oak and blackjack	Oak scrub/Shrubland 20-50% overstory more shade spp	Post oak/Elm woodland 50-80% oaks, elms and understory	Converted land			
Sandy Bottomland	Tallgrass/oak savanna <25% woody post oak and blackjack	Oak scrub/Shrubland 20-50% overstory more shade spp	Post oak/Elm woodland 50-80% oaks, elms and understory	Converted land			
Sandy Loam	Tallgrass/oak savanna <20% woody post oak and blackjack	Oak scrub/Shrubland 20-50% overstory more shade spp	Post oak/Elm woodland 50-80% oaks, elms and understory	Converted land			
Southern Chalky Ridge	Tallgrass prairie <15% woody	Midgrass prairie 15-25% woody	Midgrass/shrub 25-40% woody	Shortgrass/midgrass/shrub >40% woody. shortgrasses and low forbs sparse understory			
Southern Clay Loam	Tallgrass prairie <10% woody. tallgrasses 50%	Midgrass prairie 10-35% woody	Grass/mixed-brush 35-50% woody. Increase in Texas wintergrass, forbs and shortgrasses, three-awns and Texas grama. Decrease in midgrasses	Mixed-brush 50%+ woody.	Dense woodland. near complet canopy cover	Converted state	
Steep Adobe	Mid-tallgrass savanna X 20% oak canopy. Mid-tallgrasses w forbs	Mid shortgrass savanna X 20% oak mid-shortgrasses with perennial forbs	Oak/Juniper woodland. >20% canopy shortgrasses & forbs	Hydro-mulched			
Steep Rocky	Mid-tallgrass savanna X 20% oak canopy. Mid-tallgrasses w forbs	Mid-shortgrass savanna X 20% canopy	Shortgrass savanna	Juniper/Oak Woodland >30% canopy			
Tight Sandy Loam	Midgrass/Oak savanna. <20%woody. Mottes of hardwoods dominated by oaks. Little bluestem and other midgrasses	Oak Woodland. >20$ woody cover, primarily oaks. Midgrasses/cool-season grasses	Altered savanna community. <25% woody. mottes of hardwoods may remain or be replaced by invasive shrubs. Midgrasses<10% of canopy. shortgrassess and unpalatalbe forbs dominate understory.	Shrubland >25% canopy. Mesquite, juniper, shrubs increase. May include diverste mix of trees and shrubs	Highly distrubed state. <15%herbaceous. woody may be present as remnants. sparsely vegetated to highly vegetated with annual forbs	converted state	

USDA Natural Resources Conservation Service

Ecological site R081CY355TX Adobe 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/25/2022

General information

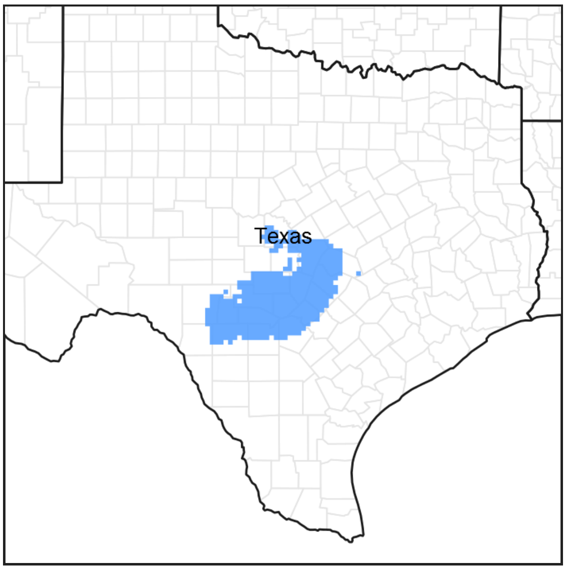


Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. Elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

These sites occur on shallow loams and clay loams over limestone bedrock. The reference vegetation consists of an oak savannah including live oak and Texas red oak, with an understory of tall and midgrasses, shrubs and forbs. Without periodic fire or brush management, woody species may increase and dominate the site.

Associated sites

R081CY362TX	**Steep Adobe 29-35 PZ** The Steep Adobe ecological site is located upslope of the Adobe ecological site.
R081CY363TX	**Steep Rocky 29-35 PZ** Slopes > 20%, soils have lower pH than Adobe.

Similar sites

R081CY362TX	**Steep Adobe 29-35 PZ** Similar soils but slopes >20%.

Table 1. Dominant plant species

Tree	(1) *Quercus texana*
Shrub	Not specified
Herbaceous	(1) *Schizachyrium scoparium*

Physiographic features

This site is classified as upland. Slope gradient range from 1 to 20 percent. It is presumed that this site was formed in residuum from weathered limestone. Elevation for this site ranges from 1000 to 1700 feet above sea level.

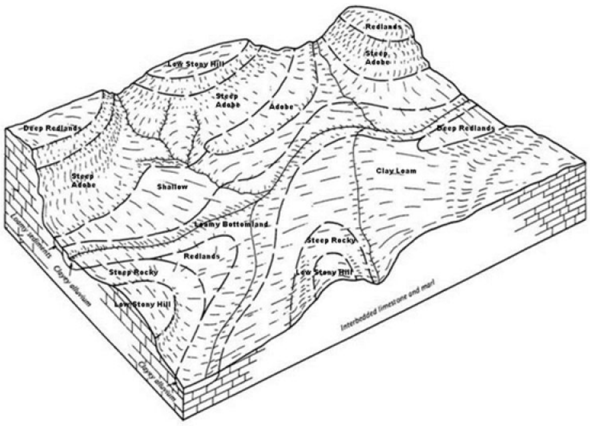


Figure 2. Geography of Adobe 29-35" Ecological Site

Table 2. Representative physiographic features

Landforms	(1) Ridge
Flooding frequency	None
Ponding frequency	None
Elevation	1,000–1,700 ft
Slope	1–20%
Ponding depth	0 in
Water table depth	60 in
Aspect	NE, SW

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below "normal" at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This is an upland site and is not influenced by water from a wetland or stream. These upland sites may shed some water via runoff during heavy rain events. The presence of good ground cover and deep rooted grasses can help facilitate infiltration and reduce sediment loss.

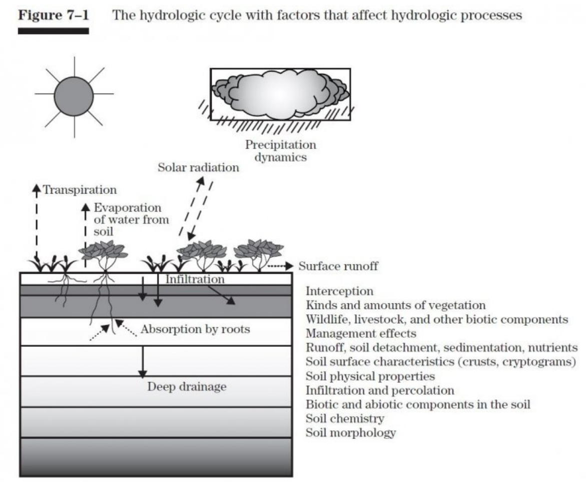


Figure 9.

Soil features

In a representative profile for the Adobe ecological site, the soils are shallow to moderately deep, usually gravelly, light-colored loam or clay loam over weakly or moderately cemented limestone with thin beds of indurated limestone. Rock fragments in the surface horizons are about 20 percent and up to 85 percent in the subsoil. There are gravelly to extremely gravelly or paragravelly to extremely paragravelly texture modifiers throughout the soil profile. The permeability of the soil is moderate and the permeability of the paralithic material is very slow to slow. On erosional sideslope positions, the organic matter development in the topsoil is low. Because of high runoff and high calcium carbonate content, the soils are droughty. They do not support a dense cover of plants, which require high amounts of water and plant nutrients. Runoff is rapid, even under good plant cover. Forage grown on the site is usually low in nutritive value and must be supplemented, especially with phosphorus as the high calcium levels tie up the phosphorus. Soils on the lower slopes of the site have organic material in the soil surface and are often characterized by the presence of Texas oaks. These sites occur on sideslopes of ridges on dissected plateaus.

Because of the scale of mapping, there are inclusions of minor components of other soils within these mapping units. Before performing any inventories, conduct a field evaluation to ensure the soils are correct for the site.

The following representative soils associated with the Adobe ecological site are Brackett, Kerrville, and Real. These are the representative map units associated with the Adobe ecological site:

Brackett association, undulating
Brackett-Rock outcrop complex, 1 to 12 percent slopes
Kerrville association, undulating
Real-Oplin complex, 1 to 20 percent slopes

Table 4. Representative soil features

Parent material	(1) Residuum–limestone
Surface texture	(1) Loam (2) Clay loam
Drainage class	Well drained
Permeability class	Very slow to slow
Soil depth	6–20 in
Surface fragment cover <=3"	12–40%
Surface fragment cover >3"	3–8%
Available water capacity (0-40in)	0.48–2.8 in
Calcium carbonate equivalent (0-40in)	40–90%

Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	7.4–8.4
Subsurface fragment volume <=3" (Depth not specified)	15–75%
Subsurface fragment volume >3" (Depth not specified)	2–10%

Ecological dynamics

The Reference Plant Community is a fire/herbivory savannah of tall grasses, Texas live oak (*Quercus fusiformis*) and Texas oak (*Quercus buckleyi*). Little bluestem (*Schizachyrium scoparium*) and sideoats grama (*Bouteloua curtipendula*) dominate the site with big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*) occurring mainly in rock crevices. Other indicator plants of this site include tall grama (Bouteloua pectinata) and seep muhly (*Muhlenbergia reverchonii*). The oak overstory usually covers less than 10 percent of the soil surface. Other important species include green sprangletop (*Leptochloa dubia*), Texas wintergrass (*Nassella leucotricha*) and kidneywood (*Eysenhardtia texana*). Small areas may exhibit water seepage or spring flow for long periods of rainfall because of small underground water-filled cavities slowly draining through the fractured rock and soil profile from the upper elevation. Muhly species (Muhlenbergia spp.) may dominate the seepy areas along with Eastern gamagrass (*Tripsacum dactyloides*) and will add to the mosaic pattern of the site. This site also grows a variety of forbs. Tall and mid grasses dominate much of the site, though portions of these sites often supported shrub and tree communities in mosaic patterns.

Early accounts consistently describe this region as a vast expanse of hills covered with "cedar" from San Antonio to Austin. Accounts also describe an abundance of clean, flowing water and abundant wildlife. These accounts seem to describe heavy wooded areas in mosaic patterns occurring along the highs and lows of the landscape. The shallow soils of the Adobe site are located on the footslopes of hills in the area. These adobe soils are laid over soft limestone and are predominated by open prairie grassland species in the Reference State. This site historically became more wooded as slope increased. This site was traditionally more open than the wooded sites along streams below, or the steep, rocky sites occurring above.

The plant communities of this site are dynamic and vary in relation to grazing, fire and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006). Historical records are not specific on the Adobe site but do reflect area sightings from the Teran expedition in 1691 of “great quantities of buffaloes” in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). Many research studies document the interaction of bison grazing and fire (Fuhlendorf, et al., 2008.). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This usually long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape.

Natural fires occurred on this site. However, low fine fuel and dissected slopes probably resulted in mosaic burns. Therefore at any given location, the plant community could be grass dominated or juniper dominated, depending upon fire frequency, over time. The accumulation of grasses set the stage for naturally occurring fires set by lightning or Native Americans for various purposes. This site is in an area where spring is reported as the principal fire season (Pyne, 1982). However in the summer, when fuel loads accumulate and dry weather decreases fine fuel moisture, convection storms with their associated lighting suggest a peak of burning occurring every 7 to 35 years (Frost, 1998).

The periodic fires kept Ashe juniper (*Juniperus ashei*), a non-sprouter, and other woody species suppressed except for the area where fuel loads were sparse or terrain precluded burning. Ashe juniper did occur on the site, but not at the level seen today because of its fire sensitivity. The degree of suppression of re-sprouting woody plants would vary in accordance with the type of fire encountered, which resulted in a mosaic of vegetation types within the same site and changing over time. Ashe juniper will increase regardless of grazing. Goat and possibly sheep will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997). The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn.

Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become nonexistent under dense juniper canopies. Many times there is a resurgence of the better grasses such as little bluestem when Ashe juniper is controlled and followed by proper grazing management. Seeds and dormant rootstocks of many plant species are contained in the leaf mulch under the junipers.

Currently, cattle, white-tailed deer, horses, and exotic animals are the primary large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which helped create population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Because of their impacts on livestock production, large predators such as red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus) and eventually coyotes (Canis latrins) were reduced in numbers or eliminated (Schmidly, 2002).

The screwworm fly (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker 1965, Bushland, 1985).

Currently, because of the reduction in livestock production and a corresponding increase in land ownership for recreational purposes, predator populations are on the increase. This includes feral hogs (Sus scrofa). Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition and monitoring of habitat quality has been effective in managing the deer herd on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of non-indigenous (exotic) ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. The axis (Axis axis) deer, in particular, has a competitive advantage over the native white-tailed deer as it can successfully change forage selection between different forage types whereas the white-tailed deer does not adapt well to the changes in forages. Many other species of medium and small sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity. Many of the exotic species have the ability to change and modify their diets depending on forage availability. This ability to use such a diverse and broad diet of vegetation may have a direct negative impact on the native wildlife and habitat if they are not properly managed.

State and transition model

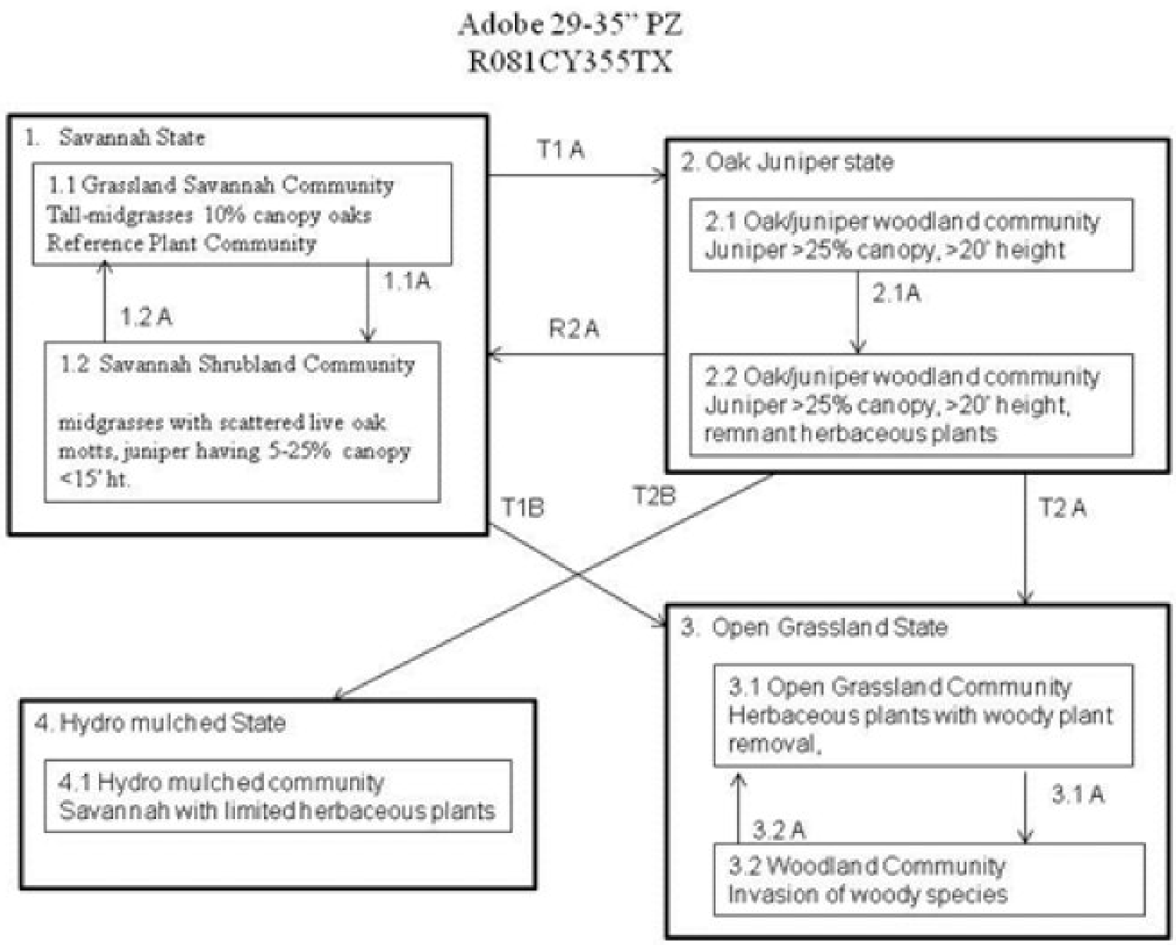


Figure 10. Adobe 29 - 35" PZ

State 1
Savannah State

Community 1.1
Grassland Savannah Community

Figure 11. Near reference condition. Brackett Soils, Toutan

Figure 12. Adobe site in near reference condition in Kendall

Figure 13. Near reference condition. Brackett Soils, Camp B

Figure 14. Near reference condition. Brackett Soils, Camp B

Figure 15. Photo 5. Near reference condition. Brackett Soi

This is the interpretive or representative plant community for the Adobe site. The data for this plant community is derived from field data collection, review of historical descriptions and professional interpretation of several representative locations. The reference plant community for the site is a plant community composed of tall and mid grasses plus scattered live oaks. The overstory canopy averages about 10 percent for the site and consists primarily of live oak, but may include Texas oak and sumac species (Rhus spp.). Other shrubs common to the site are algerita (Mahonia trifoliata), sotol (*Dasylirion texanum*), sacahuista (*Nolina texana*) and several associated species. Mid and tall grasses dominate much of the site, though portions of these sites often supported a shrub and tree communities in mosaic patterns along with some seeps or spring flow. The integrity of the reference plant community can be maintained with a few management practices. Hand cutting or mechanical alternatives are options to keep this site in a mosaic Grassland Savannah Community. Prescribed burning is also a natural, effective and economical practice for the flatter slopes of this site. Individual Plant Treatment (IPT) alternatives are other sources of brush management, which may be effective on the steeper slopes. When retrogression is livestock induced, the tall grasses are replaced by a dominance of mid and short grasses such as sideoats grama, hairy grama (*Bouteloua hirsuta*), hairy tridens (*Erioneuron pilosum*), and perennial threeawn (Aristida spp.). With continued abuse, the site is dominated by perennial threeawn, muhly spp. (Muhlenbergia), poverty dropseed (*Sporobolus vaginiflorus*), hairy tridens, cedar sedge (*Carex planostachys*), and rabbit tobacco (*Evax prolifera*). Ashe juniper will readily invade the site and become dominate when no management efforts are applied and regardless of grazing pressure except for goats.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	770	1750	3290
Shrub/Vine	110	250	470
Tree	110	250	470
Forb	110	250	470
Total	**1100**	**2500**	**4700**

Figure 17. Plant community growth curve (percent production by month). TX3770, Grassland/Oak Hillside Community. Tall and midgrasses with scattered live oak motts..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	7	13	20	15	7	5	10	7	5	5

Community 1.2
Savannah Shrubland

Figure 18. Savannah with small junipers establishing. Bracket

Figure 19. Savannah shrubland with juniper and oak. Bracke

Figure 20. Savannah shrubland with young oak and some juniper

Figure 21. Juniper established underneath oak canopy. This

Figure 22. Oak with some juniper. Brackett Soils, Camp Bulli

Figure 23. Oak with some juniper. Brackett Soils, Camp Bull

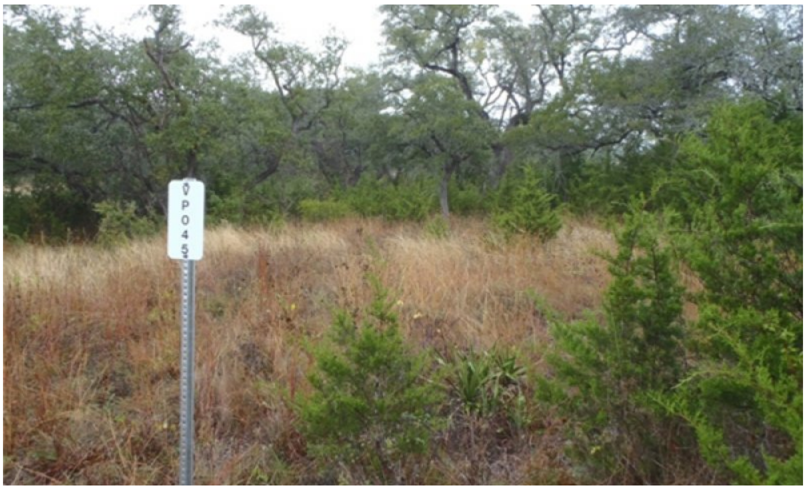


Figure 24. Savannah shrubland with juniper becoming to large

The Savannah Shrubland Community (1.2) is a result of a vegetational shift from the Reference Plant Community (1.1). The data for this plant community is derived from field data collection, review of historical descriptions and professional interpretation of several representative locations. It varies from a tall/midgrass-shrub-tree community to a moderately dense woody canopy community. Driving this shift is the suppression of fire. This site will have Ashe juniper ranging from seedling size to 6-feet tall. Live oak also increases. Canopies for this community can range as high as 25 percent. Ashe juniper may be more prevalent among hillsides and draws where historic fires would not burn. Woody cover, which is primarily live oak, may increase to form a dense canopy and suppress understory vegetation thus negatively impacting plant health and soil stability. The understory will shift to cool-season plants. Grasslike vegetation is significantly reduced when the severe competition that Ashe juniper and other woody species rob sunlight and moisture. Seepy areas and /or spring flows can be reduced by more than 20 percent over the Grassland Savannah Community. Hairy grama, sideoats grama, hairy tridens, Texas grama (*Bouteloua rigidiseta*), red threeawn (Aristida longiseta), puffsheath dropseed (*Sporobolus neglectus*) and evax (Evax spp.) are the main grasses of the site in this vegetative state. Shrubs commonly growing in the area are Texas kidneywood, sumac species, algerita (Mahonia trifoliata), Texas persimmon (*Diospyros texana*) and elbowbush (*Forestiera pubescens*). Unless management techniques of grazing management, prescribed burning, individual plant treatment (IPT) and selective brush control are applied, this plant community is at risk for transition to the Oak Juniper State (2). This transition can occur in as little as five years. Quick intervention with the proper combination of tools and management can shift this plant community back towards the Grassland Savannah Community if performed before woody cover suppresses the tall or midgrass resource. At this point as much as 25 percent of the rain that falls is trapped in the juniper and evaporate prior to reaching the soils. Even though the oak also traps some moisture in the foliage, the juniper, because of foliage density, is capturing an increasing share that is lost to evaporation. The soil itself is stable, being covered by plant litter from the juniper, live oak and herbaceous plants. Grazeable acres are decreasing rapidly and if stocking rates are not adjusted accordingly, pressure on valuable forage plants increases rapidly.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	600	1500	3150
Shrub/Vine	150	375	675
Tree	150	375	675
Forb	100	250	450
Total	**1000**	**2500**	**4950**

Figure 26. Plant community growth curve (percent production by month). TX3769, Open Grassland with Juniper. Open Grassland with Juniper Encroachment having warm season grasses with minor cool season influence..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Pathway 1.1A
Community 1.1 to 1.2

Grassland Savannah Community

Savannah Shrubland

Heavy continuous grazing/browsing reduces leaf surfaces of tall grasses resulting in loss of sunshine energy for herbaceous plants. This results in a less frequent fire regime. Woody species become established.

Pathway 1.2A
Community 1.2 to 1.1

Savannah Shrubland

Grassland Savannah Community

Prescribed grazing and a return of fire will help restore of energy capture by tall grasses and mid grasses. In some instances, IPT (Individual Plant Treatment) brush management is needed to selectively remove unwanted plants.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 2
Oak/Juniper State

Juniper is dominating the site. Most of the juniper has a full mid-story making travel by people and animals difficult because of the thickness.

Community 2.1
Oak/Juniper Woodland Community

Figure 27. Large juniper under oak. Brackett Soils, Camp B

Figure 28. Photo 16. Large juniper within oak motts. Brack


Figure 29. Juniper is dominating. Brackett Soils, Camp Bul

Figure 30. Large juniper under oak. Brackett Soils, Camp Bu

The Oak / Juniper Woodland Community (2.1) has crossed a threshold from the reference plant community, which was a grassland with scattered oak motts, to a plant community which is dominated by tall woody plants and limited grass vegetation. The elimination of fire plus the lack of brush management offered Ashe Juniper and other woody species the opportunity to overtake this site. At this point, deferment from grazing will do nothing to stop the increase of woody plants. This site will feature Ashe juniper 20 feet tall or taller, with canopies exceeding 30 percent. The understory of mixed aged juniper and shrubs is thick as well. This plant community will restrict accessibility for livestock and foot traffic. Grasslike vegetation is significantly reduced because of the severe competition from Ashe juniper and other woody species that rob sunlight and moisture. Large areas that were once grasslands are now covered with heavy woody cover consisting of species such as Ashe juniper, Live oak, Texas oak, algerita, Texas persimmon, elbowbush and lotebush (*Ziziphus obtusifolia*). Seep muhly, tall grama, tridens (Tridens spp.), threeawns (Aristida spp.) and cedar sedge (Carex spp) have increased in this community and have replaced the more palatable grasses and forbs. Seepy areas and/or spring flows are dramatically reduced and are less likely to occur. Twenty-five percent or more of the annual rainfall is trapped in the dense foliage of the juniper and evaporates before entering the soil. Dense duff under the juniper also absorbs rainfall so the hydrologic cycle is vastly altered as compared to the Grassland Savannah Community (1.1) (Thurow and Hester, 1997). Implementation of brush management programs involving heavy equipment are options that the decision-maker will need to consider if the goal is to transition this community back towards the Grassland Savannah Community (1.1). Once accelerating practices (such as brush management) are implemented, facilitating practices such as prescribed burning and prescribed grazing are needed to maintain the community as a grassland community, if this is the manager's goal. Seeding can speed up recovery. Abusive grazing by domesticated animals and wildlife will accelerate the decline and even elimination of numerous plants from this community; especially the palatable ones. There is a very low percent of grazeable acres because of the woody cover and accessibility. Little bluestem and Indiangrass have been all but lost. Sideoats grama, tall dropseed, silver bluestem (Bothriochloa sacchariodes), Texas wintergrass and muhly's are initial increasers on the site but are now reduced except in the few remaining openings. Woody species dominate this community with Ashe juniper being the dominant woody species. Shade tolerant species such as cedar sedge and uniola species (Uniola spp.) occupy the understory limited in sunlight. The majority of the soil surface on this densely canopied site will have a thick mat of cedar leaves and other woody tree and shrub leaf material. The open areas between canopies will produce a grass cover of low successional species such as gramas, threeawns, tridens, and dropseeds (Sporobolus spp.). The total grasslike production potential for this community is severely restricted.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	340	700	1400
Tree	300	600	1200
Shrub/Vine	200	400	800
Forb	145	300	600
Total	**985**	**2000**	**4000**

Table 8. Soil surface cover

Tree basal cover	1-5%
Shrub/vine/liana basal cover	0-5%
Grass/grasslike basal cover	0-5%
Forb basal cover	0-5%
Non-vascular plants	0%
Biological crusts	0-3%
Litter	15-60%
Surface fragments >0.25" and <=3"	5-10%
Surface fragments >3"	5-15%
Bedrock	1-5%
Water	0%
Bare ground	20-30%

Table 9. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-5%	0-2%
>0.5 <= 1	–	–	1-3%	1-3%
>1 <= 2	–	–	0-3%	1-3%
>2 <= 4.5	5-15%	0-3%	–	–
>4.5 <= 13	30-45%	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 32. Plant community growth curve (percent production by month). TX3763, Oak/Juniper Woodland. Oak/Juniper Woodland.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	7	8	12	15	10	5	4	12	10	7	5

Community 2.2
Juniper/Oak Woodland Community

Figure 33. Large juniper with an open understory. Brackett

Figure 34. Large juniper with an open understory. Brackett

Figure 35. Large juniper with high overstory. Brackett Soil

Figure 36. Large juniper with somewhat of an open understory.

Figure 37. . Large juniper with somewhat of an open understo

The Oak / Juniper Woodland Community (2.2) is a major shift from the original plant community. The elimination of fire plus the lack of brush management offered Ashe juniper and other woody species the opportunity to overtake this site. At this point it would take a stand replacement fire when juniper leaf moisture is low and fire weather is severe to have an impact. This site will feature Ashe juniper over 20 feet tall with canopies exceeding 25 percent. It takes over 50 years of no disturbance for this mature woodland to develop. Grasslike vegetation is significantly reduced because of the severe competition from Ashe juniper and other woody species that rob sunlight and moisture. This plant community now takes on the aspect of a woodland as compared to the Oak Juniper Woodland (2.1) community. The overstory is thick and tall with an increasingly barren understory except for snags. Once the overstory becomes about 30 feet high, the shading causes the lower limbs to drop their leaves and begin to break off or stay as snags. The soil is covered by a solid layer of duff. There is usually more air movement in this understory than in the Oak/Juniper Woodland (2.1) Community. The main understory species include cedar sedge, Texas wintergrass, Indian woodoats (*Chasmanthium latifolium*), Scribner's rosette grass and other cool season herbaceous plants. Interestingly, once the taller canopy has some openings, an occasional eastern gamagrass can be observed as it is a very photosynthetically efficient plant and it is on a remnant subsurface seep. Seepy areas and/or spring flows are dramatically reduced and are less likely to occur when dense stands of juniper and oak exist. Interception losses associated with canopy and litter are significant. Rainfall reaching the soil can be reduced by 20 to 34 percent with juniper and 54 percent with live oak. This will short circuit any water cycle (Thurow and Hester, 1997). Grazing management will not restore this community nor is there much grasslike forage from which to foster recovery. Implementation of brush management programs involving heavy equipment are options that the decision-maker will need to consider if the goal is to transition this community back towards other plant communities. Once accelerating practices (such as brush management) are implemented, facilitating practices such as prescribed burning and prescribed grazing are needed to maintain the community as a grassland community, if this is the manager’s goal. Seeding can speed up the recovery.

Table 10. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	600	1200	2500
Shrub/Vine	300	600	1260
Forb	50	100	200
Grass/Grasslike	50	100	200
Total	**1000**	**2000**	**4160**

Figure 39. Plant community growth curve (percent production by month). TX3763, Oak/Juniper Woodland. Oak/Juniper Woodland.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	7	8	12	15	10	5	4	12	10	7	5

Pathway 2.1A
Community 2.1 to 2.2

Oak/Juniper Woodland Community

Juniper/Oak Woodland Community

Sunlight is now devoted almost entirely to the woody plant community. The hydrologic cycle favors the woody plant because of interception and stem flow. Lack of brush management allows this to happen.

State 3
Open Grassland State

Community 3.1
Open Grassland Community

Figure 40. A small area has been mechanically cleared and see

Figure 41. 3.1 Open Grassland Community

Figure 42. Juniper cleared to create open grassland. Bracke

Figure 43. A small area has been mechanically cleared and see

The Open Grassland community (3.1) is created by the removal of the woody vegetation through the use of chemical and/or mechanical land clearing. Grass and forb composition may mimic that of the reference plant community as long as residual historic species exist in the seedbank or as vegetative propagules. This will be very dependent upon the past grazing management that has been applied to the particular site. In many instances, the site has been seeded to or has been invaded by non-native or introduced grasses, such as kleingrass (*Panicum coloratum*) and old world bluestems (Bothriochloa spp.). Seeps and spring flows will usually occur in above average quantities after the removal of woody vegetation and will be slightly reduced upon the establishment of grass species. Without seeding, if the site has a history of abuse, the site will be slow in the natural re-establishment of annual forbs and grasses. As succession continues, perennial grasses will establish. The species composition initially will be characterized by hairy tridens, Texas grama, red grama and perennial threeawns, silver bluestem, fall witchgrass (*Digitaria cognata*) and Hall's panicum (*Panicum hallii*) scattered throughout. Over many years of proper grazing management plants such as sideoats grama and little bluestem will return. The resprouting oak will re-establish quickly as a thicket unless goats are utilized or if there are excessive numbers of wildlife species. The use of prescribed burning and IPT will be needed to keep unwanted woody species from re-invading. Not managing brush will allow the site to revert to an Oak/Juniper state with Ashe juniper being the dominant woody species. Prescribed burning on a 4 to 7 - year rotation can be a very effective tool to use to manage Ashe juniper and suppress other woody plant growth.

Table 11. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	960	2000	3600
Forb	180	375	675
Shrub/Vine	60	125	225
Tree	0	0	0
Total	**1200**	**2500**	**4500**

Figure 45. Plant community growth curve (percent production by month). TX3764, Open Grassland. Warm season grasses with minor cool season influence on open grassland..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Community 3.2
Woodland Community

Figure 46. This area has been mechanically cleared with natur

This community has reverted to Ashe juniper and other woody plants. Willow baccharis (*Baccharis salicina*) may also invade on the site, especially if there is any ground disturbance. A lack of control measures will ensure that the area will move to an almost closed woody canopy. Seeps or spring flows will be severely reduced and may not be present. Recognizing this trend early allows the land manager the opportunity to change the shift back towards the open grassland at a lower cost. Prescribed grazing and prescribed burning can be utilized to control Ashe juniper and suppress the willow baccharis invasion. Individual chemical control measures can be used to control the baccharis. The production potential of this site can approach that of the historic plant community.

Table 12. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	540	1125	2025
Shrub/Vine	360	750	1350
Grass/Grasslike	240	500	900
Forb	60	125	225
Total	**1200**	**2500**	**4500**

Figure 48. Plant community growth curve (percent production by month). TX3763, Oak/Juniper Woodland. Oak/Juniper Woodland.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	7	8	12	15	10	5	4	12	10	7	5

Pathway 3.1A
Community 3.1 to 3.2

Open Grassland Community

Woodland Community

The re-establishment of juniper and other woody species changes sunlight capture from herbaceous plants more to woody species. Rainfall again is captured in canopy or by stem flow to the base of woody species. Lack of intervention by IPT and fire allow this to shift. This shift can occur in as little as 5 years.

Pathway 3.2A
Community 3.2 to 3.1

Woodland Community

Open Grassland Community

If fire, brush management and prescribed grazing are implemented, sunlight will be restored to the herbaceous plant community. The hydrologic cycle will be restored more to a grassland.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 4
Mulched State

The mulched state is created when heavy equipment shreds dense stands of brush, mainly juniper and reduces it to surface mulch on the soil.

Community 4.1
Mulched Community

Figure 49. . Large juniper following hydro-mulching. Brack

Figure 50. Large juniper following hydro-mulching. Brackett

This plant community has crossed a threshold from the Oak/Juniper State (2) using heavy equipment. There is a greater than 20 percent canopy of live oak and other trees with little understory. The structural aspect of this plant community is very similar to the Tall and Midgrass Prairie (1.1) but is missing many of the signature grasses, forbs and shrubs and usually contains non-native species such as introduced bluestems. Bare ground is less than 1 percent, while the depth of woody chips varies from 0 to 8 inches. The majority of chip coverage is 3 to 4 inches depth. The long-term recovery of this plant community to the Savannah State (1) is unknown and relies on several factors. The depth of the mulch, the availability of residual native seeds and roots and the rate of return of the mulch to the soils are factors. In terms of site function, the mulch captures most of the rainfall occurring with little or no runoff or subsequent erosion. Light penetration to the ground to foster the germination of plants is a limiting factor on the thickest areas of mulch. Over time the mulch begins to settle and will be very slow to return to the soil via ecological processes. Those plants that do germinate and protrude above the mulch are very robust because of the conservation of moisture in the rooting zone and the insulation from evaporation. It is anticipated that organisms living in the soil that digest the lignin and cellulose from the mulch will be benefited from an improved micro-habitat. However, on the deeper mulched portions of the site, it is unknown how these micro-organisms will persist, although it is assumed that they will increase along with a corresponding decrease in mulch amount as sunlight reaching the soil surface. With time the plant community will change. Juniper will reestablish as will other plants. Plants that are root and crown sprouters will have an advantage over those recovering from seed. The use of prescribed burning will not only accelerate the mineralization of the mulch but can also maintain the openness of this community. The frequency of prescribed burning is unknown on mulched sites as fire intensity will be different than a grassland. To prevent juniper from growing in stature until it is no longer manageable with fire, burning when juniper is less than 4 feet tall is recommended.

Table 13. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1360	1530	3000
Forb	80	90	175
Grass/Grasslike	80	90	175
Shrub/Vine	80	90	175
Total	**1600**	**1800**	**3525**

Transition T1A
State 1 to 2

Sunlight energy is being captured more by woody plants than by herbaceous plants. An increasing amount of rainfall is entrapped in the juniper canopy with less entering the soil rooting zone. Continued overgrazing/browsing, lack of the fire and lack of brush management are responsible. Drought can hasten the process although a long term severe drought can result in death of juniper.

Transition T1B
State 1 to 3

Land clearing removes all of the woody species to restore the energy capture to herbaceous plants. Range seeding has been applied that includes exotic herbaceous species or they are introduced through hay, livestock or wildlife. The hydrologic cycle resembles the reference plant community.

Restoration pathway R2A
State 2 to 1

Brush management and range planting (if needed) will change the plant community back to a more herbaceous plant community to capture sunlight. The hydrology is reclaimed with a higher percentage of rainfall entering the root zone for use by herbaceous plants. Fire will be needed to maintain the recovery.

Conservation practices

Brush Management
Prescribed Burning

Range Planting
Native Plant Community Restoration and Management
Prescribed Grazing

Transition T2A
State 2 to 3

Land clearing removes all of the woody species to restore the energy capture to herbaceous plants. Range seeding has been applied that includes exotic herbaceous species or they are introduced through hay, livestock or wildlife. The hydrologic cycle resembles the reference plant community.

Transition T2B
State 2 to 4

Mechanical conversion of primarily juniper canopy to a mulch cover restores the energy flow to the remaining species, usually oak. The hydrologic cycle retains nearly all the rainfall because of the heavy mulch. Little evaporation takes place.

Additional community tables

Table 14. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm-season Midgrass**			900–1350	
	little bluestem	SCSC	*Schizachyrium scoparium*	900–1350	–
2	**Warm-season Tallgrass**			0–300	
	Indiangrass	SONU2	*Sorghastrum nutans*	0–150	–
3	**Warm season mid grasses**			300–325	
	sideoats grama	BOCU	*Bouteloua curtipendula*	250–350	–
	tall grama	BOHIP	*Bouteloua hirsuta var. pectinata*	150–300	–
	green sprangletop	LEDU	*Leptochloa dubia*	150–300	–
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	75–150	–
	rough dropseed	SPCL	*Sporobolus clandestinus*	50–100	–
	composite dropseed	SPCO16	*Sporobolus compositus*	50–100	–
4	**Warm/Cool-season Grasses**			225	
	cedar sedge	CAPL3	*Carex planostachys*	25–40	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	25–40	–
5	**Warm Season short grasses**			100–150	
	threeawn	ARIST	*Aristida*	50–100	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	50–100	–
	seep muhly	MURE2	*Muhlenbergia reverchonii*	50–100	–
	slim tridens	TRMU	*Tridens muticus*	25–50	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	25–50	–
Forb					
6	**Forbs**			100–300	
	awnless bushsunflower	SICA7	*Simsia calva*	25–70	–
	queen's-delight	STSY	*Stillingia sylvatica*	20–50	–
	Forb, annual	2FA	*Forb, annual*	0–50	

	Forb, annual	2FA	*Forb, annual*	0–50	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	25–50	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	25–50	–
	dotted blazing star	LIPU	*Liatris punctata*	25–50	–
	trailing krameria	KRLA	*Krameria lanceolata*	20–30	–
	velvet bundleflower	DEVE2	*Desmanthus velutinus*	20–30	–
	prairie clover	DALEA	*Dalea*	10–25	–
	Indian breadroot	PEDIO2	*Pediomelum*	10–25	–
	leafflower	PHYLL	*Phyllanthus*	10–20	–
	littleleaf sensitive-briar	MIMI22	*Mimosa microphylla*	10–20	–
	yellow puff	NELU2	*Neptunia lutea*	10–20	–
	vetch	VICIA	*Vicia*	0–10	–
Shrub/Vine					
7	**Shrubs/Vines**			100–150	
	Texas sotol	DATE3	*Dasylirion texanum*	25–75	–
	evergreen sumac	RHVI3	*Rhus virens*	25–75	–
	algerita	MATR3	*Mahonia trifoliolata*	25–75	–
	Texas sacahuista	NOTE	*Nolina texana*	25–75	–
	fragrant sumac	RHAR4	*Rhus aromatica*	25–50	–
	Texas persimmon	DITE3	*Diospyros texana*	25–50	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	25–50	–
	stretchberry	FOPU2	*Forestiera pubescens*	25–50	–
	roundleaf greenbrier	SMRO	*Smilax rotundifolia*	10–25	–
	black prairie clover	DAFR2	*Dalea frutescens*	10–25	–
Tree					
8	**Trees**			300–350	
	Texas red oak	QUBU2	*Quercus buckleyi*	250–350	–
	Texas live oak	QUFU	*Quercus fusiformis*	250–350	–
	Ashe's juniper	JUAS	*Juniperus ashei*	25–50	–

Animal community

The site is usable by cattle, sheep, Angora goats and meat goats. The high pH in the soil may tie up some of the phosphorus rendering plants like little bluestem more unpalatable than on other sites. Wildlife species utilizing this site for at least a portion of their habitat needs include white-tailed deer, raccoon, cottontail rabbit, jackrabbit, Rio Grande turkey, bobwhite quail, mourning dove, mountain lion, bobcat and other wildlife species. A field assessment of vegetation is needed to calculate carrying capacity for the animals of interest. Traditional regional average stocking rates should not be used and can be misleading because of differences in plants utilized.

With the eradication of the screwworm fly (Cochilomyia hominivorax), the increase in woody vegetation and insufficient natural predation, white-tailed deer numbers have increased drastically 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 woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep and goats can cause damage to preferred vegetation and is an important consideration in livestock and wildlife management. Maintaining cover and food for wildlife on the steeper slopes is extremely important to the wildlife ecology of this site and associated sites below or above it.

Smaller animals using the site include rodents, jackrabbit, cottontail rabbit, raccoon, skunks, possum and armadillo. Mammalian predators include coyote, red fox, gray fox, bobcat, and mountain lion. Many species of snakes and lizards are also native to this site.

A diversity of birds is found on this site including game birds, songbirds and birds of prey. The different species of songbirds vary in their habitat preferences. Prairie chickens (Tympanuchus spp.) were also recorded in the general area. In general, a habitat that provides a large variety of grasses, forbs, shrubs, vines and trees and a complex of grassland, savannah, shrubland and woodland will support a variety and abundance of songbirds. Birds of prey are important to keep the numbers of rodents, rabbits and snakes in balance. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow and red deer, auodad sheep and blackbuck antelope. Axis deer are extremely competitive with the native white-tailed deer as they have the ability to shift their diets to several different plant groups while the white-tails do not. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. Feral hogs are present and can cause damage when their numbers are not managed.

Hydrological functions

The soils on this site are well drained with very low water holding capacity. Surface runoff can be rapid because of the slope and physiography of the site. Soils correlated with this site are in Hydrologic Groups C and D. The reference plant community (1.1) is dominated by tall bunchgrass species that are correlated with high hydrologic function. When conditions degrade into States 2 and 3, the composition of desirable tall grasses decreases and mid and short grasses become more dominant. If soil conditions also degrade and management is consistent with overuse, hydrologic function decreases significantly. Hydrology and erosion dynamics are discussed below for States 1, 2, and 3.

The Savannah State, representative of the historic community, is the most productive of the plant community phases. With reference to the state and transition model, state 1 is the most hydrologically stable with the lowest runoff and soil loss. This is because of the prominence of tall grass cover. The greater foliar and basal plant cover of big and little bluestem creates many raindrop interception layers. In addition, many lower statured forbs are located in the understory. Litter cover accumulating during the winter months can provide protection from raindrop impact. The morphology of big bluestem roots is characterized by thick coarse vertical and lateral roots. Rhizomes form a rigid, coarse, open network in the upper 2 inches of soil with branching roots arising from them. Where fractures occur in the underlying rock, roots can penetrate into deeper strata. Infiltration studies have shown the bluestem, Indian grass, and switchgrass are associated with higher infiltration capacity compared to other short-statured grasses which tend to have thicker fibrous surface roots (e.g., gramas, buffalograss, dropseeds, and three-awn grasses).

Where the geologic substrate is fractured (commonly associated with oat mottes), infiltration is rapid and immediate. This water percolates deep into the substrate and largely escapes the evapotranspiration (ET) process. In the non-oak mott portions of this site, runoff often occurs during high intensity, short duration storms. This is a common occurrence, even when Similarity Index is high. In this state, runoff, on the average, displaces and erodes little soil. Water quality is high with little or no sediment. Intermittent channels and water flow paths carry runoff water without appreciable degradation in the channels. Seeps and spring flow are common on this site after high rainfall periods and may last several weeks. If adequate rainfall is received throughout the growing season, spring flow may last throughout the year. Stream channels and intermittent adjacent channels serve as recharge areas--water can percolate via fractures in the geologic substrate. As this water moves downward, it contributes to the recharge of aquifers and provides a constant source of subsurface water for sustained base flow to creeks and streams.

State 1: Savannah State

Model Predictions return periods based on 50 years climate data.
(Return)(Precip)(Runoff) (Erosion)
(Period)(in) (in) (t/ac)

(50 yr) (52.7) (9.6) (2.3)
(25 yr) (49.5) (3.8) (2.0)

(10 yr) (44.5) (2.9) (1.4)
(5 yr) (40.1) (1.5) (0.7)
(2.5 yr)(35.6) (0.4) (0.2)

(50 yr) (32.9) (0.8) (0.4)
(avg.)

Based on 50 years of climate data, there is an 85 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (0.4/0.8 = 0.5). For every 1.0 inch of runoff, 0.5 tons/acre soil erosion.

Return Period Analysis
To help interpret the table, note that a 5-year value will be exceeded, on the average, about once every five years, o twice every ten. There is a one in 5 or 20 percent chance that a value equal to or greater than the 5-year value will occur in a given year. There is a (100 - 20), or 80 percent, chance that the precipitation, runoff, erosion, or sediment yield will be less than the 5-year value. In the results shown in the table, the average 50-year erosion rate is 0.4 tons/acre. There is a 20 percent chance that the annual erosion will exceed about 0.7 tons per acre. At best, any predicted runoff or erosion value, by any model, will be within plus or minus 50 percent of the true value. Erosion rates are highly variable.

Plant Community 1.2: Savannah shrubland community
This community is in an intermediate state of flux i.e., combinations of lack of fire, times of overuse, subsequent wood invasion, and increases in less desirable grasses. Grasslike vegetation is significantly reduced when Ashe juniper and other woody species preempt sunlight and moisture. Seepy areas and /or spring flows are reduced by more than 20 percent over the reference state (1). Less desirable midgrasses such as hairy grama, hairy tridens, Texas grama, red threeawn, and puffsheath dropseed (*Sporobolus neglectus*) predominate the stand. The rooting systems of these grasses are more fibrous with a majority of the roots in the upper 4 inches of the soil surface. Infiltration capacity is less in this state and can be viewed as significantly different compared to the reference state (1).

Model Predictions return periods based on 50 years climate data
(Return)(Precip)(Runoff)(Erosion)
(Period)(in) (in) (t/ac)

(50 yr)(52.7) (9.2) (7.4)
(25 yr)(49.5) (5.8) (4.5)
(10 yr)(44.5) (3.6) (3.8)
(5 yr) (40.1) (2.5) (2.0)
(2.5 yr)(35.6) (1.1) (0.9)

(50 yr) (32.9) (1.30 (1.2)
(avg.)

Based on 50 years of climate data, there is a 98 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (1.2/1.3 = 0.92. For every 1.0 inch of runoff, 0.92 tons/acre soil erosion. This ratio is almost 2 times higher than state 1.

State 2: Oak Juniper State
The Oak juniper woodland State (2) is associated with a substantial shift to woody plants. As the juniper overstory matures, these trees can grow 20 feet or taller. Grasses and forbs in the understory are shaded and conditions gradually become depauperate as tree overstory and shading increases. Understory vegetation can be dominated by weedy forbs which generally provide less protection to the soil surface compared to grasses. The hydrologic effect is significant from a runoff and accelerated soil loss point of view. Compared to State 1, the Reference State, average runoff and erosion are 1.5 and 3 times higher, respectively.

(Return)(Precip)(Runoff)(Erosion)
(Period)(in) (in) (t/ac)

(50 yr) (52.7) (11.9) (10.5)
(25 yr) (49.5) (6.5) (5.9)
(10 yr) (44.5) (4.9) (5.4)
(5 yr) (40.1) (2.7) (3.0)
(2.5 yr)(35.6) (1.3) (1.7)
(50 yr) (32.9) (1.6) (1.8)
(avg.)

Based on 50 years of climate data, there is a 98 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (1.8/1.6 = 1.1. For every 1.0 inch of runoff, 1.1 tons/acre soil erosion. This ratio is 2.2 times higher than that of State 1.

Recreational uses

This site has the potential for recreational use due to the diversity of wildlife, which can inhabit ecological sites above and below this site. The tall and mid grasses and scattered oaks produce beautiful fall color variations. Many native plants valuable for landscape may be found on sites nearer to climax. The area is used for hunting, hiking, birding and other nature tourism related enterprises.

The open grassland with widely scattered oaks has an open-space appeal. The mixture of live oak and Texas oak adds to the fall color variations. Early spring rains will produce a variety of flowering annual and perennial forbs.

Wood products

Oaks and Ashe juniper may be used for firewood, fencing material, and/or in the specialty wood industry.

Other information

Plant Preference by Animal Kind:
This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition and diet overlap between kinds of herbivores. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. An animal's preference or avoidance of certain plants is learned over time through grazing experience and maternal learning (http://extension.usu.edu/behave/Grazing). Preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food are rated. Refer to detailed habitat guides for a more complete description of a species habitat needs.

Legend: P=Preferred D=Desirable U=Undesirable N=Not Consumed T=Toxic X=Used, but not degree of utilization unknown
Preferred – Percentage of plant in animal diet is greater than it occurs on the land
Desirable – Percentage of plant in animal diet is similar to the percentage composition on the land
Undesirable – Percentage of plant in animal diet is less than it occurs on the land
Not Consumed – Plant would not be eaten under normal conditions. It is only consumed when other forages not available. This can also include plants that are unavailable during parts of the year.
Toxic – Rare occurrence in diet and, if consumed in any tangible amounts results in death or severe illness in animal (Hart, 2003). (Note: many plants can be good forage but toxic at certain doses or at certain times of the year. Animals in poor condition are most susceptible.)

Inventory data references

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

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Approval

David Kraft, 9/20/2019

Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high-intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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	Zone Rangeland Management Specialist, NRCS, San Angelo, Texas, 325-944-0147
Date	06/29/2005
Approved by	Colin Walden
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, except following extremely high intensity storms where short flow patterns may appear.

3. **Number and height of erosional pedestals or terracettes:** None

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 10% bare ground randomly distributed throughout in small and non-connected areas.

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):** Under normal rainfall, little litter movement should be expected; however, litter of all sizes may move long distances. Minimal and short.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Stability class range is expected to be 5-6

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface is light brownish gray gravelly clay loam with limestone moderately fine subangular blocky and moderately fine granular structure on the surface. SOM is approximately 1-3%. See soil survey for specific soils.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The savannah of tallgrasses, midgrasses, forbs and trees having adequate litter

and little bare ground can provide for maximum infiltration and little runoff under normal rainfall events.

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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):** No evidence of compaction.

---

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

    Sub-dominant: Forbs Trees

    Other: Warm-season tallgrasses Warm-season shortgrasses Shrubs

    Additional: Forbs make up 10 percent species composition, shrubs has about 5 percent species composition and trees have 15 percent annual production.n

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups.

---

14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1800 to 4100 pounds per acre

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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:** Ashe Juniper is dominant, Honey mesquite, Prickly pear, Bermudagrass, Johnsongrass, King Ranch bluestem

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17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing, except during periods of prolonged drought conditions, heavy natural herbivory, and wildfires.

Ecological site R081CY357TX
Clay Loam 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/25/2022

General information

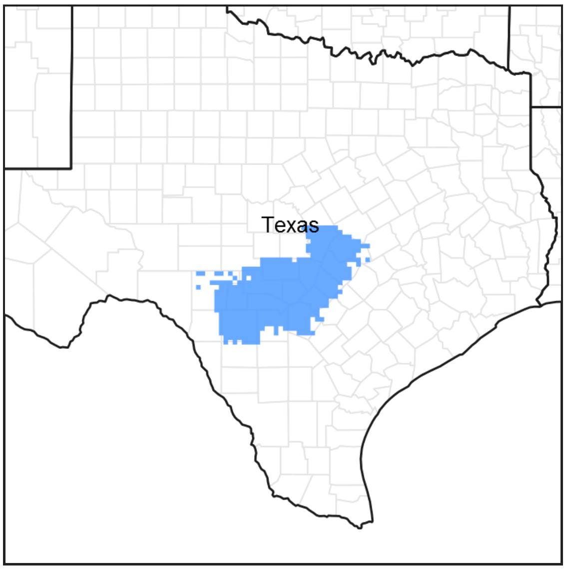


Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. Elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

These sites occur on moderately deep to deep clay loam soils over limestone. The reference vegetation on these upland sites consists of tallgrasses, numerous forbs, few shrubs and scattered live oak mottes. Without fire or brush management, woody species are likely to increase across the site. Grazing management is key to maintain the reference vegetation.

Associated sites

R081CY355TX	**Adobe 29-35 PZ** The Adobe ecological site is upslope from the clay loam.
R081CY360TX	**Low Stony Hill 29-35 PZ** The Low Stony Hill ecological site is usually upslope from the clay loam.
R081CY574TX	**Shallow 29-35 PZ** The shallow ecological site can occur as inclusions but is less productive and can have some surface limestone.

Similar sites

R081CY358TX	**Deep Redland 29-35 PZ** The Deep Redland ecological site usually has post oak with soil in shades of red that is slightly acidic to neutral.

Table 1. Dominant plant species

Tree	(1) *Quercus fusiformis*
Shrub	Not specified
Herbaceous	(1) *Schizachyrium scoparium*

Physiographic features

This site is located in the 81C, Eastern Edwards Plateau Major Land Resource Area (MLRA). It is classified as an upland site. Slope gradients are mainly less than 2 percent and range from 0.5 to 4 percent. This site was formed from alluvial loamy and clayey sediments. Elevation of this site ranges from 430 to 1500 feet above mean sea level. This site will receive runoff from Adobe, Steep Adobe and Low Stony Hill ecological sites that normally occur along the site's boundary.

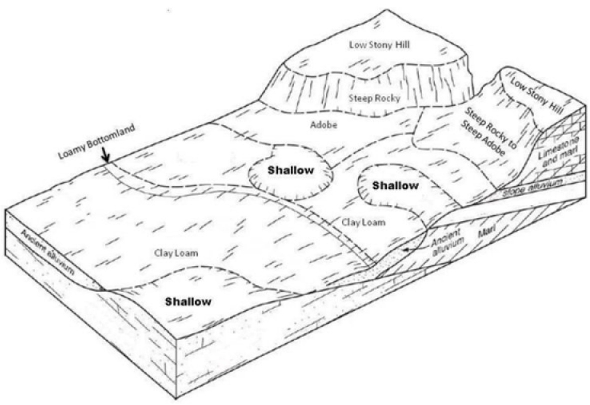


Figure 2. Clay Loam

Table 2. Representative physiographic features

Landforms	(1) Stream terrace
Flooding frequency	None
Ponding frequency	None
Elevation	430–1,499 ft
Slope	1–4%
Water table depth	60 in
Aspect	Aspect is not a significant factor

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below “normal” at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This being an upland site, it is not influenced by water from a wetland or stream.

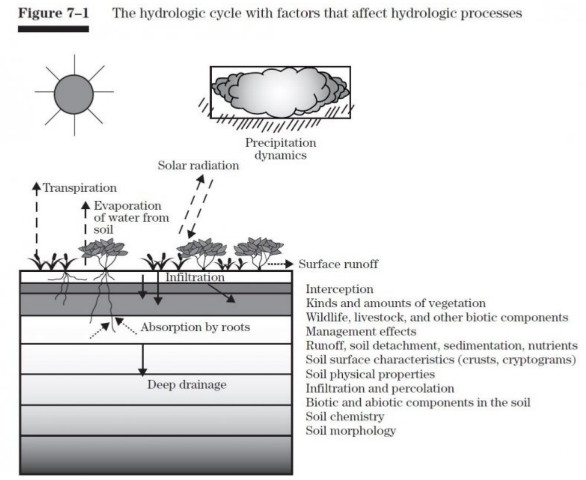


Figure 9.

Soil features

In a representative profile for the Clay Loam ecological site, the soils of this site are dark grayish brown, moderately deep to very deep clays or clay loams. Limestone fragments and rocks sometimes occur in the profile or outcrop on the soil surface, but not to the extent that they impair the production of native vegetation. Plant-soil moisture relationships are good. In healthy condition, rills, gullies, wind-scoured areas, pedestals, and soil compaction layers are not present on the site.

It should be noted that there may be inclusions of other soils that because of mapping scale are not divided out. These may include some shallow soils with sporadic surface limestone fragments typical of the Eckrant series.

The following representative soils associated with the Clay Loam ecological site are Bolar, Krum, and Pratley. These are the representative map units associated with the Clay Loam ecological site:

Bolar clay loam, 1 to 3 percent slopes
Krum clay, 1 to 3 percent slopes
Krum clay, 3 to 5 percent slopes
Krum-Pratley association, gently undulating
Pratley clay, 0 to 3 percent slopes

Table 4. Representative soil features

Parent material	(1) Alluvium–limestone
Surface texture	(1) Clay loam (2) Silty clay loam
Drainage class	Well drained
Permeability class	Moderately slow to moderate
Soil depth	33–72 in
Surface fragment cover <=3"	0–10%
Surface fragment cover >3"	0–4%
Available water capacity (0-40in)	5.9–12 in
Calcium carbonate equivalent (0-40in)	0–60%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0

Soil reaction (1:1 water) (0-40in)	7.4–8.4
Subsurface fragment volume <=3" (Depth not specified)	3–25%
Subsurface fragment volume >3" (Depth not specified)	0–15%

Ecological dynamics

The information contained in the State and Transition Diagram (STD) and the Ecological Site Description was developed using archeological and historical data, professional experience, and scientific studies. The information presented is representative of a very complex set of plant communities. Not all scenarios or plants are included. Key indicator plants, animals and ecological processes are described to inform land management decisions.

The reference plant community of the Clay Loam ecological site is perceived to be a tallgrass savannah and is a disturbance driven community. Little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), sideoats grama (*Bouteloua curtipendula*), and Eastern gamagrass (*Tripsacum dactyloides*) compose the majority of warm season grasses. The cool season grasses and grasslikes were wildrye (Elymus spp.), Texas wintergrass (Nasella leucotricha), and cedar sedges (Carex spp.). The important woody species would include Texas live oak (*Quercus fusiformis*), cedar elm (*Ulmus crassifolia*), and hackberry (Celtis spp.) Numerous perennial forbs were present. A more detailed description of the various plant communities existing on this site follows.

The plant communities of this site are dynamic and vary in relation to grazing, fire, and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006). Historical records are not specific on the Clay Loam site but do reflect area sightings from the Teran expedition in 1691 of “great quantities of buffaloes” in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). Many research studies document the interaction of bison grazing and fire (Fuhlendorf, et al. 2008). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This usually long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape.

The accumulation of tall grasses set the stage for naturally occurring fire set by Native Americans for various purposes and by lightning. This site is in an area where spring is reported as the principal fire season (Pyne, 1982). However in the summer, when fuel loads accumulate and dry weather decreases fine fuel moisture, convection storms with their associated lighting suggest a peak of burning occurring every 7 to 35 years (Frost, 1998).

The periodic fires kept Ashe juniper (*Juniperus ashei*), a non-sprouter, and other woody species suppressed. Ashe juniper may occasionally occur on the site, but not at the level seen today due to its fire sensitivity. The degree of suppression of re-sprouting woody plants would vary in accordance with the type of fire encountered, which resulted in a mosaic of vegetation types within the same site and changing over time. Ashe juniper will increase regardless of grazing. Juniper will establish with grazing and without unless goats are utilized. Goats will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997). The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn.

Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become non-existent under dense juniper canopies. Many times there is a resurgence of the better grasses such as little bluestem and Indiangrass when Ashe juniper is controlled and followed by proper grazing management. Seeds and dormant rootstocks of many plant species are contained in the leaf mulch under the junipers.

The vegetation resulting from periodic high impact grazing and fire would capture all but the heaviest rainfall to soak into the ground. Runoff from high rainfall events that did run off contained little sediment. Most of the rainfall in this climate on this site was used within the rooting zone of the existing plants and seldom percolated beyond the root zone.

Much change in the vegetation on the Clay Loam ecological site has taken place since settlement. The area has been settled by a combination of cultures and each brought their own livestock and management styles in the mid to early 1800s. Early stock growers did not understand the ecological dynamics of the vegetation on the site nor the undependable rainfall.

Continued overgrazing will weaken the plants preferred by grazing animals. These plants will accordingly decrease in abundance and be replaced by those less preferred. Drought will hasten the process. Continued removal of leaf material will replace plants that convert energy efficiently to those that are less efficient. This reduces the overall flow of energy through the system.

The loss of plant cover and litter reduces infiltration, increases evaporation losses, and increases erosion and sediment loss from the site. Soil temperatures without cover can get very hot in the summer and exceed the temperature supporting vibrant biological activity. When this site experiences long term reduced cover, it is then vulnerable to invasion by both native and not native plants such as mesquite (*Prosopis glandulosa*) or introduced bluestems (Bothriochloa spp.) Anecdotal observations suggest that these opportunistic plants are quick to establish once rainfall comes following droughts. This effect is much more pronounced on improperly grazed ranges. Little bluestem and other valuable plants seem to slowly return to the site once the ecological processes and subsequent soil health are restored.

Currently, cattle, white-tailed deer, horses, and exotic animals are the primary large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which helped create population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Because of their impact on livestock production, large predators such as red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus), and eventually coyotes (Canis latrins) were reduced in numbers or eliminated (Schmidly, 2002).

The screwworm fly (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker, 1965; Bushland, 1985).

Currently, due to the reduction in livestock production and a corresponding increase in land ownership for recreational purposes, predator populations are on the increase. This includes feral hogs (Sus scrofa).

Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition, and monitoring of habitat quality has been effective in managing the deer herd on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of non-indigenous (exotic) ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium and small sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity. Many of the exotic species have the ability to change and modify their diets depending on forage availability. This ability to use such a diverse and broad diet of vegetation may have a direct negative impact on the native wildlife and habitat if they are not properly managed.

State and Transition Diagram:
A State and Transition Diagram for the Clay Loam Ecological Site (R081CY357TX) is depicted in Figure 1. Thorough descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases.

Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal; other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are described as are other metrics. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover can drive the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating the similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

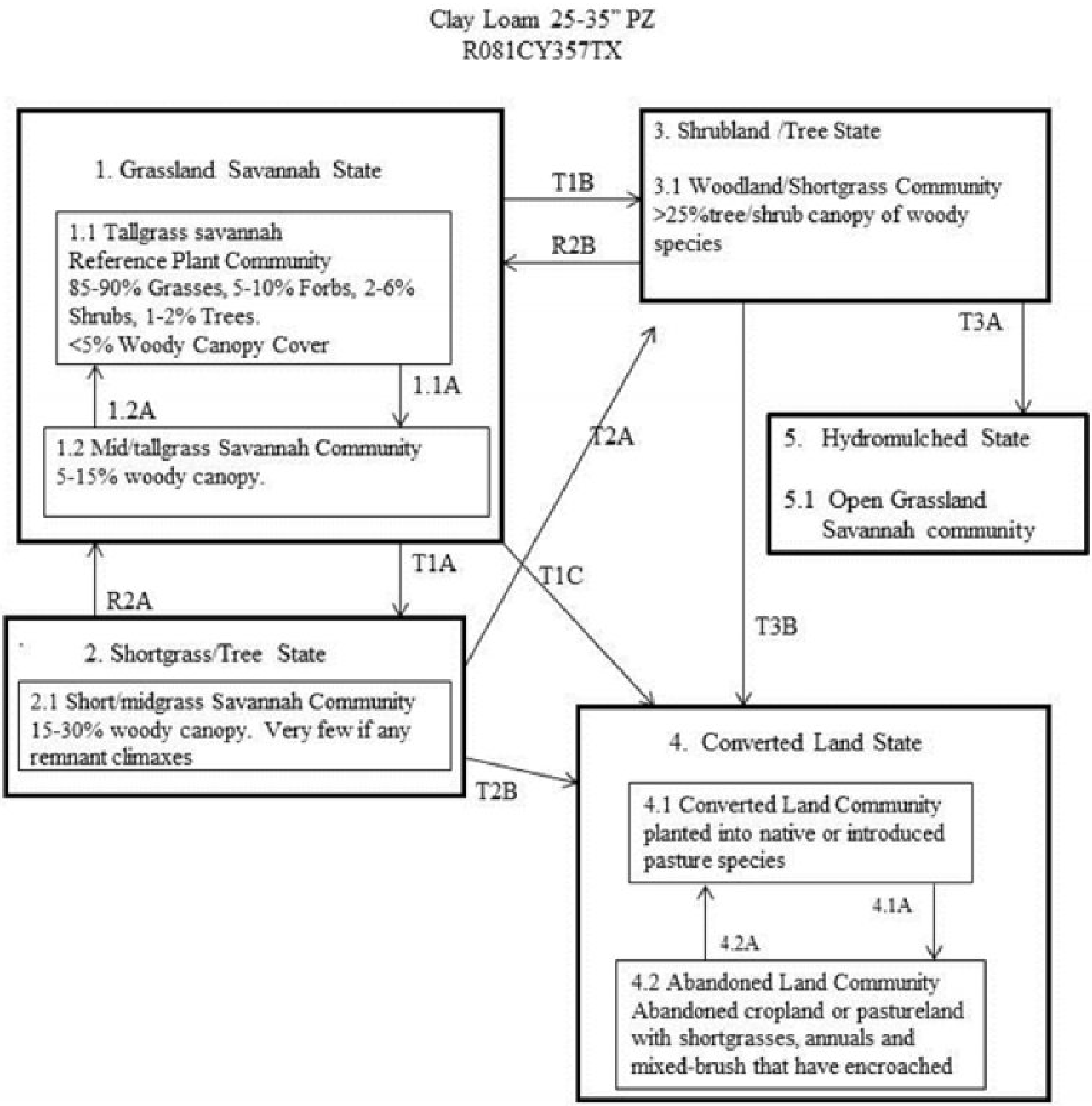


Figure 10. Clay Loam 29-35"

State 1

Grassland Savannah State

This state is a fire/herbivory managed, tallgrass savannah with about 10 percent woody canopy cover.

Community 1.1
Tall Grass Savannah

Figure 11. Reference Plant Community, Kendall County.

Figure 12. Clay loam ecological site. Kendall County, 1976

Figure 13. Clay Loam ecological site. Kendall County, Texas

Figure 14. Clay Loam ecological site. Bexar County, Camp Bull

This is the reference or interpretive community for the site. The description is based on early range site descriptions, clipping data, the professional consensus of experienced range specialists, and analysis of field work. In reference condition, this site is a fire/herbivory managed, tallgrass savannah with about 10 percent woody canopy cover. Elm and hackberry trees occur along small streams, and Texas live oak trees or motts are widely scattered. Texas live oak can exist as both a tree and as a mott depending upon fire frequency or other disturbance as it is a vigorous root sprouter. Some juniper may occur depending upon the last fire or removal. Little bluestem dominates the herbaceous plant community. Indiangrass and big bluestem are subdominants and may be locally dominant. Switchgrass and eastern gamagrass occurred in small quantities. Sideoats grama, Texas wintergrass, Texas cupgrass (*Eriochloa sericea*), silver (*Bothriochloa saccharoides*), and pinhole bluestem (*Bothriochloa barbinodis* var. perforata), vine mesquite (*Panicum obtusum*), and tall/meadow dropseed (*Sporobolus compositus*) are also prevalent but in lesser amounts. The site grows an abundance of palatable forbs and legumes such as Engelmann daisy (*Engelmannia peristenia*), orange zexmenia (Wedelia hispida), velvet bundleflower (*Desmanthus velutinus*), and trailing wildbean (*Strophostyles helvola*). This plant community is very stable and can withstand short term droughts although production will fluctuate accordingly. If the site is abused by overgrazing of the site with cattle, a reduction of the more palatable tall and mid grasses, forbs, and legumes will occur. Sideoats grama, Texas wintergrass, silver and pinhole bluestem, and buffalograss (*Bouteloua dactyloides*) will increase. Texas wintergrass, along with a small amount of wildryes (Elymus spp.), often dominates the site and furnishes considerable cool-season forage. The cool season plants will also be more prominent when abundant fall rains occur. Fire on a 5- to 10-year frequency will help suppress shrubs and add to the cycling of minerals and nutrients. Fires prevent excessive buildup of litter. Research on the effects of fire on soil organisms reveal complex results and are ecosystem dependent. Soil fauna may decrease following a burn if the burn leaves the soil bare and not insulated (Wright, 1982). It is anticipated that a burn on this site, leaving some litter on the soil, may initially depress soil fauna but then experience an increase following a burn mainly because the sun warms the ground quicker. This leads to more rapid nutrient cycling and increased production and quality. In general, if burning follows historic fire return intervals, the litter and soil fauna will be sustainable (Scifres, 1980). Grazing has a dual effect in maintaining this grassland. Grazing assists in nutrient cycling by digesting coarse grasses and depositing the digested plants through manure back to the soil surface. However, overgrazing can damage the plant community, create bare ground, and remove any opportunity for burning. Wildlife species such as birds and small mammals as well as livestock transport a variety of seeds onto the site. Shrubs will begin to establish under perches and cover for wildlife which is a place for new seedlings to establish. Once this begins to happen, the community is increasingly at risk of change. The plant community can be restored if an integrated regime of fire, maintenance brush, and proper grazing is completed. If these disturbances are not present, the 1.1 Tallgrass Savannah plant community will shift to the 1.2 Mid/Tallgrass Savannah plant community. This is within a normal range of variability for this site but if left long enough without the disturbances, the 1.2 Mid/Tallgrass Savannah plant community will transition into the Shrubland community (3) over time. If mechanical or chemical brush management were applied successfully, this community could also exist as an open, native, tallgrass prairie until the shrubs/trees inevitably reestablish. Continued mechanical or chemical suppression treatments would be needed in this case.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2380	2975	3650
Forb	224	280	350
Shrub/Vine	140	175	215
Tree	56	70	85
Total	**2800**	**3500**	**4300**

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	1-25%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	90-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 7. Soil surface cover

Tree basal cover	1-10%
Shrub/vine/liana basal cover	1-5%
Grass/grasslike basal cover	10-25%
Forb basal cover	1-10%
Non-vascular plants	0%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 8. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	–	–
>0.5 <= 1	–	–	10-20%	0-5%
>1 <= 2	–	–	10-20%	5-45%
>2 <= 4.5	–	0-5%	0-4%	–
>4.5 <= 13	0-5%	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 16. Plant community growth curve (percent production by month). TX3772, Hardwood/Grass Community. Hardwood trees with declining grass species..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4	5	7	12	20	13	5	4	13	7	5	5

Community 1.2
Mid/tallgrass Savannah Community

Figure 17. . Clay Loam ecological site. Bexar County

Figure 18. Clay Loam ecological site. Bexar County

The data for this plant community comes from the analysis of field data along with professional consensus of experienced range trained individuals. This plant community occurs with yearlong grazing by large herbivores without the application of fire or brush management practices. However a threshold has not been crossed. With management, this community will remain very similar to the reference plant community. It represents the variability within the plant community that fluctuates from events like short term droughts or heavy grazing. Defoliation reduces energy for tall grasses and they are reduced in the plant community. This reduction in tall grasses allows increases of mid grasses such as sideoats grama, tall/meadow dropseed, plains lovegrass, and woody plants such as mesquite, juniper, and pricklypear. Cedar elm (*Ulmus crassifolia*), bumelia (*Sideroxylon lanuginosum*), and hackberry also start to increase in density and stature. Texas wintergrass and cedar sedge increases as brush canopy increases. They are shade tolerant and most of their growth occurs during the cool season when brush has lost its leaves. This plant community consists generally of a 5 to 15 percent canopy of woody plants. The hydrologic cycle is basically intact although the shift to cool season plants and more shrubs and trees will change the time of year soil moisture is used and increases some losses through entrapment. The soil is intact and stable relative to erosion. The Mid and Tallgrass Prairie Community (1.2) can revert back to a plant community very similar to the Reference Plant Community (1.1) as there are sufficient remnants of tall grasses and forbs for a response. An integrated approach using tools such as selective brush management, prescribed burning, and/or prescribed grazing is needed to maintain this community or restore it to the Reference Plant Community (1.1) if that is the goal. Deferment from grazing alone will not fully shift this plant community back to the Reference Plant Community (1.1) because of the increase of woody plants and the canopy that fosters cool season plants. However, deferment does preserve fuel load that can be used for prescribed burning to help maintain the plant community. Without brush management, prescribed burning, and/or prescribed grazing, this plant community would continue to shift toward the Short and Midgrass Community (2) or Shrubland Community (3).

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2100	2600	3300
Forb	225	350	400
Tree	280	350	400
Shrub/Vine	140	175	200
Total	**2745**	**3475**	**4300**

Table 10. Ground cover

Tree foliar cover	0-10%
Shrub/vine/liana foliar cover	0-5%
Grass/grasslike foliar cover	10-15%
Forb foliar cover	5-10%
Non-vascular plants	0%
Biological crusts	0%
Litter	60-90%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 11. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	–	–
>0.5 <= 1	–	–	10-20%	0-5%
>1 <= 2	–	5-10%	10-20%	5-45%
>2 <= 4.5	–	–	0-5%	–
>4.5 <= 13	5-10%	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 20. Plant community growth curve (percent production by month). TX3772, Hardwood/Grass Community. Hardwood trees with declining grass species..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4	5	7	12	20	13	5	4	13	7	5	5

Pathway 1.1A
Community 1.1 to 1.2

Tall Grass Savannah

Mid/tallgrass Savannah Community

Continuous season-long grazing at moderate to heavy stocking rate can suppress tall grasses. This can be a short term situation within the natural variation of the community. Removal of fire and the lack of brush management, as well as adverse weather, contribute to the change in the 1.1 plant community to the 1.2.

Pathway 1.2A
Community 1.2 to 1.1

Mid/tallgrass Savannah Community

Tall Grass Savannah

Restoring ecological processes such as prescribed grazing and prescribed fire aid in the recovery. Integrated brush management such as Individual Plant Treatment will also speed the restoration.

State 2
Shortgrass/Tree State

Community 2.1
Short/midgrass Savannah Community

Figure 21. Clay Loam Site, Blanco co.

Figure 22. Clay Loam ecological site. Bexar County

Figure 23. Clay Loam ecological site. Kendall County

Figure 24. Clay Loam ecological site, Krum Soil

The description for this plant community is derived from analysis of limited field data and the professional consensus of range trained individuals. The Shortgrass/Tree Community (2.1) consists of short and midgrasses with 15 to 30 percent overstory canopy of woody plants. It generally has a savannah-like appearance and is low on herbaceous plant diversity. As this community ages, brush canopy along with grasses such as Texas wintergrass, threeawn, and annuals continue to increase. Warm-season perennial tall grasses such as Indiangrass and switchgrass have all but disappeared as have many of the warm season mid grasses such as sideoats grama and plains lovegrass. Continuous abuse by mixed classes of domestic livestock has facilitated the shift. Abusive grazing has suppressed the original plants and also removed any fuel loading that would support a prescribed burn. Subsequently, the energy flow now is transformed into the overstory of woody plants and the cool-season plants and small shrubs in the understory. This plant community is very stable as is the soil resource. Much of the hydrologic cycle has changed as the functional plants are the woody overstory and the cool-season plants. Some rainfall is trapped in the foliage of the overstory and evaporates but some also reaches the soil via stem flow. This stem flow enriches the Texas wintergrass and sedges that occupy the understory. Many times the interspaces in the canopy openings are occupied by curly mesquite, buffalograss, and other short grasses. During drought conditions, these interspaces can become bare and providing the opportunity for some surface movement of soil and increased runoff. Much of the forb population is cool-season annuals such as plantain (Plantago spp.) and common broomweed (*Amphiachyris dracunculoides*). If the management goal is to restore this plant community back to something resembling the reference community, reduction of the canopy of woody plants is needed and possibly reintroduction of seeds representative of the reference plant community. A field investigation is needed to evaluate the necessity for seeding although seeding can speed up the recovery and increase diversity. Tools that restore the restore the energy flow back to these plants and restore the hydrologic cycle include an integrated approach using brush management, fire, and prescribed grazing. It is possible to restore this plant community to something similar to the reference plant community but very difficult if not impossible to fully restore because of lost plant species having limited or no seed source in the market place. It will take many years to fully restore the soil health back to the reference condition. Even though this plant community is very stable, over time other small shrubs and cactus will populate the understory being brought to the site via birds, small mammals, feral hogs, and livestock. Therefore, over time and without treatment, the site will shift toward more dense stands of brush containing both an overstory and a midstory. The main driver to maintain this community is livestock grazing; particularly with sheep and goats having a preference for small shrubs to keep the understory open. Fire can be used as well but the use of fire with a cool season understory is limited. Wildlife browsers generally do not exert sufficient browsing pressure to maintain a savannah on this particular site. If livestock are removed or if grazed only with cattle, a change to the Shrubland/Tree State (3) may occur within 10 to 20 years unless remedial action is taken. Deferment alone will not accomplish any restoration and may well increase the rate of shrub understory establishment.

Table 12. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1650	2100	2600
Tree	700	875	1000
Shrub/Vine	300	350	500
Forb	150	175	200
Total	**2800**	**3500**	**4300**

Table 13. Ground cover

Tree foliar cover	0-10%
Shrub/vine/liana foliar cover	0-10%
Grass/grasslike foliar cover	10-40%
Forb foliar cover	5-15%
Non-vascular plants	0%
Biological crusts	0%
Litter	75-100%
Surface fragments >0.25" and <=3"	1-5%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 14. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	2-13%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 15. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	2-8% N*
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–

Tree snags** (soft***)	–
Tree snag count** (hard***)	
Tree snag count** (hard***)	

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 16. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-3%	0-1%
>0.5 <= 1	–	1-3%	10-30%	1-3%
>1 <= 2	–	3-5%	10-40%	0-5%
>2 <= 4.5	0-10%	3-5%	0-5%	–
>4.5 <= 13	5-25%	–	–	–
>13 <= 40	5-20%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 26. Plant community growth curve (percent production by month). TX3784, Short Midgrass Savannah. Short and mid grasses in a savannah setting..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

State 3
Shrubland/Tree State

Community 3.1
Woodland/Shortgrass Community

Figure 27. Clay Loam ecological site. Bexar County

Figure 28. Clay Loam ecological site. Bexar County

Figure 29. Clay Loam ecological site. Bexar County

Figure 30. Clay Loam ecological site. Bexar County

This Woodland/Shortgrass Community (3.1) represents the crossing of a threshold and is a very stable plant community having greater than 25 percent woody canopy dominated by mesquite, oak, and/or juniper with a midstory of shrubs. These shrubs may include algerita (Mahonia trilobata), ephedra (Ephedra spp.), tasijillo (*Cylindropuntia leptocaulis*), prickly pear (Opuntia spp.), and a diversity of others. This plant community formed when livestock grazing and fire have been removed for a long time; especially when sheep and goats are removed. (This plant community can actually develop from any of the other plant communities given enough time when all management activities cease.) Other species present are elm, hackberry, and live oak. The herbaceous understory is almost non-existent. Shade tolerant species such as Texas wintergrass and cedar sedge are the main herbaceous plants. When the canopy of juniper increases toward a cedar break type community most warm-season grasses have disappeared. Full restoration back to the Reference Plant Community is doubtful and requires the significant intervention of many tools over time to even recover to a resemblance of the Reference Community. The overstory entraps as much as 25 percent of the rainfall (Thurow, 1997) which then evaporates without entering the soil. Most energy is absorbed by the woody plants with some being absorbed by the cool-season herbaceous understory. The soil is covered and exhibits little erosion except for some movement as water flows under the understory. In this case terracettes and litter dams will be observed. Fire is a very limited option for this community so mechanical/chemical tools are needed. Depending upon the past management, it is doubtful that many reference plant community seeds exist for recovery, so seeding may be needed. Because of the overstory canopy, the amount of grass cover is greatly reduced which in turn reduces forage/fine fuel production. Seeding can be used in conjunction with mechanical management.

Table 17. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1800	2275	2795
Shrub/Vine	560	700	860
Grass/Grasslike	280	350	400
Forb	150	175	200
Total	**2790**	**3500**	**4255**

Table 18. Ground cover

Tree foliar cover	50-100%
Shrub/vine/liana foliar cover	10-35%
Grass/grasslike foliar cover	2-10%
Forb foliar cover	1-5%
Non-vascular plants	0%
Biological crusts	0%
Litter	75-100%
Surface fragments >0.25" and <=3"	1-5%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 19. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0%
Grass/grasslike basal cover	0%
Forb basal cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	18-35%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 20. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	15-20% N*
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	1-5% N*
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	1-5% N*
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	1-5% N*
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	
Tree snag count** (hard***)	

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 21. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	0-3%	0-1%
>0.5 <= 1	–	1-3%	0-5%	0-3%
>1 <= 2	–	3-10%	0-10%	0-5%
>2 <= 4.5	10-25%	5-20%	–	–
>4.5 <= 13	40-60%	–	–	–
>13 <= 40	5-20%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 32. Plant community growth curve (percent production by month). TX3767, Juniper Woodland. Invasion of Ashe Juniper encroaching open grassland..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	3	10	15	20	18	5	4	10	7	4	2

State 4
Converted Land State

Community 4.1
Converted Land Community

Figure 33. Clay Loam ecological site. Bexar County

This community is usually the result of mechanical brush control and range planting using a mixture of native grass species. An introduced species may be a part of the seed mixture, some of which can be invasive. Some invasive species are very abundant in the region and can be introduced by equipment, free roaming animals, hay, and means other than range planting. It should be understood however that in some cases introduced grasses can serve part of the same functionality in terms of soil protection and hydrologic characteristic as do natives. Some introduced species, such as kleingrass are not as prone to dominance as are the introduced bluestems. Once invasive grasses have established dominance, restoration to the reference plant community is impractical. If there has been past tillage, the soil heath has deteriorated and the native seed source lost. It will take a long time (if ever) for this state to again reach the reference state. Recovery will involve the use of knock-down herbicides over time as well as replanting of native seeds but even then once they are there, many of the introduced bluestems are persistent. If there is tillage along with crop production and abandonment, this plant community will shift to the 4.2 Abandoned Land Community.

Table 22. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2000	2400	3200
Tree	250	300	400
Forb	125	150	200
Shrub/Vine	125	150	200
Total	**2500**	**3000**	**4000**

Table 23. Ground cover

Tree foliar cover	0-3%
Shrub/vine/liana foliar cover	0-5%
Grass/grasslike foliar cover	10-45%
Forb foliar cover	1-5%
Non-vascular plants	0%
Biological crusts	0%
Litter	70-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0-1%

Table 24. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	10-15%	0-1%
>0.5 <= 1	–	–	10-25%	1-3%
>1 <= 2	–	–	40-60%	0-5%
>2 <= 4.5	0-5%	0-5%	10-20%	0-5%
>4.5 <= 13	0-5%	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 35. Plant community growth curve (percent production by month). TX3769, Open Grassland with Juniper. Open Grassland with Juniper Encroachment having warm season grasses with minor cool season influence..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Community 4.2
Abandoned Land Community

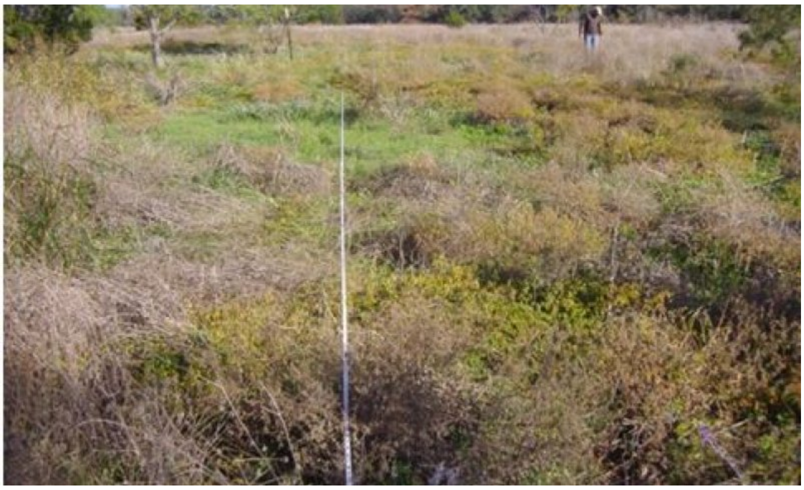


Figure 36. Clay Loam ecological site. Bexar County

Figure 37. . Clay Loam ecological site. Bexar County

Figure 38. . Clay Loam ecological site. Bexar County

Extensive conversion of the Clay Loam ecological site to cropland (primarily cotton and corn) occurred from the mid-1800s to the early 1900s. Some remains in cropland today. While restoration of this site to a semblance of the tallgrass prairie is possible with range planting, prescribed grazing, and prescribed burning—complete restoration of the historic community in a reasonable time is very unlikely because of deterioration of the soil structure and organisms. If managerial objectives are exotic grasses, these usually consist of Introduced bluestems (Bothriochloa spp.), kleingrass (*Panicum coloratum*), and bermudagrass (*Cynodon dactylon*). The production of these species is highly variable depending upon grazing management, soil health, fertility program, and undesirable plant management. More detailed information is available in Forage Suitability Groups for exotic plants. If abandon land is not seeded and left to natural recovery, it will be doubtful the land will ever recover to any semblance of the reference plant community. Much of the soil health has been degraded and unless remedial efforts to restore the living portions of the soil, the organic matter and the humus, restoration will be difficult. Depending upon the cropping history and the length of cropping, very few remnant seeds persist. Once abandoned, early successional plants that are annuals and weak perennials establish. Over time and with the introduction of some seeds from adjacent areas, higher successional plants establish. However, the plant succession, without intervention with range plantings will probability terminate in a mesquite/baccharis/juniper woody component with prickly pear and small shrubs, and Texas wintergrass as the majority of the plant component. This will be the stable community over time. This community does stabilize the soil and provide the basic building blocks of nutrients, organic matter, and soil organisms needed to restore health. This process is estimated to take over 50 years to manifest. To accelerate the recovery, range planting along with maintenance brush management, prescribed grazing, and possibly fire are needed to restore the ecological process to heal the land.

Table 25. Annual production by plant type

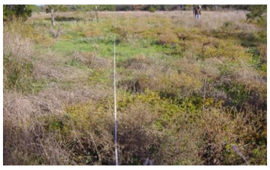
Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1750	2250	3000
Shrub/Vine	250	300	400
Tree	250	300	400
Forb	250	300	400
Total	**2500**	**3150**	**4200**

Figure 40. Plant community growth curve (percent production by month). TX3781, GoBack Land Community. Shortgrass/Mixed-brush summer growth with some cool-season grass growth. Weed and brush species may invade the site from adjacent areas..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	7	13	20	15	7	5	10	7	5	5

Pathway 4.1A
Community 4.1 to 4.2

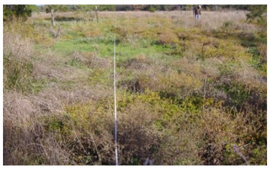
Converted Land Community



Abandoned Land Community

Tillage and farming for crops followed by abandonment triggers this shift.

Pathway 4.2A
Community 4.2 to 4.1



Abandoned Land Community

Converted Land Community

Range planting, maintenance brush management, prescribed grazing, and possibly fire are needed to restore the ecological processes.

State 5
Mulched State

Community 5.1
Hydromulched State

Figure 41. . Clay Loam ecological site. Bexar County

Figure 42. . Clay Loam ecological site. Bexar County

This plant community is a result of using mechanical hydro-mulching to reduce canopy and structure of dense woody species which is usually juniper. The objective of this treatment is to facilitate movement of foot soldiers and to provide protective ground cover. The amounts of mulch on the ground and the orientation of the mulch are dependent upon the amount of woody cover treated and the time since treatment. The mulch tends to settle over time and is very resistant to deterioration. This community can structurally appear very similar to the reference plant community but without the herbaceous cover. The understanding of how this plant community reacts over time is unknown but studies are currently under way to monitor. One result is that the soil is protected for a long time. There will be a need for maintenance to treat juniper and other species as they re-establish.

Table 26. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1500	2250	3000
Shrub/Vine	300	450	600
Forb	100	150	200
Grass/Grasslike	100	150	200
Total	**2000**	**3000**	**4000**

Figure 44. Plant community growth curve (percent production by month). TX3773, Tallgrass Savannah -10-30% canopy cover. Tallgrasses with 10-30 percent canopy cover..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Transition T1A
State 1 to 2

Continuous season long grazing at moderate to heavy stocking with mixed classes of livestock rate suppress tall grasses. Removal of fire and the lack of brush management as well as adverse weather contribute to the change in the 1.1 plant community to the 1.2.

Transition T1B
State 1 to 3

A lack of fire, integrated brush management and abusive grazing with cattle over long periods of time (30+ years). Alterations of hydrologic cycle, mineral cycle and nutrient cycle are contributing factors. Complete destocking for several years will also lead to a similar situation.

Transition T1C
State 1 to 4

Land clearing, brush management and tillage are the primary drivers to convert land.

Restoration pathway R2A
State 2 to 1

Prescribed grazing coupled with brush management and possibly range planting to restore the ecological process of energy flow and hydrology are needed. Fire should be used strategically in the recovery process. Prescribed grazing with mixed classes of livestock coupled with fire and brush management will help manage resprouts.

Transition T2A
State 2 to 3

Removal of mixed classes of herbivory, a lack of fire and brush management along with the increase of woody plants drive this transition.

Transition T2B
State 2 to 4

Land clearing, brush management and tillage are the primary drivers to convert land.

Restoration pathway R2B
State 3 to 1

Combinations of mechanical treatment, chemical treatments, and many times range planting will be needed to restore this plant community. Prescribed grazing will also be needed. Unless fire is used, prescribed grazing with mixed livestock and brush management will be needed over time.

Transition T3B
State 3 to 4

Land clearing, brush management and tillage are the primary drivers to convert land.

Transition T3A
State 3 to 5

Mechanical hydro mulching is used to reduce canopy and understory.

Additional community tables

Table 27. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			2000–3000	
	little bluestem	SCSC	*Schizachyrium scoparium*	1530–2550	–
	Indiangrass	SONU2	*Sorghastrum nutans*	375–500	–
	big bluestem	ANGE	*Andropogon gerardii*	375–500	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	75–150	–
	switchgrass	PAVI2	*Panicum virgatum*	50–80	–
2	**Midgrasses**			400–450	
	sideoats grama	BOCU	*Bouteloua curtipendula*	350–450	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	150–225	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	100–150	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	75–125	–
	vine mesquite	PAOB	*Panicum obtusum*	75–125	–
	threeawn	ARIST	*Aristida*	50–125	–
3	**Midgrasses**			150–225	
	silver beardgrass	BOLA2	*Bothriochloa laguroides*	150–225	–
4	**Short grasses**			80–100	
	curly-mesquite	HIBE	*Hilaria belangeri*	80–100	–
	fall witchgrass	DICO6	*Digitaria cognata*	25–60	–
5	**Cool-season Grasses**			180–220	
	Texas wintergrass	NALE3	*Nassella leucotricha*	150–220	–
	cedar sedge	CAPL3	*Carex planostachys*	80–125	–
	Canada wildrye	ELCA4	*Elymus canadensis*	80–125	

	Canada wildrye	ELCA4	*Elymus canadensis*	80–125	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	80–125	–
Forb					
6	**Forbs**			300–400	
	cedar sedge	CAPL3	*Carex planostachys*	200	–
	Canada wildrye	ELCA4	*Elymus canadensis*	200	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	200	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	50–100	–
	Berlandier's sundrops	CABE6	*Calylophus berlandieri*	50–100	–
	prairie clover	DALEA	*Dalea*	50–100	–
	zarzabacoa comun	DEIN3	*Desmodium incanum*	50–100	–
	bundleflower	DESMA	*Desmanthus*	50–100	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	50–100	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	50–100	–
	eastern milkpea	GARE2	*Galactia regularis*	50–100	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	50–100	–
	trailing krameria	KRLA	*Krameria lanceolata*	50–100	–
	dotted blazing star	LIPU	*Liatris punctata*	50–100	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	50–100	–
	yellow puff	NELU2	*Neptunia lutea*	50–100	–
	narrowleaf Indian breadroot	PELI10	*Pediomelum linearifolium*	50–100	–
	snoutbean	RHYNC2	*Rhynchosia*	50–100	–
	awnless bushsunflower	SICA7	*Simsia calva*	50–100	–
	fuzzybean	STROP	*Strophostyles*	50–100	–
7	**Annual Forbs**			0–1	
	prairie broomweed	AMDR	*Amphiachyris dracunculoides*	0–1	–
Shrub/Vine					
8	**Shrubs/Vines**			80–100	
	stretchberry	FOPU2	*Forestiera pubescens*	80–100	–
	sumac	RHUS	*Rhus*	80–100	–
	gum bully	SILA20	*Sideroxylon lanuginosum*	80–100	–
Tree					
9	**Trees**			70–100	
	hackberry	CELTI	*Celtis*	70–100	–
	Texas live oak	QUFU	*Quercus fusiformis*	70–100	–
	elm	ULMUS	*Ulmus*	70–100	–

Animal community

This site is suited for the production of domestic livestock and provides habitat for native wildlife and certain species of exotic wildlife. Cow-calf operations are the primary livestock enterprise although stocker cattle are also grazed. Sheep and goats were formerly raised in large numbers and are still present but in reduced numbers. Sustainable stocking rates have declined drastically over the past 100 years because of the deterioration of the historic plant community. Initial starting stocking rates should be determined with the landowner or decision maker based on the merits of the existing plants for the desired animals.

With the eradication of the screwworm fly, the increase in woody vegetation, and insufficient natural predation, white-tailed deer numbers have increased drastically 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 can keep populations in balance. Achieving a balance between woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep, and goats because of diet overlap can be an important consideration in livestock and wildlife management because of damage to preferred vegetation.

Many species will utilize the clay loam site for at least a portion of their habitat needs but rely on a landscape to meet all their needs.

Smaller mammals include many kinds of rodents, jackrabbit, cottontail rabbit, raccoon, skunks, opossum, and armadillo. Mammalian predators include coyote, red fox, gray fox, bobcat, and mountain lion. 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 Rio Grande turkey, bobwhite quail, and mourning dove. Turkey prefers plant communities with substantial amounts of shrubs and trees interspersed with grassland. Quail prefer plant communities with a combination of low shrubs, bunch grass, bare ground, and low successional forbs. The different species of songbirds vary in their habitat preferences. Prairie chickens (Tympanuchus spp.) were also recorded in the general area. In general, a habitat that provides a diversity of grasses, forbs, shrubs, vines and trees, and a complex of grassland, savannah, shrubland, and woodland will support a variety and abundance of songbirds. Birds of prey are important to keep the numbers of rodents, rabbits, and snakes in balance. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow, and red deer, aoudad sheep, and blackbuck antelope. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. Feral hogs are present and can cause damage when their numbers are not managed.

Hydrological functions

State 1: Grassland Savannah – The water cycle is most functional when the site is dominated by tall bunchgrass. Very little rainfall is entrapped by the woody canopy. Rapid rainfall infiltration, high soil organic matter, good soil structure, and good porosity are present with a cover of bunchgrass. Quality of surface runoff will be high and erosion and sedimentation rates will be low. Most of the moisture absorbed in the soil is used by the herbaceous plants in the root zone. Occasionally, when there are periods of high sustained rainfall, water may percolate below the root zone but this site does not usually recharge shallow aquifers.

State 2: Shortgrass/tree – When abusive grazing causes loss or reduction of bunchgrass and ground cover, the water cycle becomes impaired. Infiltration is decreased and runoff is increased because of poor ground cover, rainfall splash, soil capping, lowered organic matter, and poor structure. Because of the very high shrink-swell clay soil and the formation of surface cracks in dry periods, rainfall infiltration can still occur even when ground cover is poor. With a combination of a sparse ground cover and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor and sedimentation increases.

State 3: Shrubland/tree – As the site becomes dominated by woody species, especially oaks and juniper, the water cycle is further altered. Interception of rainfall by tree canopy is increased which reduces the amount of rainfall reaching the surface by as much as 25 percent. However, stem flow is increased, because of the funneling effect of the canopy, which increases soil moisture at the base of the tree. Increased transpiration, especially when evergreen species such as live oak and juniper dominate, provides less chance for deep percolation. As woody species increase, grass cover declines accordingly, which causes some of the same results as heavy grazing.

With a mature woodland canopy, a buildup of leaf litter occurs which increases the organic matter of the soil, builds the structure, improves infiltration, and retards erosion. Some, but not all values of a properly functioning water cycle are restored on this site when a woodland plant community persists.

State 4: Converted land – If the converted state is in productive grassland, the hydrologic characteristics resemble the reference plant community. However, if grazing has been done during wet weather or is abusive, soil compaction can prevent infiltration. This increases runoff and contributes to downstream flooding in high rainfall events.

State 5: Hydro mulched – Heavy mulch on the surface absorbs rainfall and protects the surface from raindrop impact. There is virtually no erosion or runoff. Many of the impacts of heavy mulch have yet to be measured, but the mulch stops most of the surface evaporation. Moisture is retained in the soil profile to be used by any plant protruding above the mulch.

Recreational uses

This site has the appeal of the wide open spaces. The abundant tall and mid grasses and scattered oaks produce beautiful fall color variations. The area is also used for hunting, birding and other eco-tourism related enterprises.

Wood products

Honey mesquite and oaks can be used for firewood and the specialty wood industry.

Other products

Plant Preference by Animal Kind:

This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition and diet overlap between kinds of herbivores. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. An animal's preference or avoidance of certain plants is learned over time through grazing experience and maternal learning (http://extension.usu.edu/behave/Grazing). Preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food are rated. Refer to detailed habitat guides for a more complete description of a species habitat needs.

Inventory data references

Information presented was derived from the site's previous Range Site Description, NRCS clipping data, literature, field observations, and personal contacts with range-trained personnel.

Other references

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Contributors

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Approval

David Kraft, 9/20/2019

Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high-intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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)	San Angelo Zone RMS
Contact for lead author	325-944-0147
Date	04/08/2013
Approved by	Colin Walden
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:** Some minimal flow patterns may be evident at the juncture of the associated sites.

3. **Number and height of erosional pedestals or terracettes:** None.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** None.

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):** Little or no litter movement or deposition during normal rainfall events, rarely over 6 inches.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Stability class range is expected to be 5-6.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 0 to 3.1 inches; brown (7.5YR 4/2) dry, loam; dark brown; 3.1 to 18.1 inches; dusky red (2.5YR 3/2) dry, clay;18.1 inches; very slightly effervescent by HCl

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The tallgrass/midgrass savanna with abundant forbs, adequate litter, and little bare ground provides for maximum infiltration and negligible 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):** No evidence of compaction.

---

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 tallgrasses

    Sub-dominant: Warm-season midgrasses

    Other: Trees Forbs Cool Season Grasses Shrubs Warm Season Short Grasses.

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Perennial grasses will naturally exhibit a minor amount (less than 5%) of senescence and some mortality every year.

---

14. **Average percent litter cover (%) and depth (in):** >90 percent litter, 0.5 to 1 inch depth.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 2800 to 4300 pounds per acre

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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:** Ashe juniper, baccharis, pricklypear, yucca, tasajillo, pricklyash, lotebush, mesquite, King Ranch bluestem, silky bluestem, annual broomweed

17. **Perennial plant reproductive capability:** All perennial species should be capable of reproducing every year unless disrupted by extended drought, overgrazing, wildfire, insect damage, or other events occuring immediately prior to, or during the reproductive phase.

USDA Natural Resources Conservation Service

Ecological site R086AY013TX Clayey Bottomland

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

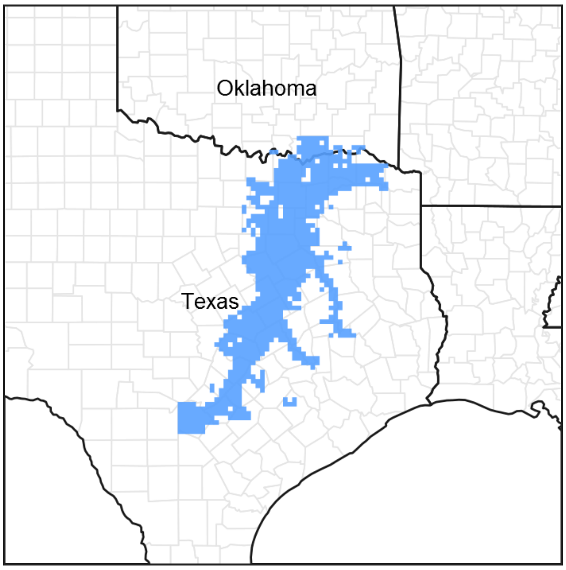


Figure 1. Mapped extent

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): 086A–Texas Blackland Prairie, Northern Part

MLRA 86A, The Northern Part of Texas Blackland Prairie is entirely in Texas. It makes up about 15,110 square miles (39,150 square kilometers). The cities of Austin, Dallas, San Antonio, San Marcos, Temple, and Waco are located within the boundaries. Interstate 35, a MLRA from San Antonio to Dallas. The area supports tall and mid-grass prairies, but improved pasture, croplands, and urban development account for the majority of the acreage.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 86A

Ecological site concept

The Clayey Bottomland is a tallgrass savannah. The site is unique because it has a hardwood overstory component with the tallgrasses. The soils are very deep clays and are associated with flooding regimes. Their heavy textured soils cause water to drain slowly and may stay for over a month.

Associated sites

R086AY004TX	**Southern Claypan Prairie** The Southern Claypan site is often adjacent to the Clayey Bottomland site. It differs from the Clayey Bottomland site by forming on stream terraces and having a sandy loam surface soil layer and lower production potential due to low to moderate soil fertility.
R086AY006TX	**Northern Clay Loam** The Northern Clay Loam site is often upslope from the Clayey Bottomland site. It differs from the Clayey Bottomland site by occurring in uplands, plains, and terraces and lacking thin stratas of varying textured soils in the soil profile from flooding events.
R086AY007TX	**Southern Clay Loam** The Southern Clay Loam site is often upslope from the Clayey Bottomland site. It differs from the Clayey Bottomland site by occurring in uplands, plains, and terraces and lacking thin stratas of varying textured soils in the soil profile from flooding events.
R086AY010TX	**Northern Blackland** The Northern Blackland site is often upslope from the Clayey Bottomland site. It differs from the Clayey Bottomland site by its position on uplands, lack of high shrink-swell and hydric soil properties, and having clay soils and higher runoff.
R086AY011TX	**Southern Blackland** The Southern Blackland site is often upslope from the Clayey Bottomland site. It differs from the Clayey Bottomland site by its position on uplands, lack of high shrink-swell and hydric soil properties, and having clay soils and higher runoff.
R086AY003TX	**Northern Claypan Prairie** The Northern Claypan site is often adjacent to the Clayey Bottomland site. It differs from the Clayey Bottomland site by forming on stream terraces and having a sandy loam surface soil layer and lower production potential due to low to moderate soil fertility.

Similar sites

R086AY012TX	**Loamy Bottomland** The Loamy Bottomland site is similar to the Clayey Bottomland site by occurring on floodplains and having similar production potential. It differs from the Clayey Bottomland site by forming in recent loamy alluvium and having higher permeability and no shrink-swell soil characteristics.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

These are on nearly level slopes and occurs along major rivers and their tributaries on floodplains. Slopes are dominantly 1 to 5 percent, but range from 0 to 10 percent. The sites can flood briefly (two to seven days) to very long (greater than one month) and pond as well. The runoff class is high to very high.

Table 2. Representative physiographic features

Landforms	(1) Flood plain
Flooding duration	Brief (2 to 7 days) to very long (more than 30 days)
Flooding frequency	Rare to frequent
Ponding duration	Brief (2 to 7 days) to long (7 to 30 days)
Ponding frequency	Rare to occasional
Elevation	100–550 ft
Slope	1–2%

Ponding depth	0–6 in
Water table depth	0–72 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 86A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. Tropical maritime air controls the climate during spring, summer and fall. In winter and early spring, frequent surges of Polar Canadian air cause sudden drops in temperatures and add considerable variety to the daily weather. When these cold air masses stagnate and are overrun by moist air from the south, several days of cold, cloudy, and rainy weather follow. Generally, these occasional cold spells are of short duration with rapid clearing following cold frontal passages. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of sunny skies, mild days, and cool nights. The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time during the summer and 50 percent in winter. The prevailing wind direction is from the south and highest wind speeds occur during the spring months. Rainfall during the spring and summer months generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. High-intensity rains of short duration are likely to produce rapid runoff almost anytime during the year. The predominantly anticyclonic atmospheric circulation over Texas in summer and the exclusion of cold fronts from North Central Texas result in a decrease in rainfall during midsummer. The amount of rain that falls varies considerably from month-to-month and from year-to-year.

Table 3. Representative climatic features

Frost-free period (average)	237 days
Freeze-free period (average)	265 days
Precipitation total (average)	39 in

Climate stations used

- (1) CEDAR CREEK 5 S [USC00411541], Cedar Creek, TX
- (2) TAYLOR 1NW [USC00418862], Taylor, TX
- (3) HILLSBORO [USC00414182], Hillsboro, TX
- (4) TEMPLE [USC00418910], Temple, TX
- (5) GREENVILLE KGVL RADIO [USC00413734], Greenville, TX
- (6) NEW BRAUNFELS [USC00416276], New Braunfels, TX
- (7) SAN MARCOS [USC00417983], San Marcos, TX
- (8) SHERMAN [USC00418274], Denison, TX
- (9) JOE POOL LAKE [USC00414597], Dallas, TX
- (10) KAUFMAN 3 SE [USC00414705], Kaufman, TX
- (11) MCKINNEY [USC00415766], McKinney, TX
- (12) SAN ANTONIO 8NNE [USC00417947], San Antonio, TX
- (13) WAXAHACHIE [USC00419522], Waxahachie, TX
- (14) AUSTIN BERGSTROM AP [USW00013904], Austin, TX

Influencing water features

This site is located in floodplains. It receives water from overflow from watercourses and runoff from higher adjacent sites. Most of the soils within this site are classified as hydric and may be wetlands. Onsite delineations are required to determine if the site is officially classified as a wetland.

Soil features

The site consists of very deep, moderately well to very poorly drained, slow to impermeable soils. The floodplain soils were formed in alkaline residuum derived from shales and clays. In a representative profile, the surface layer is very dark gray clay. The subsoils are very dark gray to olive clay. Having high shrink-swell characteristics, the soils crack when dry. In this condition, they take in water rapidly. When the soils become wet and the cracks close. The soils are very fertile and hold large amounts of water for plant use. They also have a high wilting point which reduces forage yields in extremely dry years.

The associated soil series are: Aufco, Elbon, Gladewater, Kaufman, Ovan, Redlake, Roetex, Seagoville, Ships, Tinn, Trinity, and Zilaboy.

Table 4. Representative soil features

Surface texture	(1) Clay (2) Silty clay
Family particle size	(1) Clayey
Drainage class	Moderately well drained to very poorly drained
Permeability class	Slow
Soil depth	80 in
Surface fragment cover <=3"	0–1%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	5–7 in
Calcium carbonate equivalent (0-40in)	1–35%
Electrical conductivity (0-40in)	0–24 mmhos/cm
Sodium adsorption ratio (0-40in)	0–24
Soil reaction (1:1 water) (0-40in)	7.4–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–3%
Subsurface fragment volume >3" (Depth not specified)	0%

Ecological dynamics

Introduction – The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background – Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Florida paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsuta*), and dropseeds (Sporobolus spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak (*Quercus virginiana*) and hackberry (Celtis spp.) trees are also native to the region. In some areas, cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), and honey locust (*Gleditsia triacanthos*) are abundant. In the Northern Blackland Prairie oaks (Quercus spp.) are common increasers, but in the Southern Blackland Prairie oaks are less prevalent. Junipers are common invaders, particularly in the northern part of the region.

During the first half of the nineteenth century, row crop agriculture lead to over 80 percent of the original vegetation lost. During the second half, urban development has caused even an even greater decline in the remaining prairie. Today, less than one percent of the original tallgrass prairie remains. The known remaining blocks of intact prairie range from 10 to 2,400 acres. Some areas are public, but many are privately owned and have conservation easements.

Current State – Much of the area is classified as prime farmland and has been converted to cropland. Most areas where native prairie remains have histories of long-term management as native hay pastures. Tallgrasses remain dominant when haying of warm-season grasses is done during the dormant season or before growing points are elevated, meadows are not cut more than once, and the cut area is deferred from grazing until frost.

Due to the current-widespread farming, the Northern Blackland Prairie is still relatively free from the invasion of brush that has occurred in other parts of Texas. In contrast, many of the more sloping have experienced heavy brush encroachment, and the continued increase of brush encroachment is a concern. The shrink-swell and soil cracking characteristics of the soils favor brush species with tolerance for soil movement.

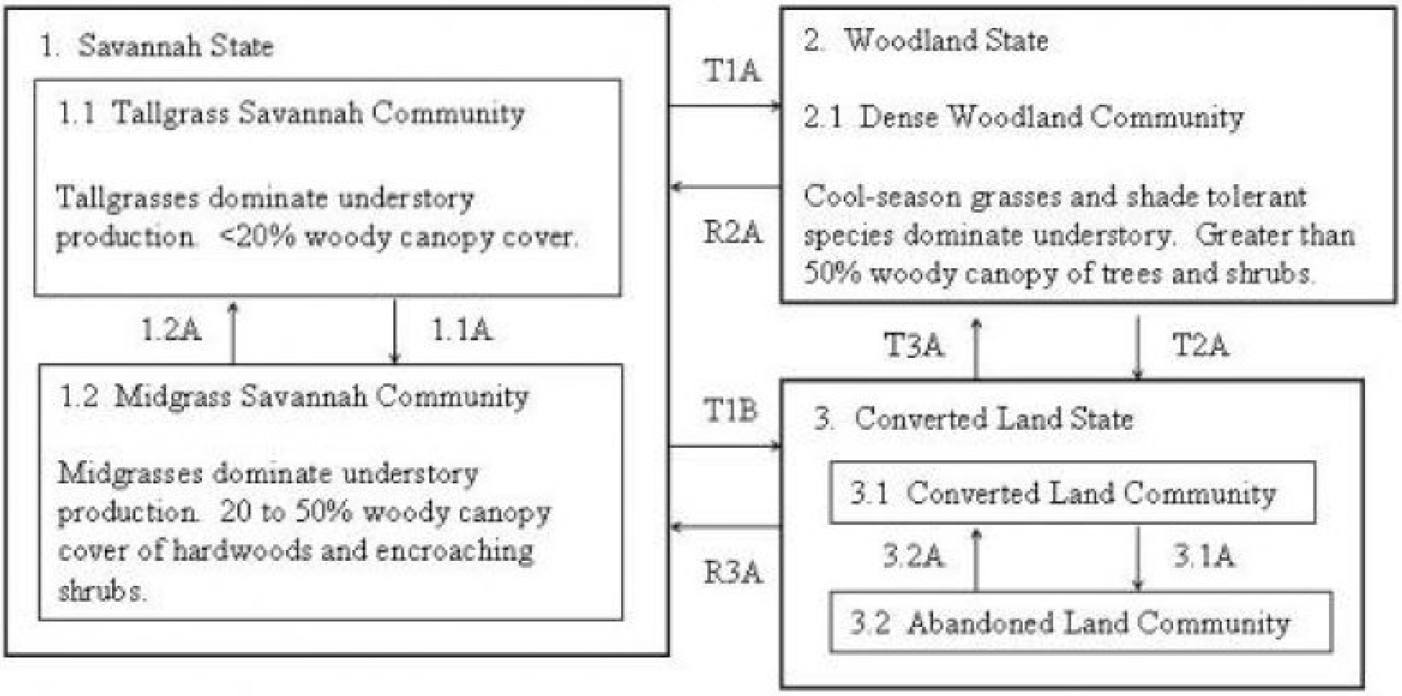
Current Management – Rangeland and pastureland are grazed primarily by beef cattle. Horse numbers are increasing rapidly in the region, and in recent years goat numbers have increased significantly. There are some areas where dairy cattle, poultry, goats, and sheep are locally important. Whitetail deer, wild turkey, bobwhite quail, and dove are the major wildlife species, and hunting leases are a major source of income for many landowners in this area.

Introduced pasture has been established on many acres of old cropland and in areas with deeper soils. Coastal bermudagrass (*Cynodon dactylon*) and kleingrass (*Panicum coloratum*) are by far the most frequently used introduced grasses for forage and hay. Hay has also been harvested from a majority of the prairie remnants, where long-term mowing at the same time of year has possibly changed the relationships of the native species. Cropland is found in the valleys, bottomlands, and deeper upland soils. Wheat (Triticum spp.), oats (Avena spp.), forage and grain sorghum (Sorghum spp.), cotton (Gossypium spp.), and corn (*Zea mays*) are the major crops in the region.

Fire Regimes – The prairies were a disturbance-maintained system. Prior to European settlement (pre-1825), fire and infrequent, but intense, short-duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes - Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases. Wet periods allow tallgrasses to increase in dominance. These natural disturbances cause shifts in the states and communities of the ecological sites.

State and transition model



Legend

1.1A Improper Grazing Management, No Fire, No Brush Management, Long-term Droughts
1.2A Proper Grazing Management, Prescribed Burning, Brush Management
T1A Improper Grazing Management, No Fire, No Brush Management, Long-term Droughts
T1B Land Clearing, Crop Cultivation, Pasture Planting, Range Planting, Tree Planting
R2A Proper Grazing Management, Prescribed Burning, Brush Management
T2A Land Clearing, Crop Cultivation, Pasture Planting, Range Planting, Tree Planting
R3A Proper Grazing Management, Brush Management, Prescribed Burning
T3A Improper Grazing Management, No Brush Management, No Fire, Long-term Droughts
3.1A Improper Grazing Management, No Brush Management, Idle Land
3.2A Proper Grazing Management, Pasture/Range/Cropland Management, Crop Cultivation, Pasture Planting, Range Planting

Figure 6. STM

State 1
Savannah

Two communities exist in the Savannah State: the 1.1 Tallgrass Savannah Community and the 1.2 Midgrass Savannah Community. Community 1.1 is characterized by tallgrasses dominating the understory with woody species creating less than 20 perecent of the canopy cover. Community 1.2 is characterized by midgrasses dominating the understory and woody species making up 20 to 50 perecent of the overstory canopy cover.

Community 1.1
Tallgrass Savannah

The Tallgrass Savannah Community (1.1) is the reference community and is characterized as a hardwood savannah with up to 20 percent tree and shrub canopy cover. Historic records in the 1700's do, however, indicate that early settlers and explorers found portions of this site to be heavily wooded. The Woodland Community (2.1) occurred as a stable community on portions of this ecological site. Other reports (Mann 2004) discuss the importance of human caused fire as an important factor in keeping open grasslands prior to European settlement. It is assumed the Tallgrass Savannah Community (1.1) occurred over the majority of this ecological site in a dynamically shifting mosaic over time with the other community in the Savannah State. Canopy cover drives the transitions between plant communities and states because of the influence of shade and interception of rainfall. Sedges, Virginia wildrye, and rustyseed paspalum (*Paspalum langei*) dominate the herbaceous plant community in shaded and wet areas. The herbaceous community in the drier, open areas is dominated by beaked panicum (*Panicum anceps*), switchgrass, Indiangrass, big bluestem, little bluestem, eastern gamagrass, vine mesquite (*Panicum obtusum*), and Florida paspalum. The balance of warm and cool season tallgrasses will be driven by the amount of canopy cover from large trees, particularly the amount and size of stands with closed canopy. When the site is open and tree cover is less than 10 percent, warm season tallgrasses will approach 30 percent species composition by weight, while the cool season grasses will approach 10 percent. As tree cover approaches the upper limit of the reference community (20 percent), cool season grasses and grasslikes will approach 30 percent and warm season tallgrasses will approach 10 percent species composition by weight. Oak, elm, hackberry, cottonwood (Populus deltoids), ash (Fraxinus spp.), black willow (*Salix nigra*), pecan (Carya illinoensis), and other large trees create 20 percent canopy cover. The overstory canopy is densest adjacent to watercourses. Woody understory species include hawthorn (Crataegus spp.), greenbriar (Smilax spp.), peppervine (Ampelopsis arborea), grape (Vitis spp.), trumpet creeper (Parthenocissus spp.) and honeysuckle (Symphoricarpos spp.). Continuous, year-long grazing for a succession of years will tend to move the reference herbaceous plant community towards a herbaceous community of common Bermudagrass, dallisgrass (*Paspalum dilatatum*), carpetgrass (Axonopus affinis), giant ragweed (*Ambrosia trifida*), and annual sumpweed (*Iva annua*). The reference Savannah community will shift to the Midgrass Savannah Community (1.2) under the stresses of improper grazing. The first species to decrease in dominance will be the most palatable and/or least grazing tolerant grasses and forbs (namely, eastern gamagrass, Indiangrass, big bluestem). This will initially result in an increase in composition of little bluestem and paspalums. If improper grazing continues, little bluestem will decrease and midgrasses such as bushy bluestem (*Andropogon glomeratus*) and Vaseygrass (*Paspalum urvillei*) will increase in composition. Less palatable forbs will also increase at this stage. Without fire and/or brush control, woody species on the site will increase and the site will transition to the Woodland State. This can occur with or without the understory transitioning to the midgrass community. This transition can occur without degradation of the herbaceous community from dominance by tallgrasses to dominance by midgrasses. Unless some form of brush control takes place, woody species will increase to the 50 percent canopy cover level that indicates a state change. This is a continual process that is always in effect. Managers need to detect the increase in woody species when canopy is less than 50 percent and take management action before the state change occurs. Continuous, year-long grazing with no weed or brush management, or abandoning the site for several years, will allow shrub saplings to establish. There is not a 10-year window before shrubs begin to increase followed by a rapid transition to the Woodland State. The drivers of the transition (lack of fire and lack of brush control) constantly pressure the system towards the Woodland State. The soils of this site are deep clays. The site receives additional water from outside the site as overflow or as runoff from adjacent sites. The soils have high shrink-swell characteristics. They crack when dry and the cracks take in water rapidly. Once wet, the cracks close and permeability becomes very slow. Soils are highly fertile and hold large amounts of soil moisture. However, the soils have a high wilting point, which reduces plant production in very dry years. In very wet years the site is subject to flooding, which reduces plant production and desirability of the site for grazing. This is a very productive site with high yields of palatable, high-quality forage. There is essentially no bare ground in this community. Plant basal cover and litter comprise all of the ground cover. Multiple layer canopy cover approaches 100 percent.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	3000	4500	5625
Shrub/Vine	800	1200	1500
Forb	200	300	375
Total	**4000**	**6000**	**7500**

Community 1.2
Midgrass Savannah

The Midgrass Savannah Community (1.2) typically results from improper cattle grazing management over a long period of time combined with a lack of brush control. It can also be the result of abandoned cropland. Indigenous or invading woody species increase on the site. Growing season stress, usually from overgrazing, causes reduction in vigor and survival of tallgrasses, which allows midgrasses and less palatable forbs to increase in the herbaceous community. When the Midgrass Savannah Community (1.2) is continually overgrazed and fire is excluded, the community crosses a threshold to a state that is dominated by woody plants, the Dense Woodland Community (2.1). Prescribed burning is not a viable option for maintaining or returning this community to a Savannah due to the moisture content and lack of quantity of the herbaceous fine fuel. Mechanical or chemical brush control as well as prescribed grazing must be applied to move this vegetative state back towards the Tallgrass Savannah Community. Remnants of Virginia wildrye and eastern gamagrass may still occur but the herbaceous component of the community becomes dominated by lesser producing grasses and forbs. Shade tolerant species such as broadleaf woodoats (*Chasmanthium latifolium*), longleaf woodoats (*Chasmanthium sessiliflorum*), Cherokee sedge (*Carex cherokeensis*), ironweed (*Vernonia baldwinii*), buttercup (Oenothera spp.), and goldenrod (Solidago spp.) are the most abundant species as canopy cover increases. Trees and shrubs begin to replace the grassland component of the Savannah Community. In addition to the naturally occurring woody species (cedar elm, water oak (*Quercus nigra*), hackberry, pecan, cottonwood, and green ash), honey locust, Chinese tallow (Sapium sebiferum), and eastern persimmon (*Diospyros virginiana*) increase in density and canopy coverage (30 to 50 percent). Species whose seeds are windblown (elm, cottonwood, and ash) or animal dispersed (persimmon, pecan, and Chinese tallow) are the first to colonize and dominate the site. Numerous shrub and tree species will encroach because overgrazing by livestock has reduced grass cover, exposed more soil, and reduced grass fuel for fire. Typically, trees such as oaks and ash will increase in size, while other tree and shrub species such as bumelia (Sideroxylon spp.), sumacs (Rhus spp.), honey locust, winged elm (*Ulmus alata*), and osage orange (*Maclura pomifera*) will increase in density. Once the tallgrasses have been reduced on the site, woody species cover exceeds 50 percent canopy cover, and the woody plants within the grassland portion of the Savannah reach fire-resistant size (over three feet in height), the site crosses a threshold into the Dense Woodland Community (2.1) in the Woodland State (2). Brown and Archer (1999) concluded that even with a healthy and dense stand of grasses, woody species will populate the site and eventually dominate the community. Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to erosion. Litter and mulch will move off-site as plant cover declines. Until the Midgrass Savannah Community (1.2) crosses the threshold into the Dense Woodland Community (2.1), this community can be managed back toward the Tallgrass Savannah Community (1.1) through the use of prescribed grazing and strategic brush control. It may take several years to achieve this state, depending upon the climate and the aggressiveness of the treatment. Once invasive woody species begin to establish, returning fully to the native community is difficult, but it is possible to return to a similar plant community. Potential exists for soils to erode to the point that irreversible damage may occur. If soil-holding herbaceous cover decreases to the point that soils are no longer stable, the shrub overstory will not prevent erosion of the A and B soil horizons. This is a critical shift in the ecology of the site. Once the A horizon has eroded, the hydrology, soil chemistry, soil microorganisms, and soil physics are altered to the point where intensive restoration is required to restore the site to another state or community. Simply changing management (improving grazing management or controlling brush) cannot create sufficient change to restore the site within a reasonable time frame.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1500	2400	3000
Shrub/Vine	750	1200	1500
Forb	250	400	500
Total	**2500**	**4000**	**5000**

Pathway 1.1A
Community 1.1 to 1.2

Tallgrass Savannah

Midgrass Savannah

The Tallgrass Savannah Community requires fire and/or brush control to maintain woody species cover below 20 percent. This community will shift to the Midgrass Savannah Community when there is continued growing-season stress on tallgrasses. These stresses include improper grazing management that creates insufficient critical growing-season deferment, excess intensity of defoliation, repeated, long-term growing-season defoliation, and long-term drought. Increaser species (midgrasses and woody species) are generally endemic species released by disturbance. Woody species canopy exceeding 20 percent and/or dominance of tallgrasses falling below 50 percent of species composition indicate a transition to the Midgrass Savannah Community. The Tallgrass Savannah Community can be maintained through the implementation of brush management combined with properly managed grazing that provides adequate growing-season deferment to allow establishment of tallgrass propagules and/or the recovery of stressed plants. Regardless of grazing management, without some form of brush control, the Tallgrass Savannah Community will transition to the Woodland State even if the understory component does not shift to dominance by midgrasses. The driver for community shift 1.1A for the herbaceous component is improper grazing management, while the driver for the woody component is lack of fire and/or brush control.

Pathway 1.2A
Community 1.2 to 1.1

Midgrass Savannah

Tallgrass Savannah

The Midgrass Savannah Community will return to the Tallgrass Savannah Community with brush control and proper grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. The understory component may return to dominance by tallgrasses in the absence of fire (at least until shrub canopy cover reaches 50 percent). Reduction of the woody component will require inputs of fire and/or brush control. The understory and overstory components can act independently when canopy cover is less than 50 percent, meaning, an increase in shrub canopy cover can occur while proper grazing management creates an increase in desirable herbaceous species. The driver for community shift 1.2A for the herbaceous component is proper grazing management, while the driver for the woody component is fire and/or brush control.

State 2
Woodland

Only one community is in the Woodland State, the 2.1 Dense Woodland Community. Community 2.1 is characterized by cool-season grasses and shade-tolerate dominating in the understory. Woody species occupy greater than 50 percent of the overstory.

Community 2.1
Dense Woodland.

The Dense Woodland Community (2.1) has over 50 percent woody plant canopy, dominated by hardwoods such as pecan and oaks. The community loses its savannah appearance with native shrubs beginning to fill the open grassland portion of the savannah. Shade from overstory is the driving factor. Lack of effective brush control creates this community. Annual herbage production decreases due to a decline in soil structure and organic matter. Production of the overstory canopy has increased by a similar amount to the decrease in herbaceous production. All unpalatable woody species have increased in size and density. This plant community is a closed overstory (50 to 80 percent) woodland dominated by green ash, cedar elm, overcup oak (*Quercus lyrata*), water oak, willow oak (*Quercus phellos*), pecan, cottonwood, sycamore (Plantanus occidentalis), and black willow. Understory shrubs and sub-shrubs include yaupon (*Ilex vomitoria*), farkleberry (*Vaccinium arboreum*), possumhaw (*Ilex decidua*), American beautyberry (*Callicarpa americana*), and hawthorn. Woody vines also occur and include rattan (*Berchemia scandens*), poison ivy (*Toxicodendron radicans*), grape, greenbrier, trumpet creeper, Virginia creeper (*Parthenocissus quinquefolia*), and peppervine. A herbaceous understory is almost nonexistent but shade tolerant species including longleaf uniola, broadleaf woodoats, sedges, ironweed, ice plant (*Verbesina lindheimeri*), switchcane (*Arundinaria gigantea*n), eastern gamagrass, and goldenrod may occur in small amounts. Plant vigor and productivity of grass species is reduced due to shade. Shade is a driving factor for the understory plant community. Without brush control, tree canopy will continue to increase until canopy cover approaches 100 percent. Prescribed fire is not a viable treatment option for conversion of this site back to a semblance of the wildrye-sedge Savannah. Chemical brush control on a large scale is not a treatment option; however, individual plant treatment with herbicides on small acreages may be a viable option. Mechanical treatment of this site, along with seeding, is the most viable treatment option although it is probably not economical.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	2000	3700	5000
Grass/Grasslike	250	400	500
Forb	250	400	500
Total	**2500**	**4500**	**6000**

State 3
Converted Land

Two communities exist in the Converted State: 3.1 Converted Land Community and the 3.2 Abandoned Land Community. The 3.1 Community is characterized by agricultural production. The site may be planted to improved pasture for hay or grazing. The site may otherwise be planted to row crops. The 3.2 community represents an agricultural state that has not been managed. The land is colonized by first successional species.

Community 3.1
Converted Land

The Converted Land Community (3.1) occurs when the site, either the Savannah State (1) or Woodland State (2), is cleared and plowed for planting to cropland, hayland, native grasses, tame pasture, or use as non-agricultural land. The Converted State includes cropland, tame pasture, hayland, rangeland, and go-back land. Agronomic practices are used with non-native forages in the Converted State and to make changes between the communities in the Converted State. The native component of the prairie is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed. The Clayey Bottomland site is frequently converted to cropland or tame pasture sites because of its deep fertile soils, favorable soil/water/plant relationship, and level terrain. Hundreds of thousands of acres have been plowed up and converted to cropland, pastureland, or hayland. Small grains are the principal crop, and Bermudagrass is the primary introduced pasture species. The Clayey Bottomland site can be an extremely productive forage producing site with the application of optimum amounts of fertilizer. Cropland, pastureland, and hayland are intensively managed with annual cultivation and/or frequent use of herbicides, pesticides, and commercial fertilizers to increase production. Both crop and pasturelands require weed and shrub control because seeds remain present on the site, either by remaining in the soil or being transported to the site. Converted sites require continual fertilization for crops or tame pasture (particularly Bermudagrass) to perform well. Common introduced species include coastal Bermudagrass, kleingrass, and Old World bluestems (Bothriochloa spp.) which are used in hayland and tame pastures. Wheat, oats, forage sorghum, grain sorghum, cotton, and corn are the major crop species. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. Without agronomic inputs, the site will eventually return to either the Savannah or Woodland state. The site is considered go-back land during the period between active management for pasture or cropland and the return to a native state.

Community 3.2
Abandoned Land

The Abandoned Land Community (3.2) occurs when the Converted Land Community (3.1) abandoned or mismanaged. Mismanagement can include poor crop or haying management. Pastureland can transition to the Abandoned Land Community when subjected to improper grazing management (typically long-term overgrazing). Heavily disturbed soils allowed to “go-back” return to the Woodland State. These sites may become an eastern red cedar break over time. Long-term cropping can create changes in soil chemistry and structure that make restoration to the reference state very difficult and/or expensive. Return to native prairie communities in the Savannah State is more likely to be successful if soil chemistry, microorganisms, and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference (or near reference) conditions. Restoration to native prairie will require seedbed preparation and seeding of native species. Protocols and plant materials for restoring prairie communities is a developing portion of restoration science. Sites can be restored to the Savannah State in the short-term by seeding mixtures of commercially-available native grasses. With proper management (prescribed grazing, weed control, brush control) these sites can come close to the diversity and complexity of Tallgrass Savannah Community (1.1). It is unlikely that abandoned farmland will return to the Savannah State without active brush management because the rate of shrub increase will exceed the rate of recovery by desirable grass species. Without active restoration the site is not likely to return to reference conditions due to the introduction of introduced forbs and grasses. The native component of the prairie is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed.

Pathway 3.1A
Community 3.1 to 3.2

The Converted Land Community (3.1) will transition to the Abandoned Land Community (3.2) if improperly managed as cropland, hayland, or pastureland. Each of these types of converted land is unstable and requires constant management input for maintenance or improvement. This community requires inputs of tillage, weed management, brush control, fertilizer, and reseeding of annual crops. The driver of this transition is the lack of management inputs necessary to maintain cropland, hayland, or pastureland.

Pathway 3.2A
Community 3.2 to 3.1

The Abandoned Land Community (3.2) will transition to the Converted Land Community (3.1) with proper management inputs. The drivers for this transition are weed control, brush control, tillage, proper grazing management, and range or pasture planting.

Transition T1A
State 1 to 2

Shrubs and trees make up a portion of the plant community in the Savannah State, hence woody propagules are present. Therefore, the Savannah State is always at risk for shrub dominance and the transition to the Woodland State in the absence of fire. The driver for Transition T1A is lack of fire and/or brush control. The mean fire return interval in the Savannah State is two to five years. Most fires will burn only the understory. Even with proper grazing and favorable climate conditions, lack of fire for 8 to 15 years will allow trees and shrubs to increase in canopy to reach the 50 percent threshold level. The introduction of aggressive woody invader species increases the risk and accelerates the rate at which this transition state is likely to occur. This transition can occur from any community within the Savannah State, it is not dependent on degradation of the herbaceous community, but on the lack of some form of brush control. Improper grazing, prolonged drought, and a warming climate will provide a competitive advantage to shrubs which will accelerate this process. Tallgrasses will decrease to less than five percent species composition.

Transition T1B
State 1 to 3

The transition to the Converted State from either the Savannah State is plowed for planting to cropland or hayland. The size and density of brush will require heavy equipment and energy-intensive practices (i.e. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration of the Woodland State to the Savannah State requires substantial energy input. Mechanical or herbicidal brush control treatments can be used to remove woody species. A long-term prescribed fire program is unlikely to sufficiently reduce brush density to a level below the threshold of the Savannah State if not accompanied by some form of mechanical or chemical brush control. Brush control in combination with prescribed fire, proper grazing, and favorable growing conditions may be the most economical means of creating and maintaining the desired plant community. If remnant populations of tallgrasses, midgrasses, and desirable forbs are not present at sufficient levels, range planting will be necessary to restore the reference plant community. The driver for Restoration Pathway R2A is fire and/or brush control combined with natural restoration of the herbaceous community or active management of the herbaceous restoration process (range seeding). Restoration may require aggressive treatment of invader species.

Transition T2A
State 2 to 3

The transition to the Converted State from the Woodland State (T2A) occurs when the Savannah is plowed for planting to cropland or hayland. The size and density of brush in the Woodland State will require heavy equipment and energy-intensive practices (i.e. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration from the Converted State can occur in the short-term through active restoration or over the long-term due to cessation of agronomic practices. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. If the soil chemistry and structure have not been overly disturbed (which is most likely to occur with tame pasture) the site can be restored to the Savannah State. Heavily disturbed soils are more likely to return to the Woodland State. Without continued disturbance from agriculture the site can eventually return to either the Savannah or Woodland state. The level of disturbance while in the converted state determines whether the site restoration pathway is likely to be R3A (a return to the Savannah State) or R3B (a return to the Woodland State). Return to native communities in the Savannah State is more likely to be successful if soil chemistry and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference (or near reference) conditions. Converted sites can be returned to the Savannah State through active restoration, including seedbed preparation and seeding of native grass and forb species. Protocols and plant materials for restoring prairie communities is a developing part of restoration science. The driver for both of these restoration pathways is the cessation of agricultural disturbances.

Transition T3A
State 3 to 2

Transition to the Woodland State (2) occurs with the cessation of agronomic practices. The site will move from the Abandoned Land Community when woody species begin to invade. After shrubs and trees have established over 50 percent, and reached a height greater than three feet, the threshold has been crossed. The driver for the change is lack of agronomic inputs, improper grazing, no brush management, and no fire.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			1200–2250	
	Virginia wildrye	ELVI3	*Elymus virginicus*	1000–1875	–
	sedge	CAREX	*Carex*	1000–1875	–
	Canada wildrye	ELCA4	*Elymus canadensis*	800–1500	–
	beaked panicgrass	PAAN	*Panicum anceps*	500–900	–
2	**Tallgrasses**			400–750	

2	**Tallgrasses**			400–750	
	big bluestem	ANGE	*Andropogon gerardii*	400–750	–
	Florida paspalum	PAFL4	*Paspalum floridanum*	400–750	–
	switchgrass	PAVI2	*Panicum virgatum*	400–750	–
	little bluestem	SCSCS	*Schizachyrium scoparium var. scoparium*	400–750	–
	Indiangrass	SONU2	*Sorghastrum nutans*	400–750	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	400–750	–
3	**Tall/midgrasses**			500–950	
	rustyseed paspalum	PALA11	*Paspalum langei*	500–950	–
	white tridens	TRAL2	*Tridens albescens*	500–950	–
	longspike tridens	TRST2	*Tridens strictus*	500–950	–
4	**Other grasses**			800–1500	
	panicgrass	PANIC	*Panicum*	600–1125	–
	vine mesquite	PAOB	*Panicum obtusum*	600–1125	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	600–1125	–
	gaping grass	STHI3	*Steinchisma hians*	600–1125	–
	purpletop tridens	TRFL2	*Tridens flavus*	600–1125	–
	Indian woodoats	CHLA5	*Chasmanthium latifolium*	200–375	–
	longleaf woodoats	CHSE2	*Chasmanthium sessiliflorum*	200–375	–
	cylinder jointtail grass	COCY	*Coelorachis cylindrica*	200–375	–
	nimblewill	MUSC	*Muhlenbergia schreberi*	200–375	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	200–375	–
Forb					
5	**Forbs**			200–375	
	partridge pea	CHFA2	*Chamaecrista fasciculata*	200–375	–
	ticktrefoil	DESMO	*Desmodium*	200–375	–
	lespedeza	LESPE	*Lespedeza*	200–375	–
	dotted blazing star	LIPU	*Liatris punctata*	200–375	–
	snoutbean	RHYNC2	*Rhynchosia*	200–375	–
	ironweed	VERNO	*Vernonia*	100–200	–
	white crownbeard	VEVI3	*Verbesina virginica*	100–200	–
	Texan great ragweed	AMTRT	*Ambrosia trifida var. texana*	100–200	–
Shrub/Vine					
6	**Shrubs/Vines/Trees**			800–1500	
	eastern cottonwood	PODE3	*Populus deltoides*	600–1125	–
	oak	QUERC	*Quercus*	600–1125	–
	black willow	SANI	*Salix nigra*	600–1125	–
	ash	FRAXI	*Fraxinus*	600–1125	–
	elm	ULMUS	*Ulmus*	600–1125	–
	hackberry	CELTI	*Celtis*	600–1125	–
	hawthorn	CRATA	*Crataegus*	200–375	–
	peppervine	AMPEL3	*Ampelopsis*	200–375	–

	Alabama supplejack	BESC	*Berchemia scandens*	200–375	–
	grape	VITIS	*Vitis*	200–375	–
	honeysuckle	LONIC	*Lonicera*	200–375	–
	saw greenbrier	SMBO2	*Smilax bona-nox*	200–375	–
	pecan	CAIL2	*Carya illinoinensis*	100–200	–

Animal community

This ecological site provides habitat which supports a resident animal community that is inhabited by white-tailed deer, turkey, and squirrels. Migratory waterfowl may use these sites if they are flooded during the late fall and winter. The riparian vegetation provides good cover for wildlife and produces browse, mast, tender grazing, and seeds for a year-round supply.

Hydrological functions

The water cycle on the Clayey Bottomland site functions best under the Tallgrass Savannah Community. When tallgrasses dominate the site infiltration is rapid, soil organic matter is high, soil structure is good, and porosity is high. The site will have high quality surface runoff with low erosion and sedimentation rates. During periods of heavy rainfall, the high infiltration rates will allow water to transport into the aquifer. The Tallgrass Savannah Community should have no rills and no gullies present. Drainageways should be vegetated and stable. This site is often in a floodplain with occasional out-of-bank flow.

Improper grazing management reduces composition of bunchgrasses and reduces ground cover (resulting in a transition to the Midgrass Savannah Community, 1.2). This decreases the quality of the water cycle: Infiltration declines and runoff increases due to poor ground cover, rainfall splash, soil capping, low organic matter and poor structure. Combining sparse ground cover with intensive rainfall creates conditions that increase the frequency and severity of flooding. The decline in the quality of the understory component and the increase in shrub canopy cover cause soil erosion to accelerate, surface runoff quality to decline, and sedimentation to increase. Streambank stability will decline and erosion of waterways will increase.

In the Woodland State interception of rainfall by tree canopies increases. This reduces the amount of rainfall reaching the surface. Stemflow increases due to the funneling effect of the canopy, which increases soil moisture at tree bases. Trees have increased transpiration compared to grasses, especially evergreen species such as live oak and juniper. The increased transpiration reduces the amount of water available for deep percolation into aquifers. An increase in woody canopy creates a decline in grass cover, which has similar impacts as those described for improper grazing above. The return of the Woodland State to the Tallgrass Savannah Community through brush management and good grazing management can help improve the hydrologic function of the site. Under the dense canopy of a mature woodland, leaf litter builds up. This increases soil organic matter, builds structure, improves infiltration, and reduces surface erosion. These conditions improve the function of the water cycle compared to lower levels of canopy cover.

Site specific information showed that the reference community has no rills or gullies. Water flow patterns are common and follow old stream meanders. Deposition and erosion is uncommon for normal rainfall but may occur during intense rainfall events. Pedestals and terracettes are not common in the reference community. There is generally less than 20 percent bare ground which is randomly distributed throughout the site. The soil surface is resistant to erosion and the soil stability class range is expected to be 5 to 6. Under reference conditions, this Savannah site is dominated by tallgrasses and forbs, having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events.

When rainfall amounts are high (three to five inches per event) and intense, the site is subject to erosion along adjacent stream banks where adequate herbaceous cover is not maintained. Erosion may also occur on heavy use areas such as roads and livestock trails. Extended periods (60 days) of little to no rainfall during the growing season are common. The site may be periodically inundated from overflow water from adjacent watercourses and may be ponded or saturated for long periods. This site may be a wetland or contain wetland inclusions as oxbows or stream meanders.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Hardwoods are used for posts, firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as wild grape. Seeds are harvested from many reference plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants. Fruit from blackberries, grapes, and plums and nuts from pecans are harvested.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

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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.

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Date	01/17/2008
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:** Water flow patterns are common and follow old stream meanders. Deposition or erosion is uncommon for normal rainfall but may occur during intense rainfall events.

3. **Number and height of erosional pedestals or terracettes:** Pedestals or terracettes are uncommon for this site.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Essentially none. Site has litter filling interspaces between plant bases.

5. **Number of gullies and erosion associated with gullies:** Some gullies may be present on side drains into perennial and intermittent streams. Drainageways should be vegetated and stable.

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

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7. **Amount of litter movement (describe size and distance expected to travel):** This is a floodplain with an occasional out-of-bank flow. Under normal rainfall, little litter movement should be expected.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Stability class range is expected to be 5 to 6.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil is 0 t 53 inches thick with colors from dark reddish brown clay to very dark gray clay with generally weak very fine subangular blocky structure. SOM is approximately 1 to 6 percent. See soil survey for specific soils.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** This bottomland site is dominated by tallgrasses and forbs. Having adequate litter and little bare ground can provide for maximum infiltration and little runoff under normal rainfall events.

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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: Cool-season grasses >

    Sub-dominant: Warm-season tallgrasses >> Warm-season midgrasses > Warm-season shortgrasses > Trees >

    Other: Forbs > Shrubs/Vines

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups in reference community.

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14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 4,000 pounds per acre for below average moisture years to 7,500 pounds per acre for above average moisture years.

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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:** Potential invasives include yellow bluestems, Bermudagrass, mesquite, elm, huisache, eastern red cedar, osage orange, and Chinese tallow.

17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing, except during periods of prolonged drought conditions, heavy natural herbivory, prolonged flooding, and intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R081CY358TX Deep Redland 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/12/2022

General information

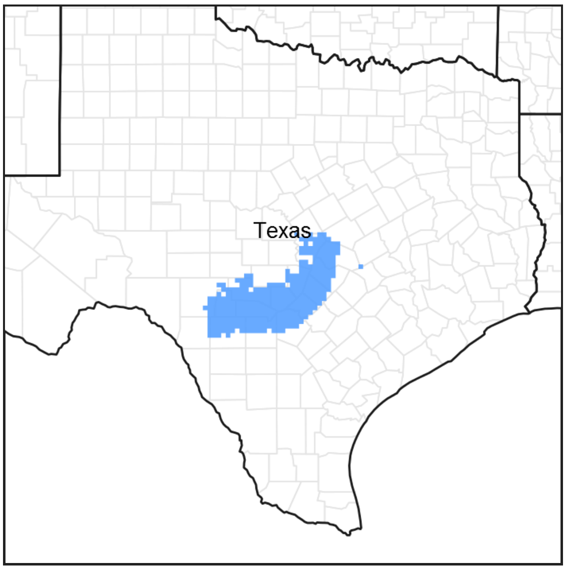

Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. Elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

The Deep Redlands have non-calcareous soils over limestone with a depth greater than 2- inches. Surface fragments 3 inches in size are less than 20 percent. The reference vegetation includes an oak savannah dominated by tallgrasses and post oaks, along with numerous forbs and other oak species. Without fire or brush management, junipers and other woody species will likely increase on the site.

Associated sites

R081CY360TX	**Low Stony Hill 29-35 PZ** The Low Stony Hill ecological site is generally higher in the landscape and is the plateau above the Deep Redland ecological site with no post oak or blackjack oak.
R081CY355TX	**Adobe 29-35 PZ** The Adobe ecological site has sparser woody cover, much less production, more slope, and more caliche-type soils of a higher pH with no post oak or blackjack oak.

Similar sites

R081CY361TX	**Redland 29-35 PZ** The Redland ecological site has shallower soils.
R081CY357TX	**Clay Loam 29-35 PZ** The Clay Loam ecological site does not have post oak or blackjack oak. The soils are darker and higher in pH.

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus fusiformis*
Shrub	(1) *Quercus marilandica*
Herbaceous	(1) *Schizachyrium scoparium*

Physiographic features

This site is classified as an upland. Slope gradients are mainly less than 2 percent and range from 0 to 3 percent. It is presumed that this site was formed in residuum from weathered limestone. Elevation of this site ranges from 1200 to 2200 feet above mean sea level. This site will receive runoff from Adobe, Steep Adobe and Low Stony Hills ecological sites that normally occur along the site's boundary.

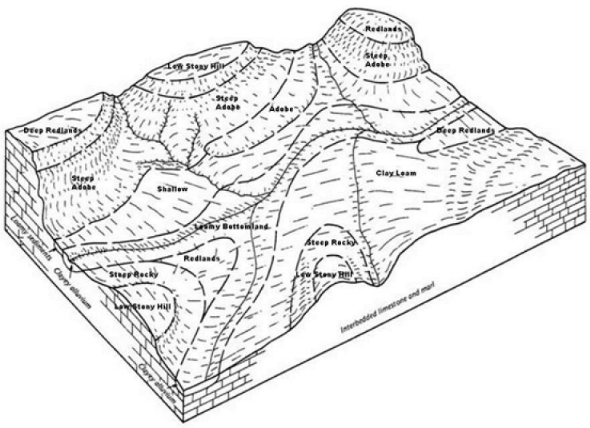

Figure 2. Deep Redland 081CY358TX

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Plateau
Flooding frequency	None
Ponding frequency	None
Elevation	1,200–2,200 ft
Slope	0–3%
Water table depth	60 in

Aspect	Aspect is not a significant factor

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below “normal” at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This being an upland site, it is not influenced by water from a wetland or stream.

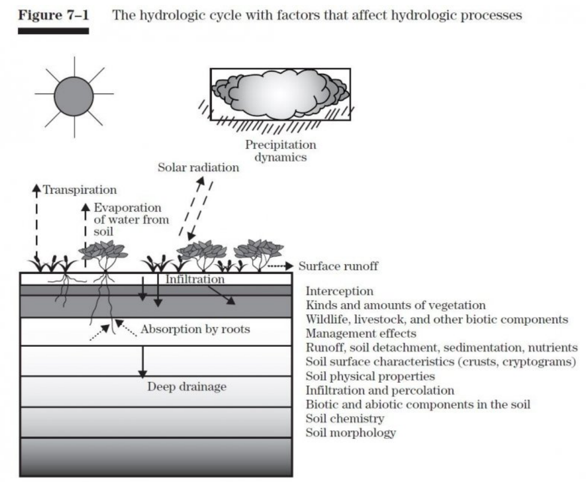

Figure 9.

Soil features

In a representative profile for the Deep Redland ecological site, the soils are reddish brown, moderately deep, non-calcareous clays, clay loams or loams. They are underlain by slightly fractured indurated limestone bedrock at depths of 20 to 40 inches. Plant roots penetrate the crevices, which are usually filled with reddish brown clay. Limestone fragments, cherts, cobbles and stones sometimes occur on the surface and may make up as much as 15 percent of the soil by volume. When dry, the soils crack and take in water rapidly. When wet, the cracks close, and the soils become sticky and plastic and take in water very slowly. Light showers are ineffective on the site, which favors the growth of deep-rooted perennial plants. When plant residues are inadequate, soil condition deteriorates and heavy surface crusts develop. In this condition water intake is very slow, runoff is rapid, erosion is a hazard, and grass recovery is slow. The mineral content and reaction of these soils enable the site to produce highly nutritious forage. In association with other sites, Deep Redland is usually the preferred grazing area. These sites occur on more stable hillslopes on dissected plateaus.

Due to the scale of mapping, there are inclusions of minor components of other soils within these mapping units. Before performing any inventories, conduct a field evaluation to insure the soils are correct for the site.

The representative soils associated with the Deep Redland ecological site are Anhalt, Crawford, and Spires. These are the representative map units associated with the Deep Redland ecological site:

Anhalt clay, 0 to 2 percent slopes
Crawford and Bexar stony soils
Spires association, gently undulating

Table 4. Representative soil features

Parent material	(1) Residuum–limestone
Surface texture	(1) Clay loam (2) Clay (3) Loam
Drainage class	Well drained
Permeability class	Very slow
Soil depth	20–40 in
Surface fragment cover <=3"	0–5%
Surface fragment cover >3"	0–2%
Available water capacity (0-40in)	2.2–6 in
Calcium carbonate equivalent (0-40in)	0–15%

Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	5–7.9
Subsurface fragment volume <=3" (Depth not specified)	0–15%
Subsurface fragment volume >3" (Depth not specified)	0–5%

Ecological dynamics

The information contained in the State and Transition Diagram (STD) and the Ecological Site Description was developed using archeological and historical data, professional experience, and scientific studies. The information presented is representative of a very complex set of plant communities. Not all scenarios or plants are included. Key indicator plants, animals and ecological processes are described to inform land management decisions.

The reference plant community, which was a post oak (*Quercus stellata*), Texas live oak (*Quercus fusiformis*), blackjack oak (*Quercus marilandica*), savannah, included little bluestem, (*Schizachyrium scoparium*) big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and eastern gamagrass (*Tripsacum dactyloides*). This is a very fertile and productive site. Because of the soil chemistry of this site with its neutral to sometimes slightly acidic pH, it is usually a preferred grazing site.

Natural plant mortality is very low with the major species producing seeds and vegetative structure each year in normal years. Litter cover is 100 percent. Physical soil crust is largely absent.

A study of early photographs of this region reveals that today these sites are much denser with woody cover and less covered with grasslike vegetation. Early accounts consistently describe this region as a vast expanse of hills covered with "cedar" from San Antonio to Austin. Accounts also describe an abundance of clean, flowing water and abundant wildlife. These accounts seem to describe heavy wooded areas in mosaic patterns occurring along the highs and lows of the landscape.

The plant communities of this site are dynamic and vary in relation to grazing, fire and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006). Historical records are not specific on the Deep Redland site but do reflect area observations. From the Teran expedition in 1691, “great quantities of buffaloes” were noted in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). Another example is an early settler, Arnold Gugger, who wrote in his journal about the mid to late 1800s in the Helotes, Texas area, “in those days buffaloes were in droves by the hundreds…..and antelopes were three to four hundred in a bunch….and deer and turkeys at any amount” (Massey, 2009). A study of early photographs of this region reveals that today, these sites are much denser with woody cover and less covered with grasslike vegetation.

Many research studies document the interaction of bison grazing and fire (Fuhlendorf, et al, 2008.). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This usually long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape both in structure and composition.

Historical fire frequencies for the region are suggested to be 13 to 25 years (Frost, 1998). When fires did occur, they were set either by Native Americans or by lighting. Woody plant control would vary in accordance with the intensity and severity of the fire encountered, which resulted in a mosaic of vegetation types within the same site.

Ashe juniper (*Juniperus ashei*) will increase regardless of grazing. Juniper will establish with grazing and without unless goats are utilized. Goats and possibly sheep will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997; Anderson, et al., 2013). The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn.

Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become non-existent under dense juniper canopies. Many times there is a resurgence of the better grasses such as little bluestem when Ashe juniper is controlled and followed by proper grazing management. Seeds and dormant rootstocks of many plant species are contained in the leaf mulch and duff under the junipers.

Currently, goats, white-tailed deer, sheep, and exotic animals are the primary large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which allowed population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Because of their impacts on livestock production, large predators such as red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus) and eventually coyotes (Canis latrins) were reduced in numbers or eliminated (Schmidly, 2002).

The screwworm (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker, 1965; Bushland, 1985).

Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition, and monitoring of habitat quality has been effective on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of exotic ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium and small-sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity.

The plants and topography aided in increasing the infiltration of rainfall into the moderately slowly permeable soil. Any loss of soil organic matter and plant cover has a negative effect on infiltration. More rainfall is directed to overland flow, which causes increased soil erosion and flooding. Soils are also more prone to drought stress since organic matter acts like a sponge aiding in moisture retention for plant growth. Mulch buildup under the Ashe juniper canopy, following brush management and incorporation into the soil, can have a positive effect on increasing infiltration.

This site contains a large diversity of plants and this document does not attempt to cover them all. The intent of this document is to describe ecological processes on representative plants.

European settlement occurred in the mid to late 1800s (Raunick, 2007). This time period also coincided with a stoppage of fire. It was during this time that large-scale fencing was initiated to help the introduction of livestock. Predators were also reduced to protect livestock. In many cases sheep and goats heavily utilized the site. Low successional, unpalatable grasses, forbs and shrubs have taken the place of the more desirable plant species. Non-preferred browse, such as juniper, fared well at the expense of the palatable browse. Juniper is undoubtedly the dominant woody plant over most of the site today.

During the early 1900s, land managers recognized the soil's ability to produce annual field crops for added food, forage, and hay. Many of the Deep Redland Sites were put to the plow removing all of the historic species. As land managers decisions changed in the 1970""s, many of the fields were reintroduced with non-native grasses such as bermudagrass (*Cynodon dactylon*), yellow bluestems (Bothriochloa spp.), and kleingrass (*Panicum coloratum*). These practices are still used today.

Plant Communities and Transitional Pathways (diagram):

A State and Transition Model for the Deep Redland Ecological Site (R081CY358TX) is depicted in this report. Descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases.

Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal but can be. Other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are described as are other metrics. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover can drive the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating the similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

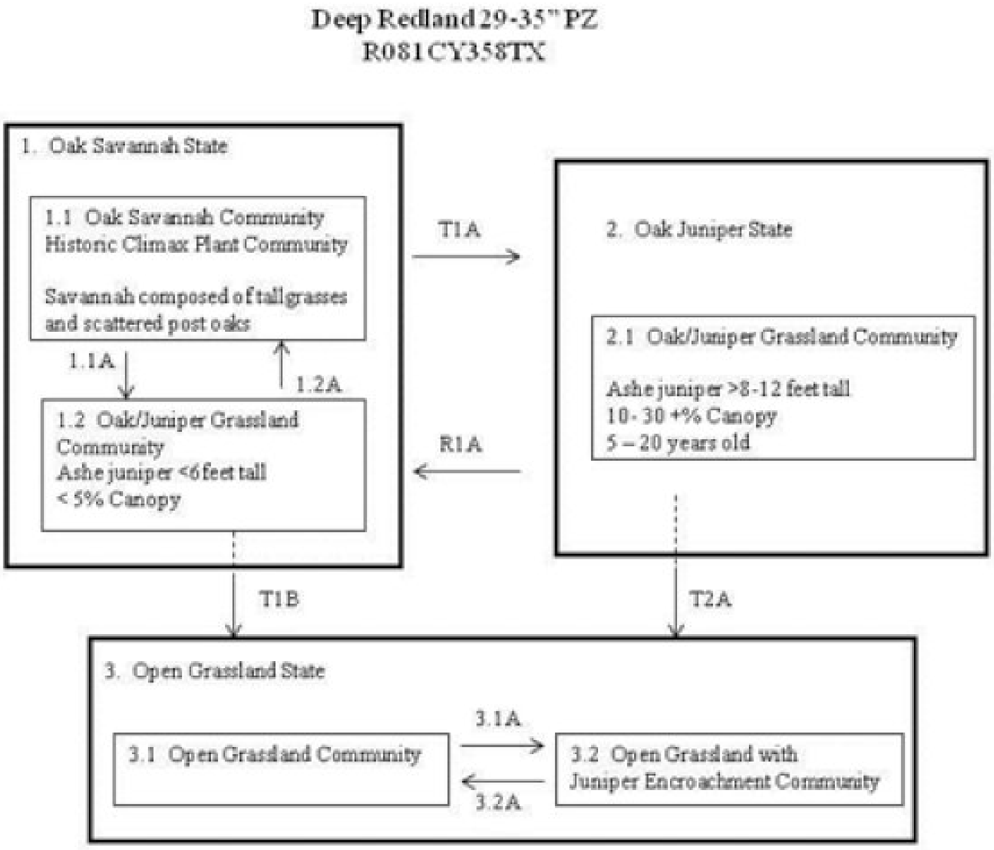

Figure 10. Deep Redland Transition Diagram

State 1
Oak Savannah State

Savannah composed of tallgrasses and scattered post oaks.

Community 1.1
Oak Savannah Community

Figure 11. Excellent example of the reference plant community

Figure 12. Oak Savannah community with tall grasses following a hard drought.

The Oak Savannah Community (1.1) is the interpretive plant community for this. The historic plant community is a fire/grazing climax savannah composed of tall grasses. The overstory shades 10 to 20 percent of the site and consists primarily of post oak, but may include Bigelow oak (*Quercus buckleyi*), Texas red oak (*Quercus texana*), Texas live oak (*Quercus fusiformis*), blackjack oak (*Quercus marilandica*), and several associated species. The pos oak and blackjack oak are signature key indicators of the Deep Redland site. Occasionally however there may only be Texas live oak. The role of fire and grazing was to keep sunlight energy flowing through the deep-rooted trees and grasses, accelerate the mineral and nutrient cycle and to capture the optimum amount of rainfall. The removal or alteration of these ecological disturbances can trigger the plant community to change. The total removal of grazing animals may, in fact, accelerate this change. Juniper is added to the site via droppings from perching birds and small mammals that eat the seeds. Ashe juniper, which is a non-sprouting woody plant easily controlled by fire, and other woody species will increase without fire or some form of brush management. Once Ashe juniper encroachment can be easily controlled with prescribed fire until the plants reach exceeds about 6 feet in height, fire options become limited. Without intervention, the Ashe juniper will continue to increase and move towards the Oak/Juniper Grassland plant community. This may occur in as little as five years.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1950	2975	3575
Tree	600	860	1100
Forb	300	430	550
Shrub/Vine	150	275	430
Total	**3000**	**4540**	**5655**

Table 6. Ground cover

Tree foliar cover	2-3%
Shrub/vine/liana foliar cover	1-2%
Grass/grasslike foliar cover	15-20%
Forb foliar cover	0-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%

Water	0%
Bare ground	0-10%

Table 7. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	5-15 per acre
Tree snag count** (hard***)	

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 8. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-3%	0-1%
>0.5 <= 1	–	1-3%	3-5%	1-3%
>1 <= 2	–	5-8%	10-15%	3-10%
>2 <= 4.5	–	5-10%	50-60%	–
>4.5 <= 13	–	–	–	–
>13 <= 40	5-20%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 14. Plant community growth curve (percent production by month). TX3760, Warm Season Native Grasses. Native warm season grasses on rangeland with scattered oaks/junipers..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Community 1.2
Oak/Juniper Grassland Community


Figure 15. Young juniper establishing underneath the oak trees.

This community still exhibits an oak savannah community, however, because of the elimination of fire and/or brush management, woody species begin to invade or increase on the site. This site had a natural variation that probably included some juniper. However, historic fires precluded it from achieving anything other than an occasional tree. The dominant grass species for this plant community are little bluestem, Indiangrass, and sideoats grama (*Bouteloua curtipendula*). The major species to invade this site is Ashe juniper. Juniper in this plant community is still about 6 feet tall and there are sufficient grasses to provide fine fuel loading for a prescribed burn. By implementing vegetative management such as prescribed burning and prescribed grazing, the land manager can shift the plant community towards the Oak Savannah with minimum labor and expense. The sun's energy being captured by the juniper can then be redirected back to the original plants. Mineral cycling, nutrient cycling and the water cycle are restored as well. A burn or some type of brush management will be needed on a 5- to 10-year return depending upon the size of the juniper. Juniper will increase on this site regardless of grazing. The best option for using animals to control cedar is the prudent and timely grazing/browsing with goats and/or possibly sheep (Taylor, 1997; Anderson, et al., 2013). If the proper vegetation management decisions are not performed, the site will transition to the Oak/Juniper Grassland State (2) in 10 to 15 years and a significant, high energy intervention will be needed for restoration.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1650	2365	2750
Tree	750	1075	1250
Forb	300	430	500
Shrub/Vine	300	430	500
Total	**3000**	**4300**	**5000**

Figure 17. Plant community growth curve (percent production by month). TX3760, Warm Season Native Grasses. Native warm season grasses on rangeland with scattered oaks/junipers..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Pathway 1.1A
Community 1.1 to 1.2

Oak Savannah Community

Oak/Juniper Grassland Community

A shift in the composition of the plant community is primarily driven by the lack of managing woody plants, juniper in particular. Juniper and other woody species are introduced from the site primarily through wildlife fecal deposits. Grazing that removes fuel loading for fire is a contributing factor. However juniper can increase regardless of grazing pressure unless possibly sheep and goats are utilized.

Pathway 1.2A
Community 1.2 to 1.1

Oak/Juniper Grassland Community

Oak Savannah Community

This recovery pathway consist of some method of brush management such as fire, mechanical or hand cutting or targeted grazing with goats and/or possibly sheep. Prescribed grazing is essential.

State 2
Oak/Juniper State

Ashe juniper >8-12 feet tall 10-30+% Canopy 5-20 years old

Community 2.1
Oak/Juniper Grassland Community

Figure 18. The Oak/Juniper Grassland (2.1) community after a burn.

Figure 19. The Oak/Juniper Grassland Community (2.1) with mature juniper.

This community has crossed a threshold from the Oak Savannah State (1). The major woody species to invade is Ashe juniper. Other woody species to commonly invade/increase this site are honey mesquite (*Prosopis glandulosa*), Texas persimmon (*Diospyros texana*), algerita Mahonia trifoliata), elbowbush (*Forestiera pubescens*), lotebush (*Ziziphus obtusifolia*), Bigelow oak (*Quercus sinuata*), and prickly pear (Opuntia spp.). This site will exhibit Ashe juniper 8 to 12 feet tall with 10 to 30 percent canopies. Foliar cover ranges from 5 to 30 percent. The juniper plants are between 5 and 20 years old. Grasslike vegetation is significantly reduced because of the competition that Ashe juniper and other brush species present regarding sunlight, nutrients and moisture. The dominant grass-like species for this plant community are meadow dropseed (*Sporobolus compositus*), silver bluestem (*Bothriochloa saccharoides*), a small amount of sideoats grama, little bluestem, and an occasional Indiangrass. Cool season plant such as Texas wintergrass (*Nassella leucotricha*) and cedar sedge (*Carex planostachys*) occur in the understory. The recovery from an Oak/Juniper Grassland Community (2.1) back to the reference community is still possible but it will involve a considerable investment of time and expense. Implementation of brush management programs involving heavy equipment and/or hand labor makes much higher treatment cost probable. In this state much more sunlight energy is captured in juniper and woody component of the community. There is entrapment of rainfall in the foliage of the juniper which never reaches and enters the soil profile. As much as 20 percent of the annual rainfall is entrapped (Thurow, 1994). The juniper will only get larger and taller unless intervention is done to prevent it. It is likely that any fires that could burn here under this condition would be wildfires that would also damage the oak community. If left alone for about 20 years, the juniper will attain heights of over 20 feet and crown canopies exceeding 30 percent. At this point the juniper is a threat to the oaks.

Table 10. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1500	2150	2500
Grass/Grasslike	600	860	1000
Shrub/Vine	600	860	1000
Forb	300	430	500
Total	**3000**	**4300**	**5000**

Table 11. Ground cover

Tree foliar cover	5-30%
Shrub/vine/liana foliar cover	3-5%
Grass/grasslike foliar cover	2-15%
Forb foliar cover	2-10%
Non-vascular plants	0%
Biological crusts	0%
Litter	90-100%

Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 12. Soil surface cover

Tree basal cover	2-5%
Shrub/vine/liana basal cover	1-2%
Grass/grasslike basal cover	15-25%
Forb basal cover	1-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 13. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	25-35 per acre
Tree snag count** (hard***)	

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 14. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-3%	0-1%
>0.5 <= 1	–	1-3%	3-5%	1-3%
>1 <= 2	–	5-8%	10-15%	3-10%
>2 <= 4.5	5-15%	5-10%	50-60%	–
>4.5 <= 13	10-25%	–	–	–
>13 <= 40	5-30%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 21. Plant community growth curve (percent production by month). TX3762, Oak/Juniper Grassland. "Grassland with warm season grasses, oaks, and juniper.".

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	5	8	13	18	12	5	3	12	10	7	4

State 3
Open Grassland State

Open grassland

Community 3.1
Open Grassland Community

Figure 22. Foreground shows the site after replanting, following its use as cropland.

This community is former cropland that has been reseeded. Depending upon the management goals, the site can be seeded to native or exotic species or a combination. Much of the species diversity and site integrity has been lost when compared to the reference plant community. Depending upon the length of plowing and the intensity of the plowing, the soil health and structure may be deteriorated. Many of the original soil organisms are missing and soil erosion may have taken place. Soil compaction is usually a problem to be dealt with. This fact makes it difficult to restore completely to the reference plant community. Through the re-introduction of fire and prescribed grazing, plus reseeding of native forbs and grasses, this site can be restored to something resembling the historic plant community as far as the grassland component. It may take many years for natural processes within the soil to restore the oak species. Utilizing native plants in the re-seeded source will greatly benefit wildlife species such as deer, turkey, quail, and other birds. This open grassland community may also represent a community of annual and/or perennial seeded species which are non-native and which may occur as monoculture communities. These monoculture type communities may be too dense for wildlife. These communities are typically not very diverse. Typically these include naturalized species such as King Ranch bluestem, bermudagrass, Johnsongrass (*Sorghum halepense*), silky bluestem (*Dichanthium sericeum*), kleingrass, and many others. In many cases, hardly any native grasses can be found. There has been a dramatic reduction in the native forb and legume diversity. Total production for this site may be similar to the productive potential of this site in reference condition except the majority of the plant community is grasses.

Table 15. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2700	3870	4500
Shrub/Vine	150	215	250
Forb	150	215	250
Tree	0	0	0
Total	**3000**	**4300**	**5000**

Table 16. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0-1%
Grass/grasslike foliar cover	15-40%
Forb foliar cover	0-5%
Non-vascular plants	0%
Biological crusts	0%
Litter	90-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 17. Soil surface cover

Tree basal cover	0%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	15-20%
Forb basal cover	1-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	0%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0%
Bedrock	0%
Water	0%
Bare ground	0%

Table 18. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-3%	0-1%
>0.5 <= 1	–	0-3%	3-5%	1-3%
>1 <= 2	–	–	20-50%	3-10%
>2 <= 4.5	–	–	60-100%	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 24. Plant community growth curve (percent production by month). TX3764, Open Grassland. Warm season grasses with minor cool season influence on open grassland..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Community 3.2
Open Grassland with Juniper Encroachment Community

Figure 25. Site re-seeded to exotic grasses following use as cropland.

This community is reseeded open grassland which has an encroachment of woody species. The introduction of integrated brush management, prescribed burning and prescribed grazing this site will successfully shift back towards the Open Grassland Community and remain productive. If brush management alternatives are not implemented in a timely manner, this site will become infested with woody species. In as little as 20 years, the brush will be utilizing most of the sunlight and moisture stored in the soil. In addition, rainfall entrapment will deteriorate the hydrologic cycle so that less moisture is absorbed into the rooting zone. Forage productivity will decline accordingly as grazeable acreage decreases.

Table 19. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1500	2150	2500
Grass/Grasslike	1200	1720	2000
Shrub/Vine	150	215	250
Forb	150	215	250
Total	**3000**	**4300**	**5000**

Figure 27. Plant community growth curve (percent production by month). TX3764, Open Grassland. Warm season grasses with minor cool season influence on open grassland..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Pathway 3.1A
Community 3.1 to 3.2

Open Grassland Community

Open Grassland with Juniper Encroachment Community

Without fire or brush management, this site may shift to community 3.2.

Pathway 3.2A
Community 3.2 to 3.1

Open Grassland with Juniper Encroachment Community

Open Grassland Community

With prescribed fire, brush management, and proper grazing management, the site may shift back to community 3.1.

Transition T1A
State 1 to 2

A transition occurs because of a lack of brush management with mechanical means, with fire or with targeted goat/possibly sheep grazing. Grazing deferment alone will not halt the increase of woody species.

Transition T1B
State 1 to 3

Land clearing of the woody species and replanting with grasses represent this transition. Recovery to the Oak Savannah State is very doubtful, especially if exotic plants are utilized. Even though the plants are exotic, many times their hydrologic function is similar to the original native plants excepting the oak species.

Restoration pathway R2A
State 2 to 1

The restoration pathway includes some form of brush management. Prescribed burning will also help and prescribed grazing will be essential. In some cases of severe long-term overharvesting of the desired plants, replanting may be necessary.

Transition T2A
State 2 to 3

Land clearing of the woody species and replanting with grasses represent this transition. Recovery to the Oak Savannah State is very doubtful, especially if exotic plants are utilized. Even though the plants are exotic, many times their hydrologic function is similar to the original native plants excepting the oak species.

Additional community tables

Table 20. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tall grass**			800–1800	
	little bluestem	SCSC	*Schizachyrium scoparium*	800–1200	–
2	**Tallgrasses**			1000–1200	
	big bluestem	ANGE	*Andropogon gerardii*	500–1000	–
	Indiangrass	SONU2	*Sorghastrum nutans*	500–1000	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	0–800	–
	switchgrass	PAVI2	*Panicum virgatum*	0–300	–
3	**Midgrasses**			400–600	
	sideoats grama	BOCU	*Bouteloua curtipendula*	400–500	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	100–200	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	100–200	–
	vine mesquite	PAOB	*Panicum obtusum*	100–200	–
	purpletop tridens	TRFL2	*Tridens flavus*	0–100	–
4	**Midgrasses**			40–200	
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	50–100	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	40–100	–
	composite dropseed	SPCO16	*Sporobolus compositus*	50–100	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	50–100	–
	white tridens	TRAL2	*Tridens albescens*	25–100	–
5	**Shortgrasses**			40–200	
	threeawn	ARIST	*Aristida*	25–100	–
	buffalograss	BODA2	*Bouteloua dactyloides*	10–100	–
	fall witchgrass	DICO6	*Digitaria cognata*	10–100	–
	curly-mesquite	HIBE	*Hilaria belangeri*	10–100	–
6	**Cool Season Grasses**			200–400	
	Canada wildrye	ELCA4	*Elymus canadensis*	50–200	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	100–200	–
	cedar sedge	CAPL3	*Carex planostachys*	50–100	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	50–100	–
Forb					

Forb					
7	**Forbs**			40–430	
	awnless bushsunflower	SICA7	*Simsia calva*	25–150	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	25–150	–
	dotted blazing star	LIPU	*Liatris punctata*	25–100	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	25–100	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	25–100	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	25–100	–
	prairie clover	DALEA	*Dalea*	25–100	–
	bundleflower	DESMA	*Desmanthus*	25–100	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	25–100	–
	fuzzybean	STROP	*Strophostyles*	25–75	–
	ticktrefoil	DESMO	*Desmodium*	25–75	–
	mallow	MALVA	*Malva*	25–75	–
	smartweed leaf-flower	PHPO3	*Phyllanthus polygonoides*	25–75	–
	scurfpea	PSORA2	*Psoralidium*	25–75	–
	snoutbean	RHYNC2	*Rhynchosia*	25–75	–
	wild petunia	RUELL	*Ruellia*	25–75	–
Shrub/Vine					
8	**Shrubs**			50–430	
	bully	SIDER2	*Sideroxylon*	50–200	–
	prairie sumac	RHLA3	*Rhus lanceolata*	50–200	–
	greenbrier	SMILA2	*Smilax*	50–150	–
	stretchberry	FOPU2	*Forestiera pubescens*	50–150	–
	algerita	MATR3	*Mahonia trifoliolata*	50–100	–
	jointfir	EPHED	*Ephedra*	0–100	–
	skunkbush sumac	RHTR	*Rhus trilobata*	50–100	–
	evergreen sumac	RHVI3	*Rhus virens*	0–100	–
	eastern redbud	CECA4	*Cercis canadensis*	50–100	–
	snailseed	CODI	*Cocculus diversifolius*	25–75	–
	Texas persimmon	DITE3	*Diospyros texana*	10–75	–
	Virginia creeper	PAQU2	*Parthenocissus quinquefolia*	25–75	–
	grape	VITIS	*Vitis*	25–75	–
	desert-thorn	LYCIU	*Lycium*	0–50	–
Tree					
9	**Tree**			40–200	
	Texas live oak	QUFU	*Quercus fusiformis*	0–200	–
	blackjack oak	QUMA3	*Quercus marilandica*	0–200	–
	post oak	QUST	*Quercus stellata*	0–200	–
	Texas red oak	QUBU2	*Quercus buckleyi*	50–150	–
	Nuttall oak	QUTE	*Quercus texana*	0–100	–
	hackberry	CELTI	*Celtis*	50–100	–

Animal community

This site is used for the production of domestic livestock and to provide habitat for native wildlife and certain species of exotic wildlife. Cow-calf operations are the primary livestock enterprise although stocker cattle are also grazed. Sheep and goats were formerly raised in large numbers and are still present in reduced numbers. Sustainable stocking rates have declined drastically over the past 100 years due to the deterioration of the historic plant community. Initial starting stocking rates will be determined with the landowner or decision maker. An assessment of vegetation is needed to determine stocking rates. Calculations used to determine an initial starting stocking rate will be based on forage production and on grazeable acres.

A large diversity of wildlife is native to this site. In the historic plant community, large migrating herds of bison, resident herds of pronghorn and large numbers of lesser prairie chickens were the more dominant species. With the demise of these species and the changes in the plant community, the kinds of wildlife have changed.

With the eradication of the screwworm fly, the increase in woody vegetation, and insufficient natural predation, white-tailed deer numbers have increased drastically and are often in excess of natural 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 woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep and goats can be an important consideration in livestock and wildlife management and can cause damage to preferred native 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. 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 Rio Grande turkey, bobwhite quail, and mourning dove. Turkey prefer plant communities with substantial amounts of shrubs and trees interspersed with grassland. Quail prefer plant communities with a combination of low shrubs, bunch grass, bare ground and low successional forbs. The different species of songbirds vary in their habitat preferences. In general, a habitat that provides a large variety of grasses, forbs, shrubs, vines and trees and a complex of grassland, savannah, shrubland, and woodland 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. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow and red deer, aoudad sheep, and blackbuck antelope. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. Feral hogs are present and can cause damage when their numbers are not managed.

Plant Preference by Animal Kind:
This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition and diet overlap between kinds of herbivores. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. An animal's preference or avoidance of certain plants is learned over time through grazing experience and maternal learning (http://extension.usu.edu/behave/Grazing). Preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food are rated. Refer to detailed habitat guides for a more complete description of a species habitat needs.

Legend: P=Preferred D=Desirable U=Undesirable N=Not Consumed T=Toxic X=Used, but the degree of utilization unknown
Preferred – Percentage of plant in animal diet is greater than it occurs on the land
Desirable – Percentage of plant in animal diet is similar to the percentage composition on the land
Undesirable – Percentage of plant in animal diet is less than it occurs on the land
Not Consumed – Plant would not be eaten under normal conditions. It is only consumed when other forages not available.

Toxic – Rare occurrence in diet and, if consumed in any tangible amounts results in death or severe illness in the animal.

Hydrological functions

The water cycle on this site functions according to the existing plant community and the management of that plant community. The water cycle is most functional when the site is dominated by tall bunchgrass and the oak savannah. Rapid rainfall infiltration, high soil organic matter, good soil structure, and good porosity are present with a good cover of bunchgrass. When dry, the soils crack and take water in readily. When wet, the cracks close and the soil becomes sticky, and plastic taking water in slowly. Light showers are ineffective to this site. Quality of surface runoff will be high and erosion and sedimentation rates will be low. With high rates of infiltration and periods of heavy rainfall, some water will move below the root zone of grasses into the fractures in the limestone. As this water moves downward it contributes to the recharge of aquifers.

When heavy grazing causes loss or reduction of bunchgrass and ground cover, the water cycle becomes impaired. Infiltration is decreased and runoff is increased because of poor ground cover, rainfall splash, soil capping, low organic matter and poor structure. Because of the very high shrink-swell clay soil and the formation of surface cracks in dry periods, rainfall infiltration can still occur even when ground cover is poor. With a combination of a sparse ground cover and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor and sedimentation increased.

As the site becomes dominated by woody species, especially oaks and juniper, the water cycle is further altered. Interception of rainfall by tree canopies is increased which reduces the amount of rainfall reaching the surface. Stem flow is increased, however, because of the funneling effect of the canopy, which increases soil moisture at the base of the tree. Increased transpiration, especially when evergreen species such as live oak and juniper dominate, provides less chance for deep percolation into aquifers. As woody species increase, grass cover declines, which causes some of the same results as heavy grazing. Brush management combined with good grazing management can help restore the natural hydrology of the site.

If a mature woodland canopy develops, a buildup of leaf litter occurs which increases the organic litter on the soil, builds structure and retards erosion. The duff, however, can store some moisture and reduce infiltration. Some, but not all values of a properly functioning water cycle are restored on this site when a woodland plant community persists.

Recreational uses

This site has the appeal of the wide open spaces. The abundant tall and mid grasses and scattered oaks produce beautiful fall color variations. The area is also used for hunting, birding, and other eco-tourism related enterprises.

Wood products

Honey mesquite and oaks can be used for firewood and the specialty wood industry.

Other products

None

Other information

None

Inventory data references

Information provided here has been derived from limited NRCS clipping data and from field observations of range trained personnel. Information has also been interpreted from scientific articles.

Type locality

Location 1: Bexar County, TX	
UTM zone	N
UTM northing	3289300.82
UTM easting	541542.267

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Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high-intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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)	San Angelo ZO
Contact for lead author	325-944-0147
Date	04/08/2013
Approved by	Colin Walden
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:** Some minimal flow patterns may be evident at the juncture of the associated sites.

3. **Number and height of erosional pedestals or terracettes:** None.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** None.

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):** Little or no litter movement or deposition during normal rainfall events.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to wind erosion. Stability range is expected to be 5-6.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 0 to 7 inches; very dark reddish brown clay, moderate fine and medium subangular blocky and granular structure; very hard, firm; very sticky and plastic; many fine roots; few fine pores and old root channels; neutral; clear smooth boundary.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The tallgrass/midgrass savanna with abundant forbs, adequate litter, and little bare ground provides for maximum infiltration and negligible runoff

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses

    Sub-dominant: Trees = Warm-season midgrasses shrubs/vines Perennial forbs

    Other: Cool-season grasses warm-season shortgrasses

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Perennial grasses will naturally exhibit a minor amount (less than 5%) of senescence and some mortality every year.

14. **Average percent litter cover (%) and depth (in):** Litter is dominantly herbaceous.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 3000 to 5000 pounds per acre.

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:** Ashe juniper, pricklypear, yucca, tasajillo, pricklyash, lotebush, mesquite, King Ranch bluestem,

silky bluestem, annual broomweed.

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17. **Perennial plant reproductive capability:** All perennial species should be capable of reproducing every year unless disrupted by extended drought, overgrazing, wildfire, insect damage, or other events occuring immediately prior to, or during the reproductive phase.

USDA Natural Resources Conservation Service

Ecological site R087AY001TX
Gravelly

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

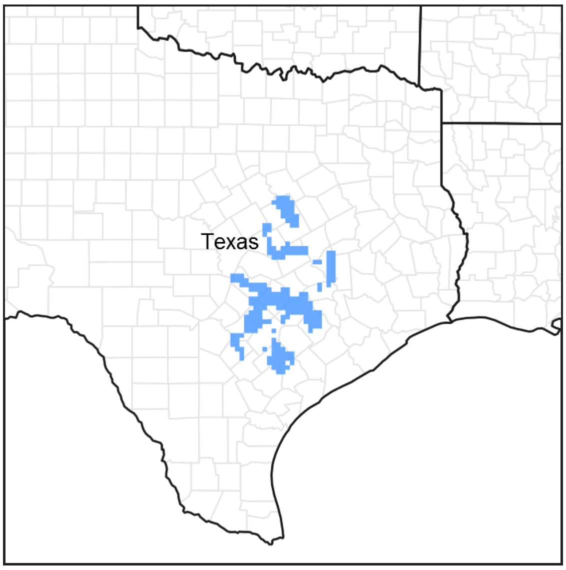


Figure 1. Mapped extent

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): 087A–Texas Claypan Area, Southern Part

This area is entirely in south-central Texas. It makes up about 10,535 square miles (27,295 square kilometers). The towns of Bastrop, Bryan, Centerville, College Station, Ennis, Fairfield, Franklin, Giddings, Gonzales, Groesbeck, La Grange, Madisonville, and Rockdale are in this MLRA. Interstate 45 crosses the northern part of the area, and Interstate 10 crosses the southern part. A number of State Parks are located throughout this area. The parks are commonly associated with reservoirs.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 87A

Ecological site concept

This ecological site is characterized by gravelly soils. Gravels are located in the surface and/or subsurface of the soil. This affects plant growth by restricting where roots can grow, and ultimately limiting the productivity of the site.

Associated sites

R087AY003TX	**Claypan Savannah** Claypan Savannah
R087AY006TX	**Sandy** Sandy

Similar sites

R087AY003TX	**Claypan Savannah** Claypan Savannah

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus marilandica*
Shrub	(1) *Ilex vomitoria* (2) *Callicarpa americana*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Sorghastrum nutans*

Physiographic features

The topography of this site is nearly level to steep. Some soils may have a perched water table as high as 30 inches. Water tables are typically highest in the late winter and early spring, or during times of heavy precipitation events.

Table 2. Representative physiographic features

Landforms	(1) Ridge (2) Stream terrace
Flooding frequency	None
Ponding frequency	None
Elevation	200–750 ft
Slope	0–20%
Water table depth	30–80 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 87A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of mild days and cool nights. The average annual precipitation in this area is 41 inches. Most of the rainfall occurs in spring and fall. The freeze-free period averages about 276 days and the frost-free period 241 days.

Table 3. Representative climatic features

Frost-free period (average)	241 days
Freeze-free period (average)	276 days
Precipitation total (average)	41 in

Climate stations used

- (1) BELLVILLE 6NNE [USC00410655], Bellville, TX

- (2) ELGIN [USC00412820], Elgin, TX
- (3) LA GRANGE [USC00414903], La Grange, TX
- (4) SMITHVILLE [USC00418415], Smithville, TX
- (5) FAIRFIELD 3W [USC00413047], Fairfield, TX
- (6) BARDWELL DAM [USC00410518], Ennis, TX
- (7) CROCKETT [USC00412114], Crockett, TX
- (8) GONZALES 1N [USC00413622], Gonzales, TX
- (9) MADISONVILLE [USC00415477], Madisonville, TX
- (10) SOMERVILLE DAM [USC00418446], Somerville, TX
- (11) FRANKLIN [USC00413321], Franklin, TX
- (12) COLLEGE STN [USW00003904], College Station, TX

Influencing water features

A stream or wetland does not influence the plant community on this site.

Soil features

These are moderately deep to very deep, gravelly, loamy and clayey soils. The dominant characteristic is the gravel in the profile. Soils of this site have profiles in which a large percent and volume is gravel. Although the soils take in water readily, the gravel content limits moisture and fertility storage capacity. The site is somewhat droughty when compared to loamy soils without the gravel. The gravel layer becomes slightly cemented when dry and restricts root growth. The site responds to light showers more favorably than do heavier soils. When range and soil condition deteriorates, surface crusting, slow infiltration, and runoff are common. It is very important to maintain a protective cover of vegetation and plant residue on the site. Many areas of these soils have been surface mined for gravel, thus reducing their vegetative potential even further. Most soil series are also correlated to another ecological site, but these series have a gravel in their mapunit names. The soils correlated include: Axtell, Boonville, Burlewash, Carmine, Crockett, Darst, Edge, Ellen, Fett, Goldmire, Gredge, Hearne, Hornsby, Jedd, Kurten, Marquez, Rek, Rosanky, Silvern, Stein, Straber, Tabor, Travis, Tremona, Vernia, and Winedale.

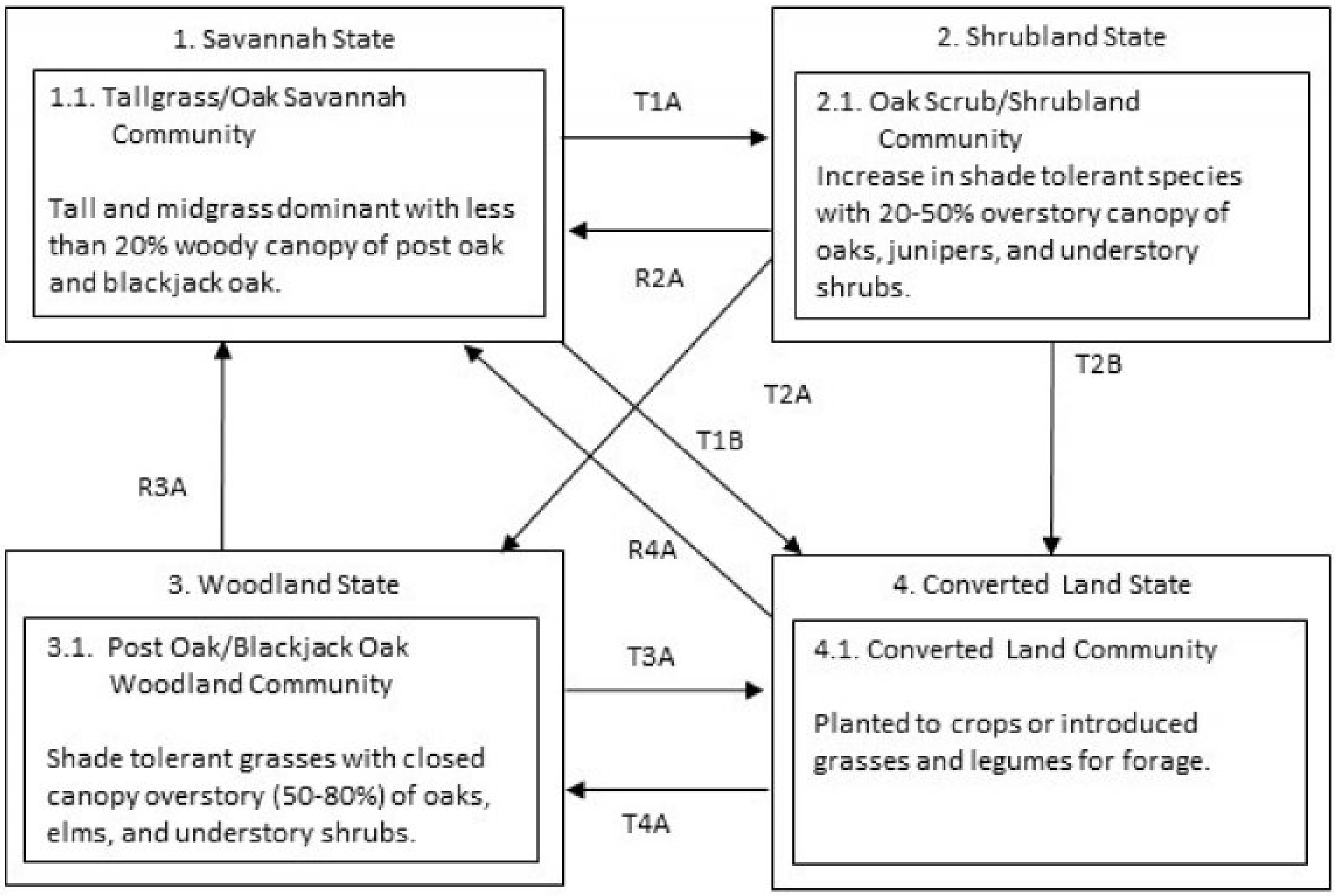
Table 4. Representative soil features

Surface texture	(1) Gravelly fine sandy loam (2) Gravelly loamy fine sand
Family particle size	(1) Loamy
Drainage class	Somewhat poorly drained to well drained
Permeability class	Very slow to moderately slow
Soil depth	25–80 in
Surface fragment cover <=3"	0–50%
Surface fragment cover >3"	0–25%
Available water capacity (0-40in)	1–6 in
Calcium carbonate equivalent (0-40in)	0–2%
Electrical conductivity (0-40in)	0–4 mmhos/cm
Sodium adsorption ratio (0-40in)	0–5
Soil reaction (1:1 water) (0-40in)	4.5–7.8
Subsurface fragment volume <=3" (Depth not specified)	0–45%
Subsurface fragment volume >3" (Depth not specified)	0–10%

Ecological dynamics

The gravelly site evolved and was maintained by the grazing and herding effects of native wild large ungulates, periodic fires, and climatic fluctuations. Conversion of this site to cropland and the subsequent abandonment of cropping removed the natural native vegetation, organic matter and fertility, and allowed woody species to dominate the site. Continuous grazing by domestic livestock and the suppression of fire on non-cropland sites removes little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), Engelmann's daisy (*Engelmannia peristenia*), yellow neptunia (*Neptunia lutea*), and gayfeather (*Liatris punctata*). Less productive perennial and annual grasses, forbs, vines, and shrubs will replace these plants. With continued continuous grazing, no brush management, and the absence of periodic fires, a community dominated by blackjack oak (*Quercus marilandica*), yaupon (*Ilex vomitoria*), post oak (*Quercus stellata*), winged elm (*Ulmus alata*), and eastern red cedar (*Juniperus virginiana*) will replace the savannah. These woody species often form dense canopies that limit herbaceous productivity due to shading and moisture utilization.

State and transition model



T1A, T2A, T4A	Heavy Continuous Grazing, No Brush Management, Abandonment
T1B, T2B, T3A	Brush Management, Crop Cultivation, Pasture Planting
R2A	Brush Management, Prescribed Grazing, Prescribed Burning
R3A	Brush Management, Range Planting, Prescribed Grazing
R4A	Range Planting, Prescribed Grazing, Prescribed Burning

Figure 6. STM

State 1
Savannah

One community exists in the Savannah State, the 1.1 Tallgrass/Oak Savannah Community. The State is dominated by warm season perennial grasses and the overstory canopy cover is less than 20 percent.

Community 1.1
Tallgrass/Oak Savannah

The characteristic plant community of this site is the reference plant community. This site is an open savannah of blackjack oak and post oak trees that shade 15 to 20 percent of the ground. The herbaceous component is tall and midgrasses and is dominated by little bluestem, which usually makes up 50 to 60 percent of the total annual yield. Indiangrass, brownseed paspalum (*Paspalum plicatulum*), purpletop tridens (*Tridens flavus*), switchgrass, tall dropseed (*Sporobolus compositus*), and thin paspalum (*Paspalum setaceum*) also occur. Cool-season forage plants are scarce on this site. A variety of shrubs, vines, and forbs occur in this community.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2000	2800	3600
Tree	250	350	450
Shrub/Vine	125	175	225
Forb	125	175	225
Total	**2500**	**3500**	**4500**

State 2
Shrubland

One community exists in the Shrubland State, the 2.1 Oak Scrub/Shrubland Community. The herbaceous production is not as great compared to the Savannah State, and overstory canopy has increased between 20 and 50 percent.

Community 2.1
Oak Scrub/Shrubland

This plant community is a transitional community between Savannah and Woodland States. It develops in the absence of fire or mechanical or chemical brush management treatments. It is usually the result of either abandonment following cropping or yearly continuous grazing. Trees and shrubs begin to encroach onto pastureland or replace the grassland component of the Savannah State. In addition to the naturally occurring oaks, other woody species such as eastern persimmon (*Diospyros virginiana*), winged elm, and eastern red cedar increase in density and canopy coverage (20 to 50 percent). Remnants of little bluestem and Indiangrass may still occur but the herbaceous component of the community becomes dominated by lesser producing grasses and forbs. Initially, species such as brownseed paspalum, tall dropseed, and fall witchgrass (*Digitaria cognata*) replace the taller grasses. As the site continues to transition, the plants which increase or invade on the site include sandbur (Cenchrus spp.), red lovegrass (*Eragrostis secundiflora*), Yankeeweed (*Eupatorium compositifolium*), bullnettle

(*Cnidoscolus texanus*), croton (Croton spp.), snake cotton (*Froelichia gracilis*), prickly pear (Opuntia spp.), queen's delight (*Stillingia texana*), beebalm (Monarda spp.), and baccharis (Baccharis spp.). Prescribed burning on a three to five year interval in conjunction with prescribed grazing may be a viable option for returning this site to a Tallgrass/Oak Savannah Community provided woody canopy cover is less than 50 percent and adequate herbaceous fine fuel still exists. When this threshold is exceeded, mechanical or chemical brush control becomes necessary to move back towards the Savannah State.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	800	1120	1440
Shrub/Vine	600	840	1080
Tree	400	560	720
Forb	400	560	720
Total	**2200**	**3080**	**3960**

State 3
Woodland

One community exists in the Woodland State, the Post Oak/Blackjack Oak Woodland Community. The site is characterized by little herbaceous production. The overstory canopy is over 50 percent and shrubs also limit light to the surface.

Community 3.1
Post Oak/Blackjack Oak Woodland

This plant community is a closed overstory (50 to 80 percent) woodland dominated by post oak, blackjack oak, winged elm, and eastern red cedar. Understory shrubs and sub-shrubs include yaupon, farkleberry (*Vaccinium arboreum*), possumhaw (*Ilex decidua*), and American beautyberry (*Callicarpa americana*). Woody vines also occur and include poison ivy (toxicodendron radicans), grape (Vitis spp.), greenbriar (Smilax spp.), and peppervine (Ampelopsis arborea). A herbaceous understory is almost nonexistent but shade-tolerant species including longleaf woodoats (*Chasmanthium sessiliflorum*), cedar sedge (*Carex planostachys*), ironweed (*Vernonia baldwinii*), and goldenrod (Solidago spp.) may occur in small amounts. Prescribed fire may be used to convert this site back to the Tallgrass/Oak Savannah Community but will generally take many consecutive years of burning due to light fine fuel loads. Chemical brush control on a large scale is usually not a treatment option on this site due to the herbicide resistance of yaupon; however, individual plant treatment with herbicides on small acreage is a viable option. Mechanical treatment of this site, along with seeding, is the most viable option for reversion back to a Savannah State, although the economic viability of this option is questionable.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	875	1225	1575
Shrub/Vine	500	700	900
Grass/Grasslike	200	280	360
Forb	60	90	120
Total	**1635**	**2295**	**2955**

State 4
Converted

The Converted Land State contains one community, the 4.1 Converted Land Community. The state is characterized by the land manager farming crops or planted grasses.

Community 4.1
Converted Land

Conversion of this site to cropland occurred from the middle 1800's to the early 1900's. Some remains in cropland today, typically cotton (Gossypium spp.), corn (*Zea mays*), sorghum (Sorghum spp.), and soybeans (*Glycine max*). Ditching, land leveling, and levee construction has significantly changed the topography and hydrology on many acres of this site. While restoration of this site to a semblance of the reference plant community is possible with seeding and prescribed grazing, complete restoration of the reference community in a reasonable time is very unlikely. Following crop production, this site is often planted to native or introduced grasses and legumes for livestock grazing or hay production. Typical species planted include improved Bermudagrass varieties, bahiagrass, switchgrass, dallisgrass, kleingrass (*Panicum coloratum*), old world bluestems (Bothriochloa spp.), annual ryegrass (Lolium multiflorum), and white clover. Many of the introduced species (bahiagrass, Bermudagrass, and dallisgrass) are invasive-moving by wind, water, and animals. Once established, they are extremely difficult to remove and will hinder the reestablishment of native species. The establishment and maintenance of these species requires cultivation, fertilization, weed control, and prescribed grazing management.

Transition T1A
State 1 to 2

The Savannah State will transition to the Shrubland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 20 percent and grasses shift composition to more shade-tolerant species.

Transition T1B
State 1 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration back to the Savannah State requires brush management, prescribed grazing and/or prescribed fire. Mechanical or chemical controls can be used to remove the woody overstory species and shrubs. Prescribed grazing may require destocking and/or deferment.

Restoration pathway T2A
State 2 to 3

The Shrubland State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Restoration pathway T2B
State 2 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration back to the Savannah State requires substantial energy inputs. Brush management and prescribed grazing will be need to shift the community back to the reference state. Mechanical or chemical controls can be used to remove the woody overstory species back below 20 percent. Prescribed grazing may require destocking and/or deferment to manage the understory grasses back to those found in the reference community. Fire may be an option, but only if adequate amounts of fine fuel exist in the understory.

Transition T3A
State 3 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R4A
State 4 to 1

The restoration to State 1 can occur when the land manager ceases agronomic practices. Range planting of native species found in the reference community will be required to bring back a similar community as the State 1 plant composition. The extent of previous soil disturbances will determine how much seedbed preparation will be needed, as well as the ability to be restored. Proper grazing and brush management will be required to ensure success.

Transition T4A
State 4 to 3

The Converted Land State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Additional community tables

Table 8. Community 1.1 plant community composition

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

Grass/Grasslike					
1	**Tallgrass**			1375–2475	
	little bluestem	SCSC	*Schizachyrium scoparium*	1375–2475	–
2	**Tall/Midgrasses**			375–675	
	big bluestem	ANGE	*Andropogon gerardii*	375–675	–
	longleaf woodoats	CHSE2	*Chasmanthium sessiliflorum*	375–675	–
	beaked panicgrass	PAAN	*Panicum anceps*	375–675	–
	switchgrass	PAVI2	*Panicum virgatum*	375–675	–
	Indiangrass	SONU2	*Sorghastrum nutans*	375–675	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	375–675	–
	purpletop tridens	TRFL2	*Tridens flavus*	375–675	–
3	**Mid/Shortgrasses**			250–450	
	arrowfeather threeawn	ARPU8	*Aristida purpurascens*	250–450	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	250–450	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	250–450	–
	cedar sedge	CAPL3	*Carex planostachys*	250–450	–
	cylinder jointtail grass	COCY	*Coelorachis cylindrica*	250–450	–
	fall witchgrass	DICO6	*Digitaria cognata*	250–450	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	250–450	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	250–450	–
	purple lovegrass	ERSP	*Eragrostis spectabilis*	250–450	–
	Hall's panicgrass	PAHA	*Panicum hallii*	250–450	–
	brownseed paspalum	PAPL3	*Paspalum plicatulum*	250–450	–
	thin paspalum	PASE5	*Paspalum setaceum*	250–450	–
Forb					
4	**Forbs**			125–225	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	125–225	–
	Virginia dayflower	COVI3	*Commelina virginica*	125–225	–
	Illinois bundleflower	DEIL	*Desmanthus illinoensis*	125–225	–
	ticktrefoil	DESMO	*Desmodium*	125–225	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	125–225	–
	coastal indigo	INMI	*Indigofera miniata*	125–225	–
	lespedeza	LESPE	*Lespedeza*	125–225	–
	littleleaf sensitive-briar	MIMI22	*Mimosa microphylla*	125–225	–
	yellow puff	NELU2	*Neptunia lutea*	125–225	–
	prairie snoutbean	RHLA5	*Rhynchosia latifolia*	125–225	–
	fuzzybean	STROP	*Strophostyles*	125–225	–
Shrub/Vine					
5	**Shrubs/Vines**			125–225	
	American beautyberry	CAAM2	*Callicarpa americana*	125–225	–
	parsley hawthorn	CRMA5	*Crataegus marshallii*	125–225	–

	yaupon	ILVO	*Ilex vomitoria*	125–225	–
	winged sumac	RHCO	*Rhus copallinum*	125–225	–
	southern dewberry	RUTR	*Rubus trivialis*	125–225	–
	cat greenbrier	SMGL	*Smilax glauca*	125–225	–
	coralberry	SYOR	*Symphoricarpos orbiculatus*	125–225	–
	farkleberry	VAAR	*Vaccinium arboreum*	125–225	–
	muscadine	VIRO3	*Vitis rotundifolia*	125–225	–
Tree					
6	**Trees**			250–450	
	blackjack oak	QUMA3	*Quercus marilandica*	250–450	–
	post oak	QUST	*Quercus stellata*	250–450	–
	winged elm	ULAL	*Ulmus alata*	250–450	–

Animal community

The historic savannah provided habitat to bison, deer, turkey, migratory birds and large predators such as wolves, coyotes, mountain lions, and black bear. White-tailed deer, turkey, coyotes, bobcats, and resident and migratory birds find suitable habitat in these savannahs today. Domestic livestock and exotic ungulates are the dominant grazers and browsers of this site. As the savannah transitions through the various vegetative states towards woodlands, the quality of the habitat may improve for some species and decline for others. Management must be applied to maintain a vegetative state in optimum habitat quality for the desired animal species.

Hydrological functions

Peak rainfall periods occur in May and June from frontal passage thunderstorms and in September and October from tropical systems as well as frontal passages. Rainfall amounts may be high (three to five inches per event) and events may be intense. The site is subject to erosion where adequate herbaceous cover is not maintained and on heavy use areas such as roads and livestock trails. Gullies following livestock trails to water are common on this site where continuous grazing is practiced and adequate herbaceous cover is not maintained. Extended periods (60 days) of little to no rainfall during the growing season are common. The hydrology of this site may be manipulated through management to yield higher runoff volumes or greater infiltration to groundwater. Management for less herbaceous cover will favor higher surface runoff while dense herbaceous cover and litter will favor ground water recharge. Potential pollution from sediment, pesticides, and both organic and inorganic fertilizers should always be considered when managing for higher volumes of surface runoff.

Recreational uses

Hunting, camping, bird watching, equestrian, and photography are common activities.

Wood products

Oaks are used for firewood. Hickory and mesquite are used for barbecue wood. Yaupon is used for landscaping.

Other products

Gravel is mined from this site. Fruit from dewberries, grapes, and plums are harvested.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

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Approval

David Kraft, 5/06/2020

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)	Mike Stellbauer, David Polk, and Bill Deauman
Contact for lead author	Mike Stellbauer, Zone RMS, NRCS, Bryan, Texas
Date	05/18/2005
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:** Some water flow patterns may be present on this site due to landscape position and slopes.

3. **Number and height of erosional pedestals or terracettes:** Pedestals or terracettes are uncommon for this site when occupied by the reference community.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 25 percent bare ground randomly distributed in small patches.

5. **Number of gullies and erosion associated with gullies:** Some gullies associated with animal trails may be present. Head and side slopes should be stable and covered with vegetation.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site has slowly permeable sub-soils. On sloping sites, small to medium-sized litter will move short distances with intense storms.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Soil Stability class range is expected to be 3 to 5.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** The soil surface structure is less than 10 inches thick with colors from brown fine sandy loam to dark yellowish brown fine sandy loam and generally subangular blocky structures. SOM is 0.5 to 1.0 percent.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The savannah of trees, shrubs, vines, grasses, and forbs, along with adequate litter and little bare ground, provides for maximum infiltration and little runoff under normal rainfall events.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses >>

Sub-dominant: Warm-season midgrasses >

Other: Trees > Shrubs/Vines > Forbs

Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional group.

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14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 2,500 pounds per acre for below average moisture years to 4,500 pounds per acre for above average moisture years.

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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:** Potential invasive species include bahiagrass, Bermudagrass, mesquite, eastern persimmon, eastern red cedar, post oak, winged elm, and yaupon.

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17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing, except during periods of prolonged drought conditions, heavy natural herbivory and intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R086AY012TX
Loamy Bottomland

Last updated: 5/06/2020
Accessed: 10/13/2022

General information

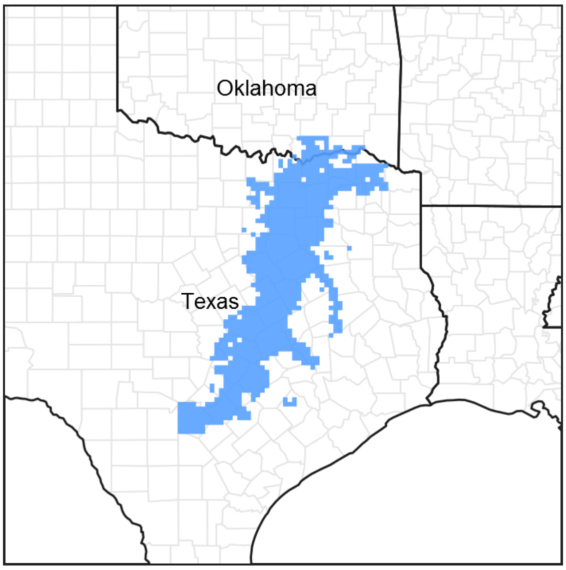

Figure 1. Mapped extent

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): 086A–Texas Blackland Prairie, Northern Part

MLRA 86A, The Northern Part of Texas Blackland Prairie is entirely in Texas. It makes up about 15,110 square miles (39,150 square kilometers). The cities of Austin, Dallas, San Antonio, San Marcos, Temple, and Waco are located within the boundaries. Interstate 35, a MLRA from San Antonio to Dallas. The area supports tall and mid-grass prairies, but improved pasture, croplands, and urban development account for the majority of the acreage.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 86A

Ecological site concept

The Loamy Bottomland is a tallgrass savannah. The site is unique because it has a hardwood overstory component with the tallgrasses. The soils are very deep loams and are associated with flooding regimes. The loamy textured soils allow the water to drain and sites do not usually flood for longer than seven days.

Associated sites

R086AY006TX	**Northern Clay Loam** The Northern Clay Loam site is often upslope from the Loamy Bottomland site. It differs from the Loamy Bottomland site by occurring in uplands, plains, and terraces and lacking thin stratas of varying textured soils in the soil profile from flooding events.
R086AY007TX	**Southern Clay Loam** The Southern Clay Loam site is often upslope from the Loamy Bottomland site. It differs from the Loamy Bottomland site by occurring in uplands, plains, and terraces and lacking thin stratas of varying textured soils in the soil profile from flooding events.
R086AY010TX	**Northern Blackland** The Northern Blackland site is often upslope from the Loamy Bottomland site. It differs from the Loamy Bottomland site by its position on uplands, high shrink-swell properties, and having clay soils and higher runoff.
R086AY011TX	**Southern Blackland** The Southern Blackland site is often upslope from the Loamy Bottomland site. It differs from the Loamy Bottomland site by its position on uplands, high shrink-swell properties, and having clay soils and higher runoff.

Similar sites

R086AY013TX	**Clayey Bottomland** The Clayey Bottomland site is similar to the Loamy Bottomland site by occurring on floodplains and having similar production potential. It differs from the Loamy Bottomland site by having clay soils with high shrink-swell properties, inclusions of hydric soils, and very slow permeability. The clayey bottomland does not produce as much as the Loamy Bottomland.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

These are on nearly level slopes on floodplains. Slopes can range from 0 to 8 percent, but are usually 1 to 3 percent. The sites flood throughout the year, but the water does not usually persist longer than seven days. The runoff class is negligible to low.

Table 2. Representative physiographic features

Landforms	(1) Flood plain
Flooding duration	Very brief (4 to 48 hours) to brief (2 to 7 days)
Flooding frequency	Rare to frequent
Ponding frequency	None
Elevation	200–2,300 ft
Slope	0–8%
Water table depth	30–72 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 86A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. Tropical maritime air controls the climate during spring, summer and fall. In winter and early spring, frequent surges of Polar Canadian air cause sudden drops in temperatures and add considerable variety to the daily weather. When these cold air masses stagnate and are overrun by moist air from the south, several days of cold, cloudy, and rainy weather follow. Generally, these occasional cold spells are of short duration with rapid clearing following cold frontal passages. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of sunny skies, mild days, and cool nights. The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time during the summer and 50 percent in winter. The prevailing wind direction is from the south and highest wind speeds occur during the spring months. Rainfall during the spring and summer months generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. High-intensity rains of short duration are likely to produce rapid runoff almost anytime during the year. The predominantly anticyclonic atmospheric circulation over Texas in summer and the exclusion of cold fronts from North Central Texas result in a decrease in rainfall during midsummer. The amount of rain that falls varies considerably from month-to-month and from year-to-year.

Table 3. Representative climatic features

Frost-free period (average)	237 days
Freeze-free period (average)	265 days
Precipitation total (average)	39 in

Climate stations used

- (1) JOE POOL LAKE [USC00414597], Dallas, TX
- (2) KAUFMAN 3 SE [USC00414705], Kaufman, TX
- (3) NEW BRAUNFELS [USC00416276], New Braunfels, TX
- (4) SAN ANTONIO 8NNE [USC00417947], San Antonio, TX
- (5) CEDAR CREEK 5 S [USC00411541], Cedar Creek, TX
- (6) HILLSBORO [USC00414182], Hillsboro, TX
- (7) MCKINNEY [USC00415766], McKinney, TX
- (8) TEMPLE [USC00418910], Temple, TX
- (9) WAXAHACHIE [USC00419522], Waxahachie, TX
- (10) GREENVILLE KGVL RADIO [USC00413734], Greenville, TX
- (11) SAN MARCOS [USC00417983], San Marcos, TX
- (12) SHERMAN [USC00418274], Denison, TX
- (13) TAYLOR 1NW [USC00418862], Taylor, TX
- (14) AUSTIN BERGSTROM AP [USW00013904], Austin, TX

Influencing water features

This site is located in floodplains. It receives water from overflow from watercourses and runoff from higher adjacent sites. All soils within this site are classified as hydric and may be wetlands. Onsite delineations are required to determine if the site is officially classified as a wetland.

Soil features

The site consists of very deep, well to somewhat poorly drained soils with moderate to very slow permeability. The floodplain soils were formed in recent alluvium. In a representative profile the surface layer is dark grayish brown loam about 29 inches deep. The subsoil is brown clay loam or silty clay loam to a depth of more than 60 inches from the soil surface. Thin stratas of varying textured soils are present throughout this soil as evidence of flooding events.

Associated soil series include: Bergstrom, Bosque, Bunyan, Frio, Gowen, Highbank, Hopco, Kemp, Oakalla, Pursley, Seguin, Uhland, Weswood, Whitesboro, and Yahola.

Table 4. Representative soil features

Surface texture	(1) Loam (2) Fine sandy loam (3) Silt loam
Family particle size	(1) Loamy
Drainage class	Well drained to somewhat poorly drained
Permeability class	Moderate to very slow
Soil depth	80 in
Surface fragment cover <=3"	0–2%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	5–7 in
Calcium carbonate equivalent (0-40in)	2–40%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–2
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–6%
Subsurface fragment volume >3" (Depth not specified)	0–2%

Ecological dynamics

Introduction – The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background – Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Florida paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsuta*), and dropseeds (Sporobolus spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak (*Quercus virginiana*) and hackberry (Celtis spp.) trees are also native to the region. In some areas, cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), and honey locust (*Gleditsia triacanthos*) are abundant. In the Northern Blackland Prairie oaks (Quercus spp.) are common increasers, but in the Southern Blackland Prairie oaks are less prevalent. Junipers are common invaders, particularly in the northern part of the region.

During the first half of the nineteenth century, row crop agriculture lead to over 80 percent of the original vegetation lost. During the second half, urban development has caused even an even greater decline in the remaining prairie. Today, less than one percent of the original tallgrass prairie remains. The known remaining blocks of intact prairie range from 10 to 2,400 acres. Some areas are public, but many are privately owned and have conservation easements.

Current State – Much of the area is classified as prime farmland and has been converted to cropland. Most areas where native prairie remains have histories of long-term management as native hay pastures. Tallgrasses remain dominant when haying of warm-season grasses is done during the dormant season or before growing points are elevated, meadows are not cut more than once, and the cut area is deferred from grazing until frost.

Due to the current-widespread farming, the Northern Blackland Prairie is still relatively free from the invasion of brush that has occurred in other parts of Texas. In contrast, many of the more sloping have experienced heavy brush encroachment, and the continued increase of brush encroachment is a concern. The shrink-swell and soil cracking characteristics of the soils favor brush species with tolerance for soil movement.

Current Management – Rangeland and pastureland are grazed primarily by beef cattle. Horse numbers are increasing rapidly in the region, and in recent years goat numbers have increased significantly. There are some areas where dairy cattle, poultry, goats, and sheep are locally important. Whitetail deer, wild turkey, bobwhite quail, and dove are the major wildlife species, and hunting leases are a major source of income for many landowners in this area.

Introduced pasture has been established on many acres of old cropland and in areas with deeper soils. Coastal bermudagrass (*Cynodon dactylon*) and kleingrass (*Panicum coloratum*) are by far the most frequently used introduced grasses for forage and hay. Hay has also been harvested from a majority of the prairie remnants, where long-term mowing at the same time of year has possibly changed the relationships of the native species. Cropland is found in the valleys, bottomlands, and deeper upland soils. Wheat (Triticum spp.), oats (Avena spp.), forage and grain sorghum (Sorghum spp.), cotton (Gossypium spp.), and corn (*Zea mays*) are the major crops in the region.

Fire Regimes – The prairies were a disturbance-maintained system. Prior to European settlement (pre-1825), fire and infrequent, but intense, short-duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes - Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases. Wet periods allow tallgrasses to increase in dominance. These natural disturbances cause shifts in the states and communities of the ecological sites.

State and transition model

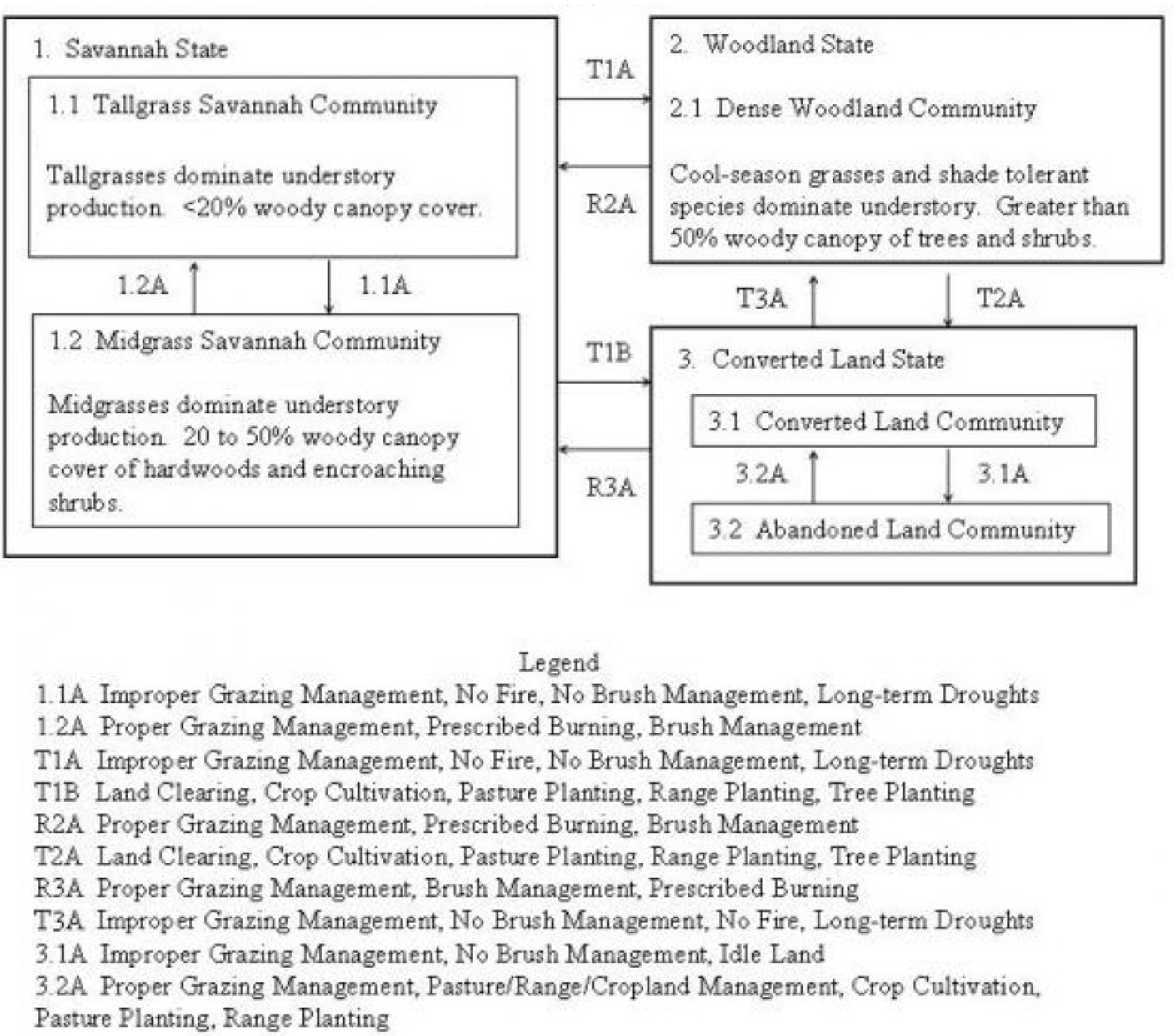

Figure 6. STM

State 1
Savannah

Two communities exist in the Savannah State: the 1.1 Tallgrass Savannah Community and the 1.2 Midgrass Savannah Community. Community 1.1 is characterized by tallgrasses dominating the understory with woody species creating less than 20 perecent of the canopy cover. Community 1.2 is characterized by midgrasses dominating the understory and woody species making up 20 to 50 perecent of the overstory canopy cover.

Community 1.1
Tallgrass Savannah

The Tallgrass Savannah Community (1.1) is the reference community and is characterized as a hardwood savannah with up to 20 percent tree and shrub canopy cover. Historic records in the 1700's do, however, indicate that early settlers and explorers found portions of this site to be heavily wooded. Other reports (Mann 2004) discuss the importance of human caused fire as an important factor in keeping open grasslands prior to European settlement. It is assumed the Tallgrass Savannah Community (1.1) occurred over the majority of this ecological site in a dynamically shifting mosaic over time with the other communities in the Savannah State. Canopy cover drives the transitions between plant communities and states because of the influence of shade and interception of rainfall. Eastern gamagrass, Virginia wildrye, Canada wildrye (*Elymus canadensis*), sedges (Carex spp.), switchgrass, Indiangrass, big bluestem, little bluestem, beaked panicum (*Panicum anceps*), and rustyseed paspalum (*Paspalum langei*) dominate the herbaceous component of the site. Forbs commonly found on the site include tickclover (Desmodium spp.), wildbeans (Strophostyles spp.), lespedezas (Lespedeza spp.), and partridge pea (*Chamaecrista fasciculata*). Shrub and tree species found in the Tallgrass Savannah Community (1.1) include species of oaks (Quercus spp.), pecan (Carya illinoensis), hackberry, and elm (Ulmus spp.). Vines include greenbrier (Smilax spp.), grape (Vitis spp.), honeysuckle (Lonicera spp.), and peppervine (Ampelopsis spp.). The reference savannah community will shift to the Midgrass Savannah Community (1.2) under the stresses of improper grazing. The first species to decrease in dominance will be the most palatable grasses and forbs (namely, eastern gamagrass, Indiangrass, and big bluestem). This will initially result in an increase in composition of little bluestem and paspalums. If improper grazing continues, little bluestem will decrease and midgrasses such as broomsedge bluestem (*Andropogon virginicus*) and Vaseygrass (*Paspalum urvillei*) will increase in composition. Less palatable forbs will also increase at this stage. Without fire and/or brush control, woody species on the site will increase and transition the site to the Woodland State. This can occur with or without the understory transitioning to the midgrass community. This transition can occur without degradation of the herbaceous community from dominance by tallgrasses to dominance by midgrasses. Brown and Archer (1999) concluded that even with a healthy and dense stand of grasses, woody species will populate the site and eventually dominate the community. Because the woody species that dominate in the Woodland State are native species that occur as part of the Savannah State, the transition to the Woodland State is a linear process with shrubs starting to increase soon after fire or brush control ceases. Unless some form of brush control takes place, woody species will increase to the 50 percent canopy cover level that indicates a state change. This is a continual process. Managers need to detect the increase in woody species when canopy is less than 50 percent and take management action before the state change occurs. There is not a 10-year window before shrubs begin to increase followed by a rapid transition to the Woodland State. The drivers of the transition (lack of fire and lack of brush control) constantly pressure the system towards the Woodland State. The soils of this site are deep, loamy textured, and moderately permeable. The site generally receives additional water from outside the site. Infiltration is moderate and runoff is low. There is essentially no bare soil in this community. Plant basal cover and litter comprise all of the ground cover. Soils are highly fertile and hold moderately large amounts of soil moisture. This is a very productive site with high yields of good quality forage.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	3000	4500	6375
Shrub/Vine	800	1200	1700
Forb	200	300	425
Total	**4000**	**6000**	**8500**

Community 1.2
Midgrass Savannah

The Midgrass Savannah Community (1.2) typically results from improper cattle grazing management over a long period of time combined with a lack of brush control. Indigenous or invading woody species increase on the site (with or without fire). Growing season stress, usually from overgrazing, causes reduction in vigor and survival of tallgrasses, which allows midgrasses and less palatable forbs to increase in the herbaceous community. When the Midgrass Savannah Community (1.2) is continually overgrazed and fire is excluded, the community shifts to a community dominated by woody plants, the Dense Woodland Community (2.1). Important grasses are little bluestem, broomsedge bluestem (*Andropogon virginicus*), bushy bluestem (*Andropogon glomeratus*), and Vaseygrass. Unpalatable, shade-tolerant grasses and forbs begin replacing the midgrasses. Examples include cocklebur (*Xanthium spinosum*), sumpweed (Cyclachaena xanthifolia), and beebalm (Monarda spp.). Shaded conditions favor cool-season grasses such as Texas wintergrass and woodoats (Chasmanthium spp.). Woody canopy varies between 30 and 50 percent, depending on the severity of grazing, fire interval, amount of brush control, and availability of increaser species. Numerous shrub and tree species will encroach because overgrazing by livestock has reduced grass cover, exposed more soil, and reduced grass fuel for fire. Typically, trees such as oaks and ash (Fraxinus spp.) will increase in size, while other tree and shrub species such as bumelia (Sideroxylon spp.), sumacs (Rhus spp.), honey locust, winged elm (*Ulmus alata*), and osage orange (*Maclura pomifera*) will increase in density. To control woody species populations, prescribed grazing and/or browsing and fire can be used to control smaller shrubs and trees, and mechanical removal of larger shrubs and trees may be necessary in older stands. Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to erosion. Litter and mulch will move off-site as plant cover declines. Increasing woody dominants are oaks and eastern red cedar (*Juniperus virginiana*). Once the tallgrasses have been reduced on the site, woody species cover exceeds 50 percent canopy cover, and the woody plants within the grassland portion of the savannah reach fire-resistant size (over three feet in height), the site crosses a threshold into the Woodland Community (2.1) in the Woodland State (2). Until the Midgrass Savannah Community (1.2) crosses the threshold into the Dense Woodland Community (2.1), this community can be managed back toward the Savannah State (1.1) through the use of management practices including prescribed grazing, prescribed burning, and strategic brush control. It may take several years to achieve this state, depending upon the climate and the aggressiveness of the treatment. Once invasive woody species begin to establish, returning fully to the native community is difficult, but it is possible to return to a similar plant community. Potential exists for soils to erode to the point that irreversible damage may occur. If soil-holding herbaceous cover decreases to the point that soils are no longer stable, the shrub overstory will not prevent erosion of the A and B soil horizons. This is a critical shift in the ecology of the site. Once the A horizon has eroded, the hydrology, soil chemistry, soil microorganisms, and soil physics are altered to the point where intensive restoration is required to restore the site to another state or community. Simply changing management (improving grazing management or controlling brush) cannot create sufficient change to restore the site within a reasonable time frame.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1500	2400	3000
Shrub/Vine	750	1200	1500
Forb	250	400	500
Total	**2500**	**4000**	**5000**

Pathway 1.1A
Community 1.1 to 1.2

Tallgrass Savannah

Midgrass Savannah

The Tallgrass Savannah Community (1.1) requires fire and/or brush control to maintain woody species cover below 20 percent. This community will shift to the Midgrass Savannah Community (1.2) when there is continued growing season stress on tallgrasses. These stresses include improper grazing management that creates insufficient critical growing season deferment, excess intensity of defoliation, repeated, long-term growing season defoliation, and long-term drought. Increaser species (midgrasses and woody species) are generally endemic species released by disturbance. Woody species canopy exceeding 20 percent and/or dominance of tallgrasses falling below 50 percent of species composition indicate a transition to the Midgrass Savannah Community. The Tallgrass Savannah Community can be maintained through the implementation of brush management combined with properly managed grazing that provides adequate growing season deferment to allow establishment of tallgrass propagules and/or the recovery of vigor of stressed plants. Regardless of grazing management, without some form of brush control, the Tallgrass Savannah Community will transition to the Woodland State even if the understory component does not shift to dominance by midgrasses. The driver for community shift 1.1A for the herbaceous component is improper grazing management, while the driver for the woody component is lack of fire and/or brush control.

Pathway 1.2A
Community 1.2 to 1.1

Midgrass Savannah

Tallgrass Savannah

The Midgrass Savannah Community (1.2) will return to the Tallgrass Savannah Community (1.1) with brush control and proper grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. The understory component may return to dominance by tallgrasses in the absence of fire (at least until shrub canopy cover reaches 50 percent). Reduction of the woody component will require inputs of fire and/or brush control. The understory and overstory components can act independently when canopy cover is less than 50 percent, meaning, an increase in shrub canopy cover can occur while proper grazing management creates an increase in desirable herbaceous species. The driver for community shift 1.2A for the herbaceous component is proper grazing management, while the driver for the woody component is fire and/or brush control.

State 2

Woodland

Only one community is in the Woodland State, the 2.1 Dense woodland Community. Community 2.1 is characterized by cool-season and shade-tolerate grasses dominating the understory. Woody species occupy greater than 50 percent of the overstory.

Community 2.1
Dense Woodland

The Dense Woodland Community (2.1) has over 50 percent woody plant canopy, dominated by hardwoods such as pecan and oaks. The community loses its savannah appearance with native shrubs beginning to fill the open grassland portion of the savannah. Shade from overstory is the driving factor. This community results from the lack of effective brush control. Annual herbage production decreases due to a decline in soil structure and organic matter. Production of the overstory canopy has increased by a similar amount to the decrease in herbaceous production. All unpalatable woody species have increased in size and density. Common understory and midstory species that grow under a dense canopy include the following grasses and grasslikes: Panicums, paspalums, tridens (Tridens spp.), woodoats, wildryes, Texas wintergrass, bristlegrass (Setaria spp.), sedges, flatsedges (Cyperus spp.) rushes (Juncus spp.), and fimbry (Fimbristylis spp.). Forbs include: western ragweed (*Ambrosia psilostachya*), blood ragweed (*Ambrosia trifida* var. texana), sumpweed (*Iva angustifolia*), cocklebur, mare's tail (Equisetum spp.), and cattail (*Typha latifolia*). Trees, shrubs, and vines include: Elm (Ulmus spp.), bumelia (*Sideroxylon lanuginosum*), sumacs (Rhus spp.), hawthorn (Crataegus spp.), buttonbush (*Cephalanthus occidentalis*), grape (Vitis spp.), greenbriar (Smilax spp.), and ivy treebine (Cissus incisa). Texas wintergrass, threeawns (Aristida spp.) and annuals increase in the shade of the trees. Unpalatable invaders may occupy the interspaces between trees and shrubs. Plant vigor and productivity of grass species is reduced due to shade. Shade is a driving factor for the understory plant community. Without brush control, tree canopy will continue to increase until canopy cover approaches 80 percent. In this plant community, annual production is dominated by woody species. Browsing animals such as goats and deer can find fair food value if browse plants have not been grazed excessively. Forage quantity and quality for cattle is low. Prescribed fire is not a viable treatment option for conversion of this site back to a semblance of the Tallgrass Savannah Community. Chemical brush control on a large scale may not a treatment option; however, individual plant treatment with herbicides on small acreages may be a viable option. Mechanical treatment of this site, along with seeding, is the most viable treatment option although it may not be economical.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	2800	4000	5600
Grass/Grasslike	350	550	700
Forb	350	550	700
Total	**3500**	**5100**	**7000**

State 3

Converted Land

Two communities exist in the Converted State: 3.1 Converted Land Community and the 3.2 Abandoned Land Community. The 3.1 Community is characterized by agricultural production. The site may be planted to improved pasture for hay or grazing. The site may otherwise be planted to row crops. The 3.2 community represents an agricultural state that has not been managed. The land is colonized by first successional species.

Community 3.1
Converted Land

The Converted Land Community (3.1) occurs when the site, either the Savannah State (1) or Woodland State (2), is cleared and plowed for planting to cropland, hayland, native grasses, tame pasture, or use as non-agricultural land. The Converted State includes cropland, tame pasture, hayland, rangeland, and go-back land. Agronomic practices are used with non-native forages in the Converted State and to make changes between the communities in the Converted State. The native component of the prairie is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed. The Loamy Bottomland site is frequently converted to cropland or tame pasture sites because of its deep fertile soils, favorable soil/water/plant relationship, and level terrain. Hundreds of thousands of acres have been plowed up and converted to cropland, pastureland, or hayland. Small grains are the principal crop, and Bermudagrass is the primary introduced pasture species on loamy soils in this area. The Loamy Bottomland site can be an extremely productive forage producing site with the application of optimum amounts of fertilizer. Cropland, pastureland, and hayland are intensively managed with annual cultivation and/or frequent use of herbicides, pesticides, and commercial fertilizers to increase production. Both crop and pasturelands require weed and shrub control because seeds remain present on the site, either by remaining in the soil or being transported to the site. Converted sites require continual fertilization for crops or tame pasture (particularly Bermudagrass) to perform well. Common introduced species include coastal Bermudagrass, kleingrass, and Old World bluestems (Bothriochloa spp.) which are used in hayland and tame pastures. Wheat, oats, forage sorghum, grain sorghum, cotton, and corn are the major crop species. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. Without agronomic inputs, the site will eventually return to either the Savannah or Woodland state. The site is considered go-back land during the period between active management for pasture or cropland and the return to a native state.

Community 3.2
Abandoned Land

The Abandoned Land Community (3.2) occurs when the Converted Land Community (3.1) abandoned or mismanaged. Mismanagement can include poor crop or haying management. Pastureland can transition to the Abandoned Land Community when subjected to improper grazing management (typically long-term overgrazing). Heavily disturbed soils allowed to “go-back” return to the Woodland State. These sites may become an eastern red cedar brake over time. Long-term cropping can create changes in soil chemistry and structure that make restoration to the reference state very difficult and/or expensive. Return to native prairie communities in the Savannah State is more likely to be successful if soil chemistry, microorganisms, and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference (or near reference) conditions. Restoration to native prairie will require seedbed preparation and seeding of native species. Protocols and plant materials for restoring prairie communities is a developing portion of restoration science. Sites can be restored to the Savannah State in the short-term by seeding mixtures of commercially-available native grasses. With proper management (prescribed grazing, weed control, brush control) these sites can come close to the diversity and complexity of Tallgrass Savannah Community (1.1). It is unlikely that abandoned farmland will return to the Savannah State without active brush management because the rate of shrub increase will exceed the rate of recovery by desirable grass species. Without active restoration the site is not likely to return to reference conditions due to the introduction of introduced forbs and grasses. The native component of the prairie is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed.

Pathway 3.1A
Community 3.1 to 3.2

The Converted Land Community (3.1) will transition to the Abandoned Land Community (3.2) if improperly managed as cropland, hayland, or pastureland. Each of these types of converted land is unstable and requires constant management input for maintenance or improvement. This community requires inputs of tillage, weed management, brush control, fertilizer, and reseeding of annual crops. The driver of this transition is the lack of management inputs necessary to maintain cropland, hayland, or pastureland.

Pathway 3.2A
Community 3.2 to 3.1

The Abandoned Land Community (3.2) will transition to the Converted Land Community (3.1) with proper management inputs. The drivers for this transition are weed control, brush control, tillage, proper grazing management, and range or pasture planting.

Transition T1A
State 1 to 2

Shrubs and trees make up a portion of the plant community in the Savannah State, hence woody propagules are present. Therefore, the Savannah State is always at risk for shrub dominance and the transition to the Woodland State in the absence of fire. The driver for Transition T1A is lack of fire and/or brush control. The mean fire return interval in the Savannah State is two to five years. Most fires will burn only the understory. Even with proper grazing and favorable climate conditions, lack of fire for 8 to 15 years will allow trees and shrubs to increase in canopy to reach the 50 percent threshold level. The introduction of aggressive woody invader species increases the risk and accelerates the rate at which this transition state is likely to occur. This transition can occur from any community within the Savannah State, it is not dependent on degradation of the herbaceous community, but on the lack of some form of brush control. Improper grazing and prolonged drought will provide a competitive advantage to shrubs which will accelerate this process. Tallgrasses will decrease to less than five percent species composition.

Transition T1B
State 1 to 3

The transition to the Converted State from either the Savannah State is plowed for planting to cropland or hayland. The size and density of brush will require heavy equipment and energy-intensive practices (i.e. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration of the Woodland State to the Savannah State requires substantial energy input. The driver for this restoration pathway is removal of invasive woody species, restoration of native herbaceous and overstory species, and ongoing management of invasives. Without maintenance, invasive species are likely to return (probably rapidly) due to presence of propagules in the soil.

Transition T2A
State 2 to 3

The transition to the Converted State from the Woodland State (T2A) occurs when the Savannah is plowed for planting to cropland or hayland. The size and density of brush in the Woodland State will require heavy equipment and energy-intensive practices (i.e. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration from the Converted State can occur in the short-term through active restoration or over the long-term due to cessation of agronomic practices. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. If the soil chemistry and structure have not been overly disturbed (which is most likely to occur with tame pasture) the site can be restored to the Savannah State. Heavily disturbed soils are more likely to return to the Woodland State. Without continued disturbance from agriculture the site can eventually return to either the Savannah or Woodland State. The level of disturbance while in the converted state determines whether the site restoration pathway is likely to be R3A (a return to the Savannah State) or T3A (a return to the Woodland State). Return to native prairie communities in the Savannah State is more likely to be successful if soil chemistry and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions. Converted sites can be returned to the Savannah State through active restoration, including seedbed preparation and seeding of native grass and forb species. Protocols and plant materials for restoring prairie communities are a developing part of restoration science. The driver for both of these restoration pathways is the cessation of agricultural disturbances.

Transition T3A
State 3 to 2

Transition to the Shrubland State (2) occurs with the cessation of agronomic practices. The site will move from the Abandoned Land Community when woody species begin to invade. After shrubs and trees have established over 50 percent, and reached a height greater than three feet, the threshold has been crossed. The driver for the change is lack of agronomic inputs, improper grazing, no brush management, and no fire.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			2000–4250	
	Indiangrass	SONU2	*Sorghastrum nutans*	400–1625	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	400–1625	–
	big bluestem	ANGE	*Andropogon gerardii*	400–1625	–
	switchgrass	PAVI2	*Panicum virgatum*	400–1500	–
	little bluestem	SCSCS	*Schizachyrium scoparium var. scoparium*	400–1500	–
2	**Tall/Midgrasses**			800–1700	
	Canada wildrye	ELCA4	*Elymus canadensis*	200–750	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	200–750	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	200–750	–
	Florida paspalum	PAFL4	*Paspalum floridanum*	200–750	–
3	**Midgrasses/Grasslikes**			200–425	
	beaked panicgrass	PAAN	*Panicum anceps*	200–425	–
	rustyseed paspalum	PALA11	*Paspalum langei*	200–425	–
	panicgrass	PANIC	*Panicum*	200–425	–
	vine mesquite	PAOB	*Panicum obtusum*	200–425	–
	redtop panicgrass	PARI4	*Panicum rigidulum*	200–425	–
	gaping grass	STHI3	*Steinchisma hians*	200–425	–
	white tridens	TRAL2	*Tridens albescens*	200–425	–

	purpletop tridens	TRFL2	*Tridens flavus*	200–425	–
	longspike tridens	TRST2	*Tridens strictus*	200–425	–
	sedge	CAREX	*Carex*	100–375	–
	Indian woodoats	CHLA5	*Chasmanthium latifolium*	100–375	–
	longleaf woodoats	CHSE2	*Chasmanthium sessiliflorum*	100–375	–
	cylinder jointtail grass	COCY	*Coelorachis cylindrica*	100–375	–
	nimblewill	MUSC	*Muhlenbergia schreberi*	100–375	–
Forb					
4	**Forbs**			200–425	
	Texan great ragweed	AMTRT	*Ambrosia trifida var. texana*	200–425	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	200–425	–
	ticktrefoil	DESMO	*Desmodium*	200–425	–
	lespedeza	LESPE	*Lespedeza*	200–425	–
	dotted blazing star	LIPU	*Liatris punctata*	200–425	–
	snoutbean	RHYNC2	*Rhynchosia*	200–425	–
	fuzzybean	STROP	*Strophostyles*	200–425	–
	ironweed	VERNO	*Vernonia*	200–425	–
	white crownbeard	VEVI3	*Verbesina virginica*	200–425	–
Shrub/Vine					
5	**Shrubs/Vines/Trees**			800–1700	
	pecan	CAIL2	*Carya illinoinensis*	600–1125	–
	hackberry	CELTI	*Celtis*	600–1125	–
	American sycamore	PLOC	*Platanus occidentalis*	600–1125	–
	eastern cottonwood	PODE3	*Populus deltoides*	600–1125	–
	oak	QUERC	*Quercus*	600–1125	–
	black willow	SANI	*Salix nigra*	600–1125	–
	ash	FRAXI	*Fraxinus*	600–1125	–
	elm	ULMUS	*Ulmus*	600–1125	–
	grape	VITIS	*Vitis*	200–375	–
	honeysuckle	LONIC	*Lonicera*	200–375	–
	saw greenbrier	SMBO2	*Smilax bona-nox*	200–375	–
	hawthorn	CRATA	*Crataegus*	200–375	–
	peppervine	AMPEL3	*Ampelopsis*	200–375	–
	Alabama supplejack	BESC	*Berchemia scandens*	200–375	–

Animal community

This ecological site provides habitat which supports a resident animal community that is inhabited by white-tailed deer, Wild Turkey, and squirrels. Migratory waterfowl may use these sites if they are flooded during the late fall and winter. The riparian vegetation provides good cover for wildlife and produces browse, mast, tender grazing, and seeds for a year-round supply.

Hydrological functions

Under the Tallgrass Savannah Community (1.1), site infiltration is rapid, soil organic matter is high, soil structure is good, sediments are trapped, and porosity is high. The site will have high quality surface runoff with low erosion and sedimentation rates. During periods of heavy rainfall, the high infiltration rates will allow water to fill the soil profile. The large trees will dissipate flood energy and the root masses will bind the soil. The grasses will lie flat to also protect the soils much like the shingles on a roof. The Tallgrass Savannah Community should have no rills and no gullies present. Drainageways should be vegetated and stable. This site is often in a floodplain with occasional out-of-bank flow.

Under the Dense Woodland Community (2.1) leaf litter can build up to the point that herbaceous vegetation can be suppressed. Shading also suppresses warm season grasses. The large wood can dissipate flood energy, trap sediments, and the root masses help bind the soil. This is a stable community with no rills or gullies.

Improper grazing management reduces composition of bunchgrasses and reduces ground cover (resulting in a transition to the Midgrass Savannah Community, 1.2). This decreases the function of the water cycle: infiltration declines and runoff increases due to poor ground cover, rainfall splash, soil capping, low organic matter and poor structure. Combining sparse ground cover with intensive rainfall creates conditions that increase the frequency and severity of flooding. The decline in the quality of the understory component and the increase in shrub canopy cover cause soil erosion to accelerate, surface runoff quality to decline, and sedimentation to increase. Streambank stability will decline and erosion of waterways will increase.

In the Woodland State interception of rainfall by tree canopies increases. This reduces the amount of rainfall reaching the soil surface. The funneling effect of the canopy increases stemflow and soil moisture at tree bases. Trees have increased transpiration compared to grasses, especially evergreen species such as live oak and juniper. The increased transpiration reduces the amount of water available for other plants to use. An increase in woody canopy creates a decline in grass cover, which has similar impacts as those described for improper grazing above.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Hardwoods are used for posts, firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as and wild grape. Seeds are harvested from many reference plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants. This is a very good site for pecan production.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

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Approval

David Kraft, 5/06/2020

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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)	Lem Creswell, RMS, NRCS, Weatherford, Texas
Contact for lead author	817-596-2865
Date	06/01/2005

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:** Water flow patterns are common and follow old stream meanders. Deposition or erosion is uncommon for normal rainfall but may occur during intense rainfall events.

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

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Essentially none. Site has litter filling interspaces between plant bases.

5. **Number of gullies and erosion associated with gullies:** No gullies should be present on side drains into perennial or intermittent streams. Drainageways should be vegetated and stable.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site is a floodplain with occasional out of bank flow. Under normal rainfall, little litter movement should be expected; however, litter of all sizes may move long distances due to obstructions during high flows.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Stability class ranges expected to be 4 to 6.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 0 to 9 inches thick with colors from reddish brown silty clay loam to dark grayish brown loams and generally weak fine and medium subangular blocky structure. SOM is 0.5 to 3 percent.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Under reference conditions, this bottomland site is dominated by tall grasses and forbs having adequate litter and little bare ground and provides for maximum infiltration and little runoff under normal rainfall events.

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 tallgrasses >

    Sub-dominant: Cool-season grasses >> Warm-season midgrasses > Trees

    Other: Forbs > Shrubs/Vines

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Grasses, trees, and forbs due to their growth habit will exhibit some mortality and decadence, though very slight due to long-lived nature of plants. Open spaces from disturbance are quickly filled by new plants through seedlings and vegetative reproduction (tillering).

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14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 4,000 to 8,500 pounds per acre.

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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:** Yellow bluestems, common Bermudagrass, mesquite, elms, huisache, eastern red cedar, osage orange, Chinese tallow.

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17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing except during periods of prolonged drought conditions, heavy natural herbivory, prolonged flooding, or intense wildfires.

Ecological site R081CY360TX
Low Stony Hill 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/12/2022

General information

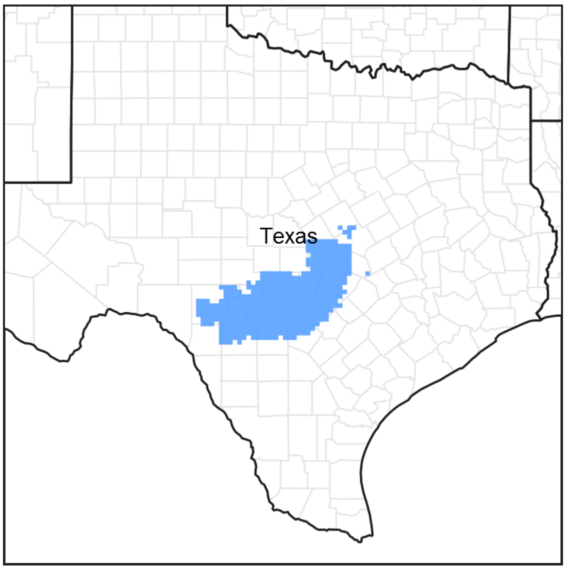

Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. The elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

These sites occur on very shallow and shallow clay loam soils over indurated limestone bedrock. The reference vegetation includes tall and midgrasses along with numerous forbs and scattered mottes of live oak. Without fire or brush management, juniper and other woody species are likely to increase across the site.

Associated sites

R081CY355TX	**Adobe 29-35 PZ** The Adobe ecological site and Low Stony Hill ecological sites occur in much the same areas with the Adobe ecological site steeper in nature and many times separating Low Stony Hill from Steep Adobe.
R081CY357TX	**Clay Loam 29-35 PZ** The Clay Loam ecological site will be encountered down the slope from the Low Stony Hill ecological site. The Clay Loam ecological site will be associated more with the concentrated drainage that low stony hill runoff will enter.
R081CY358TX	**Deep Redland 29-35 PZ** The Deep Redland ecological site usually has post oak with a reddish colored soil that is slightly acidic to neutral.

Similar sites

R081CY574TX	**Shallow 29-35 PZ** The fact that both of these sites are shallow in nature that are underlain by limestone make them similar. The Shallow ecological site generally has more depth and less surface bedrock.
R081CY355TX	**Adobe 29-35 PZ** The Adobe ecological site has a higher pH soil.

Table 1. Dominant plant species

Tree	(1) *Quercus fusiformis*
Shrub	Not specified
Herbaceous	(1) *Schizachyrium scoparium* (2) *Bouteloua curtipendula*

Physiographic features

This is an upland site. Slope gradients are mainly 1 to 8 percent but can range up to 12 percent. Slopes exceeding 12 percent are classified as Steep Rocky. The very shallow to shallow, well-drained, moderately slow permeability soils of this site were formed in residuum over interbedded limestone, marls, and chalk. The site will receive runoff from the associated Steep Rocky Ecological Site.

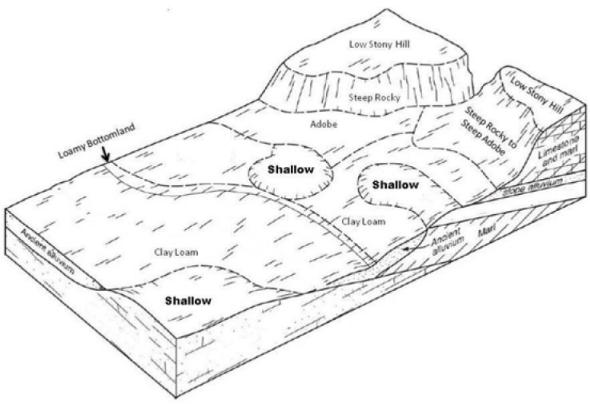

Figure 2. Block Diagram of Low Stony Hill Site

Table 2. Representative physiographic features

Landforms	(1) Ridge
Flooding frequency	None
Ponding frequency	None

Elevation	1,200–2,200 ft
Slope	1–12%
Water table depth	60 in
Aspect	Aspect is not a significant factor

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below “normal” at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This being an upland site, it is not influenced by water from a wetland or stream.

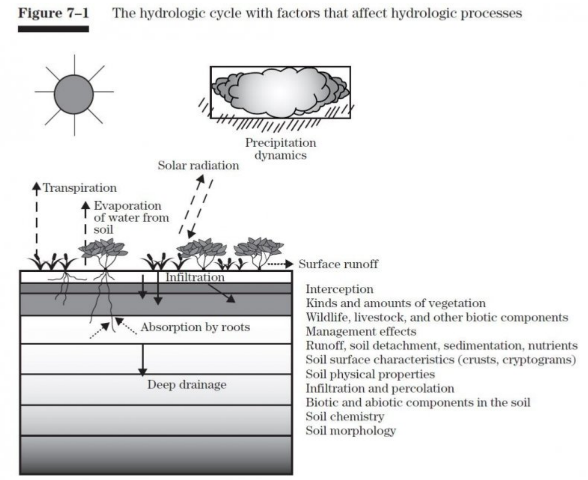

Figure 9.

Soil features

In a representative profile for the Low Stony Hill ecological site, these soils are very shallow or shallow to indurated limestone. Depth of bedrock ranges from 4 to 20 inches. The soil is a black clayey soil and is neutral to alkaline. Subrounded to angular pebbles, cobbles, and stones of limestone comprise 35 to 70 percent by volume of the soil. Surface fragments reduce surface evaporation and help protect palatable grasses and forbs from overuse. The soils are fertile, usually have good structure, and take in water readily. Their fertility and moisture-holding capacity, however, is limited by soil depth and fragment volume. Fractures in the limestone bedrock, on the other hand, generally contain fine soil particles and store moisture. Plant roots penetrate these cracks and crevices, and thus have access to more moisture and plant nutrients than is apparent in the soil. Forage produced on the site is of good quality. These sites occur on interfluves and sideslopes of ridges on dissected plateaus.

Due to the scale of mapping, there are inclusions of minor components of other soils within these mapping units. Before performing any inventories, conduct a field evaluation to ensure the soils are correct for the site.

The representative soil associated with the Low Stony Hill ecological site is Eckrant. These are the representative map units associated with the Low Stony Hill ecological site:

Eckrant association, undulating
Eckrant cobbly clay, 1 to 8 percent slopes
Eckrant-Comfort association, gently undulating
Eckrant-Rock outcrop association, undulating

Table 4. Representative soil features

Parent material	(1) Residuum–limestone
Surface texture	(1) Clay loam (2) Clay
Drainage class	Well drained
Permeability class	Very slow
Soil depth	4–20 in
Surface fragment cover <=3"	5–15%
Surface fragment cover >3"	10–25%
Available water capacity (0-40in)	0.5–1.8 in

Calcium carbonate equivalent (0-40in)	1–8%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	15–30%
Subsurface fragment volume >3" (Depth not specified)	20–40%

Ecological dynamics

The reference plant community, which was a diverse open grassland with scattered Texas live oak (*Quercus fusiformis*) motts and trees, is the diagnostic or reference plant community. The information contained in this description is based on historical accounts, previous range site descriptions, field data, and professional consensus. Grass species included little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), sideoats grama (*Bouteloua curtipendula*), and some Eastern gamagrass (*Tripsacum dactyloides*). Other important species include green sprangletop (*Leptochloa dubia*), Texas wintergrass (*Nassella leucotricha*), and kidneywood (*Eysenhardtia texana*). Continued overuse, exacerbated by droughts, has brought about the removal of these and many other species from a large portion of the site. Low successional, unpalatable grasses, forbs, and shrubs have taken the place of the more desirable plant species. The loss of topsoil and soil organic matter makes it almost impossible for these abused areas to return to the reference plant community in a reasonable period of time. The diversity of native forbs and grasses has been dramatically reduced, while the presence of introduced and non-native species seems to be increasing daily. However, little bluestem and other native species will slowly return to the site with a sound range management program mimicking the historic management.

A study of early photographs of this region reveals that today these sites are much denser with woody cover and less covered with grasslike vegetation. Early accounts consistently describe this region as a vast expanse of hills covered with "cedar" from San Antonio to Austin. Accounts also describe an abundance of clean, flowing water and abundant wildlife. These accounts seem to describe heavy wooded areas in mosaic patterns occurring along the highs and lows of the landscape. The shallow soils of the Low Stony Hill site are located on the footslopes of hills in the area.

The plant communities of this site are dynamic and vary in relation to grazing, fire, and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006). Historical records are not specific on the Low Stony Hill site but do reflect area observations. From the Teran expedition in 1691, “great quantities of buffaloes” were noted in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). Another example is an early settler, Arnold Gugger, who wrote in his journal about the mid to late 1800s in the Helotes, Texas area, “in those days buffaloes were in droves by the hundreds…..and antelopes were three to four hundred in a bunch….and deer and turkeys at any amount” (Massey, 2009).

Many research studies document the interaction of bison grazing and fire (Fuhlendorf, et al., 2008). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This usually long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape both in structure and composition.

Species, such as Ashe juniper (*Juniperus ashei*), would invade the site, but not at the level seen today. Periodic fires set either by Native Americans or by lightning kept Ashe juniper and other woody species under control. Woody plant control would vary in accordance with the intensity and severity of the fire encountered, which resulted in a mosaic of vegetation types within the same site.

The periodic fires kept Ashe juniper (a non-sprouter) and other woody species suppressed except for the area where fuel loads were sparse or terrain precluded burning. Ashe juniper did occur on the site, but not near the level seen today because of its fire sensitivity. The degree of suppression of re-sprouting woody plants would vary in accordance with the type of fire encountered, which resulted in a mosaic of vegetation types within the same site and changing over time.

Ashe juniper will increase regardless of grazing. Goats and possibly sheep will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997). The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn.

Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become nonexistent under dense juniper canopies. Many times there is a resurgence of the better grasses such as little bluestem when Ashe juniper is controlled and followed by proper grazing management. Seeds and dormant rootstocks of many plant species are contained in the leaf mulch and duff under the junipers.

Currently, cattle, white-tailed deer, horses, and exotic animals are the primary large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which allowed population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Because of their impacts on livestock production, large predators such as red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus), and eventually coyotes (Canis latrins) were reduced in numbers or eliminated (Schmidly, 2002).

The screwworm fly (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker, 1965; Bushland, 1985).

Currently, due to the increase in land ownership for recreational purposes and a corresponding reduction in livestock production, predator populations are on the increase. This includes feral hogs (Sus scrofa).

Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition, and monitoring of habitat quality has been effective on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of exotic ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium- and small-sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity.

The tall grasses aided in increasing the infiltration of rainfall into the slowly permeable soil. The loss of soil organic matter because of overgrazing has a negative effect on infiltration. More rainfall is directed to overland flow, which causes increased soil erosion and flooding. Soils are also more prone to drought stress since organic matter acts like a sponge aiding in moisture retention for plant growth. Mulch buildup under the Ashe juniper canopy, following brush management and incorporation into the soil, can have a positive effect on increasing infiltration.

This site contains a large diversity of plants and this document does not attempt to cover them all. The intent of this document is to describe ecological processes on representative plants.

Plant Communities and Transitional Pathways (diagram)
A State and Transition Diagram for the Low Stony Hill Ecological Site (R081CY360TX) is depicted in this report. Descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to

change as knowledge increases.

Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal; other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are described as are other metrics. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover can drive the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

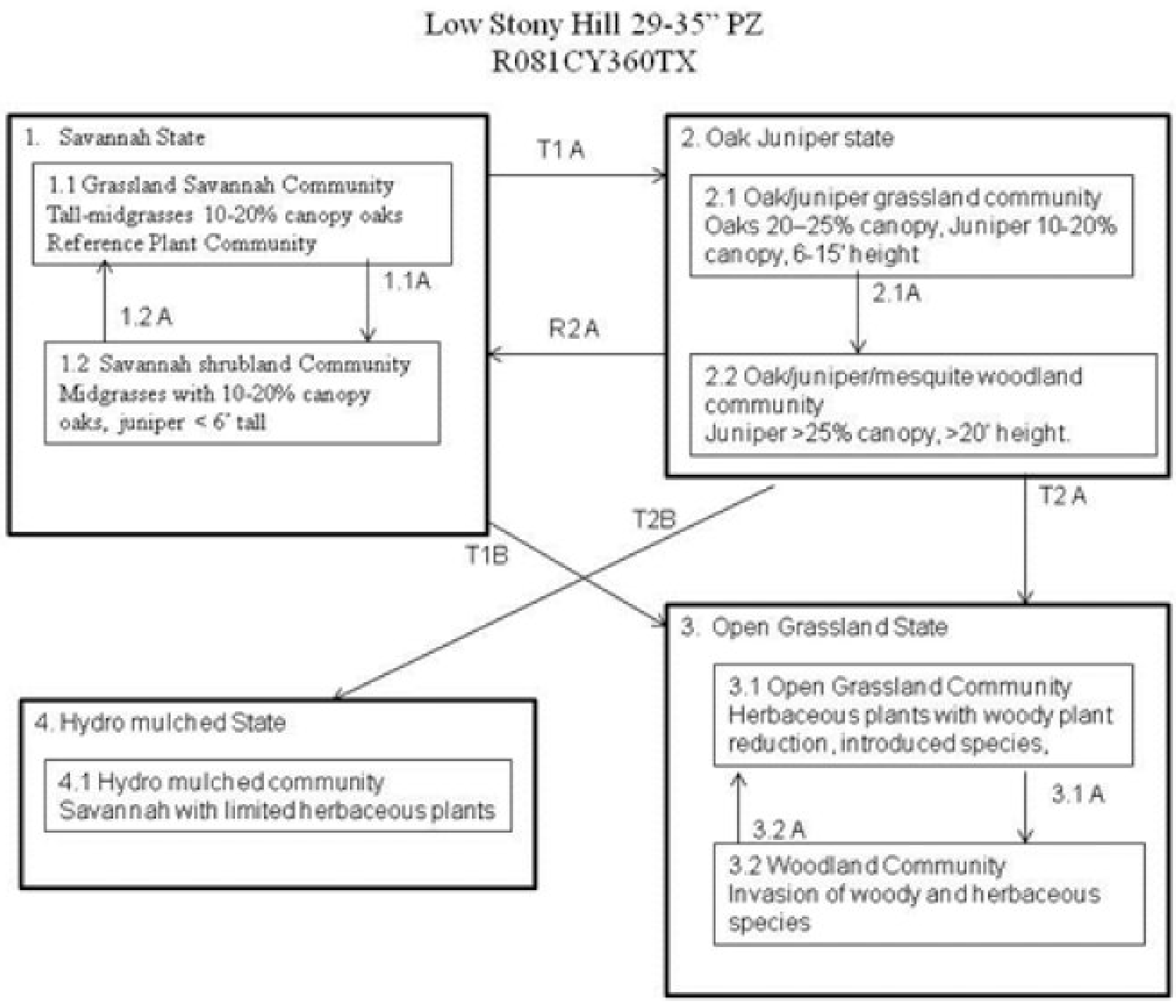

Figure 10. State and Transition Diagram for Low Stony Hill

State 1

Savannah State

Community 1.1
Grassland Savannah Community

Figure 11. 1. Open Grassland with Oak Mottes Community

Figure 12. Grassland State, Eckrant Soil

Figure 13. Grassland State, Eckrant Soil

The data for this community is derived from field data collections and professional consensus. This site is a fire managed, open grassland with scattered oak mottes with about 10 to 20 percent tree canopy. The live oak is most abundant along watercourses, where elm (Ulmus spp.) and hackberry (Celtis spp.) trees also grow. Under a fire regime, the live oak can exist both as a tree and as a mott or thicket as it is a vigorous root sprouter. The herbaceous plant community is dominated by little bluestem. Indiangrass and big bluestem are subdominants, and may even dominate locally. Also native to the site, but occurring less frequency or in lesser amounts are the wildryes (Elymus spp.), Sideoats grama, tall dropseed (*Sporobolus compositus*), feathery bluestems (Bothriochloa spp.), green sprangletop (*Leptochloa dubia*), vine mesquite (*Panicum obtusum*), Texas wintergrass (*Nassella* *leucotricha*), and Texas cupgrass (*Eriochloa sericea*). The site also grows an abundance of forbs, shrubs and woody vines. Overstocking and thus overgrazing by domesticated animals can cause a decline and even the elimination of numerous plants from this community. As the plant community degenerates, big bluestem, little bluestem, Indiangrass, and the wildryes decrease. Sideoats grama, tall dropseed, silver bluestem, Texas wintergrass, and buffalograss (*Bouteloua dactyloides*) are initial increasers on the site. Prolonged overuse of these plants usually results in a community of Texas wintergrass, curlymesquite (*Hilaria belangeri*), buffalograss, and woody species. The following grasses and forbs are commonly found on this site in a deteriorated condition: Western ragweed (*Ambrosia psilostachya*), Broomweed (Amphiachyris spp.), prairie coneflower (*Ratibida columnifera*), Snow-on-the-Mountain (*Euphorbia marginata*), silverleaf nightshade (*Solanum elaeagnifolium*), milkweeds (Asclepias spp.), Leavenworth eryngo (*Eryngium leavenworthii*), twin-leaf senna (Cassia roemariana), gray goldaster (*Heterotheca canescens*), horehound (Marrabium vulgare), evax (Evax spp.), Texas grama (*Bouteloua rigidiseta*), hairy tridens (*Erioneuron pilosum*), red grama (*Bouteloua trifida*), tumblegrass (Schedonnardus panniculatus), windmillgrasses (Chloris spp.), and annual brome grasses (Bromus spp.).

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1430	1950	2275
Forb	330	450	525
Tree	330	450	525
Shrub/Vine	110	150	175
Total	**2200**	**3000**	**3500**

Table 6. Ground cover

Tree foliar cover	0-20%
Shrub/vine/liana foliar cover	0-15%
Grass/grasslike foliar cover	5-40%
Forb foliar cover	0-15%
Non-vascular plants	0%
Biological crusts	0-3%
Litter	70-80%
Surface fragments >0.25" and <=3"	5-10%
Surface fragments >3"	10-25%
Bedrock	5-10%
Water	0%
Bare ground	0-10%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-2%	5-10%	5-10%
>0.5 <= 1	–	0-5%	5-15%	5-15%
>1 <= 2	–	0-10%	15-40%	5-15%
>2 <= 4.5	0-5%	0-15%	0-10%	0-10%
>4.5 <= 13	5-15%	5-15%	–	–
>13 <= 40	5-20%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 15. Plant community growth curve (percent production by month). TX3760, Warm Season Native Grasses. Native warm season grasses on rangeland with scattered oaks/junipers..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Community 1.2
Savannah Shrubland Community

Figure 16. Photo 4. Savannah Shrubland Community, Eckrant So

Figure 17. Photo 5 Savannah Shrubland Community

This community closely resembles the reference plant community of an open grassland with interspersed mottes of live oak and other oak species. The elimination of fire and brush management will allow for the invasion of woody plant species, both native and non-native. The main woody species to invade the site is Ashe juniper, usually introduced in wildlife droppings. The dominate grass species for the site are little bluestem, Indiangrass, big bluestem, and sideoats grama. There may be a shift from a little bluestem dominated plant community to a sideoats grama-Texas wintergrass-Silver bluestem (*Bothriochloa laguroides*) dominated plant community. This community with Ashe juniper of 5 feet or less in height presents a critical decision point for the land resource manager and is at risk of crossing a threshold. Applying a prescribed burn or individual plant treatment of Ashe juniper at this time will allow the site to move back towards the reference plant community at a more reasonable cost than waiting until the juniper is too big. Once juniper gets to about 10 feet high, then options for fire and individual plant treatment become more limited. Applying no control methods at this time will allow the juniper to increase in size and density with a corresponding reduction in fine fuel production. The community is at risk and will transition to the Oak /Juniper State (2). To move from this community back toward the Savannah State (1) will take a more considerable investment of resources if not treated now.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1302	1800	2100
Forb	330	450	525
Tree	330	450	525
Shrub/Vine	220	300	350
Total	**2182**	**3000**	**3500**

Figure 19. Plant community growth curve (percent production by month). TX3782, Open Grassland with Juniper Encroachment.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	7	13	20	15	7	5	10	7	5	5

Pathway 1.1A
Community 1.1 to 1.2

Grassland Savannah Community

Savannah Shrubland Community

Heavy continuous grazing/browsing reduces leaf tissue of palatable plants resulting in loss of sunshine energy through plants to the root system. This results in a less frequent fire regime. Woody species become established.

Pathway 1.2A
Community 1.2 to 1.1

Savannah Shrubland Community

Grassland Savannah Community

Restoration of energy capture by tall grasses and mid grasses by implementing prescribed grazing and a return of fire will restore the plant composition and energy cycle. In some instances, IPT (Individual Plant Treatment) brush management is needed to selectively remove unwanted plants.

State 2

Oak Juniper State

Community 2.1
Oak/Juniper Grassland Community

Figure 20. Photo 6. Oak/Juniper Grassland Community

Figure 21. Photo 7. Oak/ Juniper Grassland Community

Figure 22. Photo 8 Oak/Juniper Grassland Community

Figure 23. Photo 10. Oak/Juniper Grassland Community

Figure 24. Photo 9. Oak/Juniper Grassland

The Oak/Juniper Grassland (2.1) developed because fire and brush management were removed. Many times brush has to increase to this level before natural resource managers recognize there is a problem. The cost involved in returning this to an open grassland community can be 2 to 4 times the cost of controlling the invading species in the previous community of Savannah Shrubland (1.2) since the threshold has been crossed. Herbaceous production of the key grazing plants such as little bluestem, Indiangrass, and sideoats grama is negatively impacted. Production may be reduced by 30 to 50 percent. There is no longer enough fine fuel to conduct a conventional prescribed burn. The decision to not perform brush management at this time will allow the site to transition to the Oak/Juniper/Mesquite Woodland Community (2.2). The invasion of juniper seems to build exponentially.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	675	1125	1350
Tree	450	750	900
Shrub/Vine	225	375	450
Forb	150	250	300
Total	**1500**	**2500**	**3000**

Figure 26. Plant community growth curve (percent production by month). TX3762, Oak/Juniper Grassland. "Grassland with warm season grasses, oaks, and juniper.".

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	5	8	13	18	12	5	3	12	10	7	4

Community 2.2
Oak/Juniper/Mesquite Woodland Community

Figure 27. Photo 11. Oak/Juniper/Mesquite Woodland

Figure 28. Photo 12. Oak/Juniper/Mesquite Woodland

Figure 29. Photo 13. Oak/Juniper/Mesquite Woodland

Figure 30. Photo 14. Oak/Juniper/Mesquite Woodland

Figure 31. Photo 15. Oak/Juniper/Mesquite Woodland

Figure 32. Photo 16. Severe wildlfire in this plant community.

The Oak/Juniper/Mesquite Woodland Community (2.2) has developed as a result of a major vegetational shift from the original plant community, which was a grassland with scattered oak mottes, to a plant community which is predominately tall woody plants and limited tall grass vegetation. This site will exhibit Ashe juniper 20 feet tall and taller, with canopies in excess of 30 percent. Grasslike vegetation is significantly reduced because of the severe competition from woody species for sunlight, nutrients, and moisture. Large areas that were once vast grasslands are now infested with a heavy woody cover consisting of species such as Ashe juniper, live oak, honey mesquite (*Prosopis glandulosa*), algerita (Mahonia trifoliata), Texas persimmon (Diospryos texana), elbowbush (*Forestiera pubescens*), and lotebush (*Ziziphus obtusifolia*). Management alone will not allow this community to shift back towards the reference community. Implementation of brush management programs involving heavy equipment may be the only option if the decision-maker desires to transition this site back towards the reference plant community. Some form of brush removal or reduction is needed to release the herbaceous plants to build fuel for a burn. By implementing other conservation measures such as prescribed burning and prescribed grazing, through time the land manager can move the community more toward a savannah. The elimination of fire plus the lack of brush management or targeted goat grazing allowed Ashe juniper and other woody species to overtake this site. Woody species dominate the site in this community with Ashe juniper being dominant. Shade tolerant species such as cedar sedge (*Carex planostachys*) and uniola species (Uniola spp.) dominate the understory that is void of sunlight. The majority of the soil surface on this densely canopied site will have a thick mat of cedar duff and other woody tree and shrub leaf material. The open areas between canopies will produce a grass cover of primarily low successional species such as grammas, threeawns, tridens, and dropseeds. The total grasslike production potential for this community is severely restricted.

Table 10. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	600	1000	1200
Grass/Grasslike	450	750	900
Shrub/Vine	375	625	750
Forb	75	125	150
Total	**1500**	**2500**	**3000**

Figure 34. Plant community growth curve (percent production by month). TX3763, Oak/Juniper Woodland. Oak/Juniper Woodland.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	7	8	12	15	10	5	4	12	10	7	5

Pathway 2.1A
Community 2.1 to 2.2

Oak/Juniper Grassland Community

Oak/Juniper/Mesquite Woodland Community

Sunlight is now increasingly devoted to the woody plant community. The woody plant group is overtopping the herbaceous plant group. The hydrologic cycle favors the woody plant through interception and stem flow. Lack of brush management allows this to happen.

State 3
Open Grassland State

Community 3.1
Open Grassland Community

Figure 35. Photo 17. Open Grassland Community

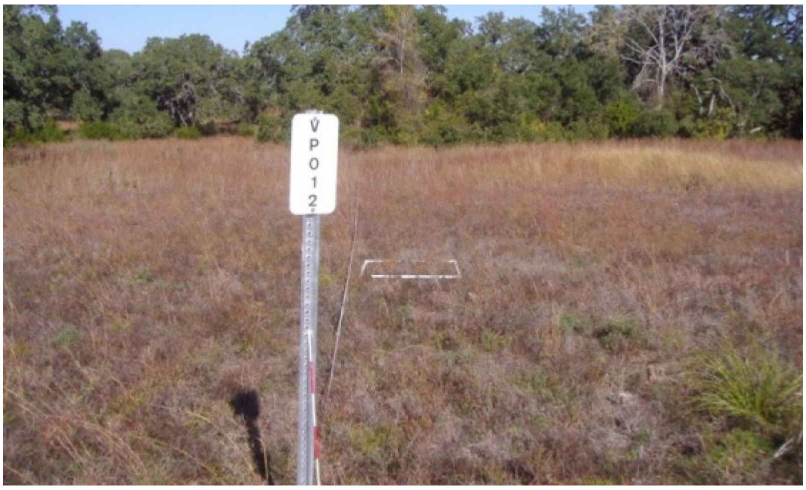

Figure 36. Photo 18. Open Grassland Community

In some cases, attempts were made to remove most of the woody species. Sometimes this would have been a management goal and other times it may be a result of futility trying to farm a deeper soil phase of this site. Species composition of the grass and forb groups may be similar to that outlined under the reference plant community provided that the area has not been overgrazed for a number of years. If the area has been overgrazed for a number of years, then seeding will be required for the site to move back towards the reference plant community. Restoration of the site may have been done by range seeding which included exotic grasses or they may have been introduced to the site via hay, livestock, or wildlife. Examples of these grasses include old world bluestems (*Bothriochloa ischaemum*) and silky bluestem (*Dichanthium sericeum*). These plants have the ability to establish quickly and potentially dominate a site. Unless there was long term farming, which was rare, the woody plants will also re-establish. Many times these plants include some invasive natives such as persimmon, algerita, and others. Live oak and associated shrub species will need to be reduced significantly for the site to begin resembling the reference plant community (1). As time goes by, juniper will establish on the site. If integrated management action such as goat and/or possibly sheep grazing (Anderson, 2013), brush management or fires are not implemented, in as little as 5 to 10 years, the juniper and other species will have increased to the point where they utilize most of the sun's energy and the herbaceous cover declines. The fuel for prescribed burning is lost. This plant community is at risk for transitioning into the Woodland Community (3.2). Fire and other brush management options will maintain the site in the Open Grassland (3.1) community. It will be difficult and one must be persistent as most of these species are resprouting species.

Table 11. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1870	2550	2975
Shrub/Vine	110	150	175
Tree	110	150	175
Forb	110	150	175
Total	**2200**	**3000**	**3500**

Figure 38. Plant community growth curve (percent production by month). TX3768, Oak Motte/Shrubland. Oak motts with shrubs..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	5	8	13	18	12	5	3	12	10	7	4

Community 3.2
Woodland Community

Without woody plant control, the Ashe juniper and mixed woody plants will increase until they dominate the site. At that point, a threshold has been crossed resulting in the Woodland Community (3.2). Fire is limited as a control method because of the lack of fuel to burn and the size of the juniper. It is doubtful any amount of deferment will restore the fuel load. In these cases, mechanical intervention is required. Additional seeding may be required and can restore some plant diversity to move this plant community back to the Open Grassland Community (3.1).

Table 12. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	750	1250	1750
Shrub/Vine	525	875	1225
Grass/Grasslike	150	250	350
Forb	75	125	175
Total	**1500**	**2500**	**3500**

Figure 40. Plant community growth curve (percent production by month). TX3768, Oak Motte/Shrubland. Oak motts with shrubs..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	5	8	13	18	12	5	3	12	10	7	4

Pathway 3.1A
Community 3.1 to 3.2

The re-establishment of juniper and other woody species changes sunlight capture from herbaceous plants more to woody species. Rainfall again is captured in canopy or by stem flow to the base of woody species. The exotic grasses can function much the same as the native grasses hydrologically. Lack of intervention by IPT and fire allow this to shift. This shift can occur in as little as 5 years.

Pathway 3.2A
Community 3.2 to 3.1

If brush management and prescribed grazing are implemented, sunlight will be restored to the herbaceous plant community. The hydrologic cycle will be restored more to a grassland. Because of the exotic species, this community will not return to the Savannah State (1).

State 4
Mulched State

Community 4.1
Mulched Community

Figure 41. Photo 19. Mulched Community

Figure 42. Photo 20. Mulched Community

Figure 43. Photo 21. Mulched Community

Figure 44. Photo 22. Mulched Community

This plant community is a result of using mechanical mulching to reduce canopy and structure of dense woody species which is usually juniper. The amounts of mulch on the ground and the orientation of the mulch are dependent upon the amount of woody cover treated and the time since treatment. The mulch tends to settle over time and is very resistant to deterioration. This community can structurally appear very similar to the reference plant community but without the herbaceous cover. The understanding of how this plant community reacts over time is unknown but studies are currently underway to monitor. One result is that the soil is protected for a long time. There will be a need for maintenance to treat juniper and other species as they re-establish.

Table 13. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	2125	2720	3230
Forb	125	160	190
Grass/Grasslike	125	160	190
Shrub/Vine	125	160	190
Total	**2500**	**3200**	**3800**

Figure 46. Plant community growth curve (percent production by month). TX3783, Hydro-Mulched Community. Scattered Oaks and shrubs in a heavily mulched area..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	3	25	30	15	1	5	10	5	2	1

Transition T1A
State 1 to 2

Sunlight energy is being captured more by woody plants than by herbaceous plants. An increasing amount of rainfall is entrapped in the juniper canopy with less entering the soil rooting zone. Continued overgrazing/browsing, lack of the fire, and lack of brush management are responsible. Drought can hasten the process although a long term severe drought can result in the death of juniper.

Transition T1B
State 1 to 3

Mis-applied, brush management removes most of the woody species to restore the energy capture back to herbaceous plants. Range seeding is applied that sometimes includes exotic herbaceous species or they are introduced through hay, livestock, or wildlife. The hydrologic cycle resembles the reference plant community.

Restoration pathway R2A

State 2 to 1

Brush management and range planting, if needed, will change the plant community back to a more herbaceous plant community to capture sunlight. The hydrology is reclaimed with a higher percentage of rainfall entering the root zone for use by herbaceous plants. Fire and brush management will be needed to maintain the recovery.

Transition T2A
State 2 to 3

Mis-applied, brush management removes most of the woody species to restore the energy capture back to herbaceous plants. Range seeding is applied that sometimes includes exotic herbaceous species or they are introduced through hay, livestock, or wildlife. The hydrologic cycle resembles the reference plant community.

Transition T2B
State 2 to 4

Mechanical conversion of primarily juniper canopy to a mulch cover restores the energy flow to the remaining species, usually oak. The hydrologic cycle retains nearly all the rainfall because of the heavy mulch. Little evaporation takes place.

Additional community tables

Table 14. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrass**			1100–1450	
	little bluestem	SCSC	*Schizachyrium scoparium*	850–1100	–
	Indiangrass	SONU2	*Sorghastrum nutans*	150–250	–
	big bluestem	ANGE	*Andropogon gerardii*	150–250	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	50–100	–
2	**Midgrasses**			250–350	
	sideoats grama	BOCU	*Bouteloua curtipendula*	100–200	–
	vine mesquite	PAOB	*Panicum obtusum*	100–150	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	50–100	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	50–100	–
	green sprangletop	LEDU	*Leptochloa dubia*	25–50	–
3	**Midgrasses**			150–250	
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	75–100	–
	Drummond's dropseed	SPCOD3	*Sporobolus compositus var. drummondii*	50–100	–
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	75–100	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	50–75	–
	slim tridens	TRMU	*Tridens muticus*	25–50	–
	threeawn	ARIST	*Aristida*	25–50	–
4	**Short Grasses**			50–150	
	buffalograss	BODA2	*Bouteloua dactyloides*	50–100	–
	curly-mesquite	HIBE	*Hilaria belangeri*	50–100	–
	fall witchgrass	DICO6	*Digitaria cognata*	25–50	–
5	**Cool Season Grasses**			0–100	

	Canada wildrye	ELCA4	*Elymus canadensis*	50–100	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	50–100	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	50–100	–
	cedar sedge	CAPL3	*Carex planostachys*	25–50	–
Forb					
6	**Forbs**			40–100	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	25–50	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	25–50	–
	Berlandier's sundrops	CABE6	*Calylophus berlandieri*	25–50	–
	prairie clover	DALEA	*Dalea*	25–50	–
	zarzabacoa comun	DEIN3	*Desmodium incanum*	25–50	–
	bundleflower	DESMA	*Desmanthus*	25–50	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	25–50	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	25–50	–
	eastern milkpea	GARE2	*Galactia regularis*	25–50	–
	trailing krameria	KRLA	*Krameria lanceolata*	25–50	–
	dotted blazing star	LIPU	*Liatris punctata*	25–50	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	25–50	–
	yellow puff	NELU2	*Neptunia lutea*	25–50	–
	beardtongue	PENST	*Penstemon*	25–50	–
	snoutbean	RHYNC2	*Rhynchosia*	25–50	–
	meadow checkerbloom	SICA2	*Sidalcea campestris*	25–50	–
	fuzzybean	STROP	*Strophostyles*	25–50	–
	Forb, annual	2FA	*Forb, annual*	1–25	–
Shrub/Vine					
7	**Shrubs/Vines**			100–200	
	stretchberry	FOPU2	*Forestiera pubescens*	50–150	–
	bastard oak	QUSI	*Quercus sinuata*	50–100	–
	winged sumac	RHCO	*Rhus copallinum*	50–100	–
	gum bully	SILAO	*Sideroxylon lanuginosum ssp. oblongifolium*	25–50	–
	greenbrier	SMILA2	*Smilax*	25–50	–
	western white honeysuckle	LOAL	*Lonicera albiflora*	25–50	–
	algerita	MATR3	*Mahonia trifoliolata*	25–50	–
	Texas redbud	CECAT	*Cercis canadensis var. texensis*	25–50	–
	Texas persimmon	DITE3	*Diospyros texana*	25–50	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	25–50	–
Tree					
8	**Trees**			300–600	
	Texas live oak	QUFU	*Quercus fusiformis*	150–400	–
	Nuttall oak	QUTE	*Quercus texana*	25–100	–
	hackberry	CELTI	*Celtis*	50–100	–
	Eve's necklacepod	STAF4	*Styphnolobium affine*	0–100	–

	elm	ULMUS	*Ulmus*	50–100	–
	Ashe's juniper	JUAS	*Juniperus ashei*	25–50	–
	walnut	JUGLA	*Juglans*	25–50	–
	littleleaf leadtree	LERE5	*Leucaena retusa*	25–50	–
	black cherry	PRSE2	*Prunus serotina*	0–50	–
	sandpaper oak	QUVA5	*Quercus vaseyana*	0–50	–

Animal community

This site is used for the production of domestic livestock and to provide habitat for native wildlife and certain species of exotic wildlife. The site is somewhat accessible to use by cattle but is more accessible to deer, sheep, Angora goats, and meat goats. Global Positioning Systems studies reveal slopes above 11 percent are generally less accessible to cattle while sheep and goats can utilize slopes up to 45 percent. Also revealed is that cattle will avoid a site once it contains about 30 percent surface rocks. (Hanselka, et al.)

Cow-calf operations are the primary livestock enterprise although stocker cattle are also grazed. Sheep and goats were formerly raised in large numbers and are still present in reduced numbers. Carrying capacity has declined drastically over the past 100 years because of the deterioration of the reference plant community. A field assessment of vegetation is needed to determine stocking rates based on the forage needs of desired animal species.

Many species, including domestic livestock, use more than one ecological site to meet their habitat needs.

Managing all the grazing/browsing animals is important to keep populations in balance and provide an economically important ranching enterprise. Achieving a balance between woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep, and goats is an important consideration in livestock and wildlife management and can cause damage to preferred vegetation.

Smaller mammals include many kinds of rodents, jackrabbit, cottontail rabbit, raccoon, skunks, opossum, and armadillo. Mammalian predators include coyote, red fox, gray fox, bobcat, and mountain lion. 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 Rio Grande turkey, bobwhite quail, and mourning dove. Turkey prefers plant communities with substantial amounts of shrubs and trees interspersed with grassland. Quail prefer plant communities with a combination of low shrubs, bunch grass, bare ground, and low successional forbs. The different species of songbirds vary in their habitat preferences. In general, a habitat that provides a large variety of grasses, forbs, shrubs, vines, and trees and a complex of grassland, savannah, shrubland, and woodland will support a good variety and abundance of songbirds. Prairie chickens (Tympanuchus spp.) were also noted in the general area. Birds of prey are important to keep the numbers of rodents, rabbits, and snakes in balance. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow and red deer, aoudad sheep, and blackbuck antelope. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. This is especially true for exotics such as axis deer which have the ability to switch their diet readily among different plant types rendering them highly competitive for the native white-tailed deer. Feral hogs are present and can cause damage when their numbers are not managed.

Plant Preference by Animal Kind:
This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition and diet overlap between kinds of herbivores. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. An animal’s preference or avoidance of certain plants is learned over time through grazing experience and maternal learning (http://extension.usu.edu/behave/Grazing). Preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food are rated. Refer to detailed habitat guides for a more complete description of a species habitat needs.

Legend
Rating Preference Description
P Preferred Percentage of plant in animal diet is greater than it occurs on the land
D Desirable Percentage of plant in animal diet similar to the percentage composition on the land
U Undesirable Percentage of plant in animal diet is less than it occurs on the land
N Not Consumed Plant would not be eaten under normal conditions. It is only consumed when other forages are not available
T Toxic Rare occurrence in diet and, if consumed in any tangible amounts results in death or severe illness in animal
X Used Degree of utilization unknown

Hydrological functions

The existing plant community with representative plant species, current soil conditions (soil health), current management, and climate determine the dynamics of the water cycle on this site. Plant and litter cover are important factors which protect the site from erosion; however, total production and particularly the types of plant species present have a greater impact on hydrologic dynamics infiltration capacity, runoff, and soil losses). For example, foliar cover values could be similar among the various states as depicted in the state and transition diagram; however, hydrology (infiltration capacity, water holding capacity, and runoff) will be different. The common denominator is not cover: the most important factors are the types of plants and their abundance on the site. Plant biomass of the desirable native grasses is the most important variable that is correlated with the hydrologic function on this site. Another important factor is the structure and morphology of the root system associated with plant species. Soil factors most associated with high hydrologic function are organic matter content, non-compacted soil surface (lower bulk density), intact soil structure, high porosity, high aggregate stability, and the presence of soil biotic factors, such as earthworms, fungi, blue-green algae, and mosses (when moist).

As the site becomes dominated by woody species, especially oaks and juniper, the water cycle altered. Interception of rainfall by tree canopies is increased which reduces the amount of rainfall reaching the surface. Stem flow is increased because of the funneling effect along the stems which increases soil moisture at the base of the tree. Increased transpiration, especially when evergreen species such as live oak and juniper dominate, provides less chance for deep percolation into aquifers. As woody species increase, grass cover declines, which causes some of the same results as heavy grazing, higher runoff, and erosion. Brush management combined with good grazing management can help restore the natural hydrology of the site.

The soils on this site are well drained with very low water holding capacity. Surface runoff can be rapid because of the slope and physiography of the site. Soils correlated with this site are in Hydrologic Groups C and D.

State 1: Savannah State
With reference to the transitional pathway diagram, the open grassland with oak mottes is associated with the maximum hydrologic function. The high degree of hydrologic function in State 1 is because of the dominance of rhizomatous tall and mid grasses (see narrative). As explained above, when properly managed, these species provide adequate cover. However, one of the keys to high hydrologic function is the structure or morphology of the root system. During high rainfall periods, water will percolate beyond the immediate surface root zone via fractures in the soil strata. As this water moves downward, it contributes to the recharge of aquifers if the underlying soils and geology are appropriate. When conditions are representative of the high composition of tall and midgrass species, little runoff occurs.

The reference plant community is dominated by tall bunchgrass species that are correlated with high hydrologic function. When conditions degrade, into states 2 and 3, the composition of desirable tall grasses decreases and mid and short grasses become more dominant. If soil conditions also degrade and management is consistent with overuse, hydrologic function decreases significantly.

The Grassland Savannah Community of State 1 features little bluestem as the dominant native grass species. The root system of little bluestem consists of a vast network of roots and masses of finely branched rootlets, some more than 30 inches in length. The largest roots are about 0.5 to 1mm in diameter. The soil beneath the grass crown and several inches to the sides are threaded with dense mats of roots to a depth of 4 to 5 feet. Stem bases and surface roots bind the soil in and around the plant bunches—most of the space between bunches is occupied by a dense network of roots. Litter cover accumulating during the winter months can provide protection from raindrop impact. Infiltration studies have shown that bluestem, Indiangrass, and sideoats grama are associated with higher infiltration capacity compared to other short-statured grasses which tend to have thicker fibrous surface roots (e.g., gramas, buffalograss, dropseeds, threeawn grasses). The thick fibrous root system of these grasses is associated with less infiltration capacity. (commonly associated with oat mottes), infiltration is rapid and immediate.

Model Predictions return periods based on 50 years climate data.
(Return)(Precip)(Runoff) (Erosion)
(Period)(in) (in) (t/ac)

(50 yr) (52.7) (10.1) (1.3)
(25 yr) (49.5) (5.8) (1.1)
(10 yr) (44.5) (3.2) (0.6)
(5 yr) (40.1) (1.7) (0.3)
(2.5 yr)(35.6) (0.5) (0.1)

(50 yr) (32.9) (0.9) (0.2)
(avg.)

Based on 50 years of climate data, there is an 82 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (0.2/0.9 = 0.2. For every 1.0 inch of runoff, 0.2 t/ac soil erosion.

Community 1.2 Savannah Shrubland Community
This state is associated with 10 to 20 percent juniper canopy. There is also a shift to less desirable grasses. The consequence is that the hydrologic function decreases.

Model Predictions return periods based on 50 years climate data.
(Return)(Precip)(Runoff) (Erosion)
(Period)(in) (in) (t/ac)

(50 yr) (52.7) (9.5) (4.3)
(25 yr) (49.5) (6.8) (2.7)
(10 yr) (44.5) (3.8) (2.1)
(5 yr) (40.1) (2.7) (1.0)
(2.5 yr)(35.6) (1.0) (0.6)

(50 yr) (32.9) (1.4) (0.7)
(avg.)

Based on 50 years of climate data, there is a 98 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (0.7/1.4 = 0.5. For every 1.0 inch of runoff, 0.5 t/ac soil erosion.

State 2: Oak-Juniper State
Woody species dominate the site in this community with Ashe juniper being the dominant plant.
Canopy exceeds 30 percent and shade tolerant species such as cedar sedge and uniola species dominate the understory that is void of sunlight. The majority of the soil surface on this densely canopied site will have a thick mat of cedar leaves and other woody tree and shrub leaf material. The open areas between canopies will produce a grass cover of primarily low successional species such as gramas, threeawns, tridens, and dropseeds. The total grasslike production potential for this community is severely restricted. These grasses do not protect the soil as the rooting systems are more shallow than the bluestems and other tall native grass species. Patches of bare ground become connected in the interspaces between trees. Plants become pedestalled and litter may be found in debris dams or lodged against rocks and brush. A significant amount of soil erosion occurs in these interspace areas and often the surface soil is severely depleted in old juniper stands.

(Return)(Precip)(Runoff) (Erosion)
(Period)(in) (in) (t/ac)

(50 yr) (52.7) (11.8) (6.2)
(25 yr) (49.5) (7.4) (3.6)
(10 yr) (44.5) (4.1) (2.8)
(5 yr) (40.1) (3.5 (1.6)
(2.5 yr)(35.6) (1.7) (0.9)

(50 yr) (32.9) (1.8) (1.1)
(avg.)

Based on 50 years of climate data, there is a 100 percent chance there will be runoff and delivered sediment for these conditions. [Rangeland Hydrology and Erosion Model (RHEM) predictions—model calibrated from field data]. The average sediment to runoff ratio is (1.1/1.8 = 0.6. For every 1.0 inch of runoff, 0.6 t/ac soil erosion.

Recreational uses

This site has the appeal of the wide open spaces. The abundant tall and mid grasses and scattered oaks produce beautiful fall color variations. The area is also used for hunting, birding, and other eco-tourism related enterprises.

Wood products

Honey mesquite and oaks can be used for firewood and the specialty wood industry.

Inventory data references

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

Other references

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Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high-intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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.

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Contact for lead author	RMS, NRCS, Boerne, Texas
Date	06/29/2005
Approved by	Colin Walden
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, except following extremely high intensity storms when short flow patterns may exist.

3. **Number and height of erosional pedestals or terracettes:** None, except small ones in the shallowest part of the soil.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** 0-10 percent, non-connected.

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):** Minimal and short, less than 3-7".

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Stability class range is expected to be 5-6.

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

reddish brown clay surface with subrounded to angular pebbles, cobbles, and stones. Soil Organic Matter is 1 - 4 percent.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** High canopy of trees, bunch grasses and sod forming grasses, small interspaces should make rainfall impact negligible. Site is will drained, slowly permeable, 1-12 percent slopes.

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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):** No evidence of compaction.

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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 tallgrasses

    Sub-dominant: Warm-season midgrasses Cool-season grasses Trees

    Other: (S) warm season shortgrasses (M) forbs (M) shrubs (M).

    Additional: Forbs make up 3 percent species composition while trees and shrubs compose of 20 percent species composition.

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

---

14. **Average percent litter cover (%) and depth (in):** Litter is dominantly herbaceous.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 2200# for below average moisture years to 3500# for above average moisture years.

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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:** Ashe juniper, old world bluestems, prickly pear and mesquite.

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17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing, except during periods of prolonged drought conditions, heavy natural herbivory or intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R081CY361TX
Redland 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/26/2022

General information

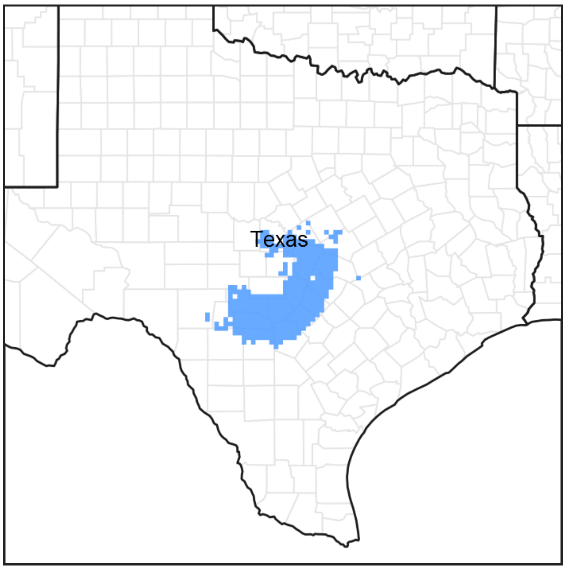

Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. The elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

The Redlands Ecological Site has non-calcareous soils over limestone. The reference vegetation is an oak savannah with mid and tallgrasses, forbs and few shrubs. Without periodic fire or brush management, woody species will likely increase and dominate the site.

Associated sites

R081CY355TX	**Adobe 29-35 PZ** The Adobe ecological site has sparser woody cover, much less production, more slope, and more caliche type soils of a higher pH with no post oak or blackjack oak.
R081CY360TX	**Low Stony Hill 29-35 PZ** The Low Stony Hill ecological site is generally higher in the landscape and is the plateau above the Redland with no post oak or blackjack oak.

Similar sites

R081CY358TX	**Deep Redland 29-35 PZ** The Deep Redland ecological site has deeper soils and is more productive.

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus fusiformis*
Shrub	Not specified
Herbaceous	(1) *Schizachyrium scoparium*

Physiographic features

This site is located in the 81C, Eastern Edwards Plateau Major Land Resource Area (MLRA). It is classified as an upland site. Soils occur on nearly level to moderately sloping upland plateaus and ridges. Slopes range from 0 to 8 percent. This site was formed in residuum from weathered limestone. These soils consist of shallow, well drained, slowly permeable soils that formed in calcareous clay residuum over indurated limestone bedrock of the Lower Cretaceous and Pennsylvania period. Elevation of this site ranges from 850 to 2200 feet above mean sea level. Runoff from these sites ranges from low to high and is directly correlated to slope percentage. This site will receive runoff from Adobe, Steep Adobe and Low Stony Hills ecological sites that normally occur along the site’s boundary.

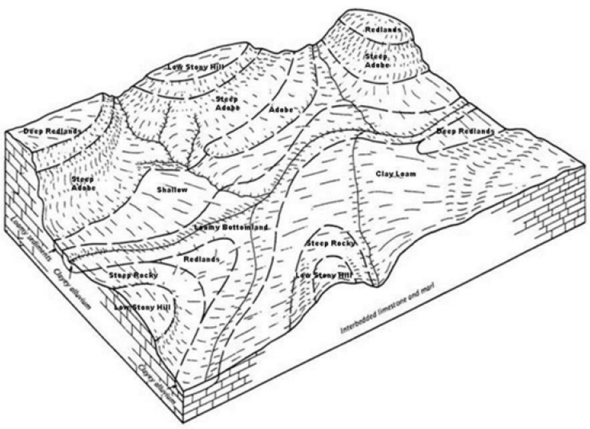

Figure 2. Redland 081CY361TX

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Plateau
Flooding frequency	None
Ponding frequency	None
Elevation	850–2,200 ft
Slope	0–8%
Water table depth	60 in

Aspect	Aspect is not a significant factor

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below “normal” at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This being an upland site, it is not influenced by water from a wetland or stream.

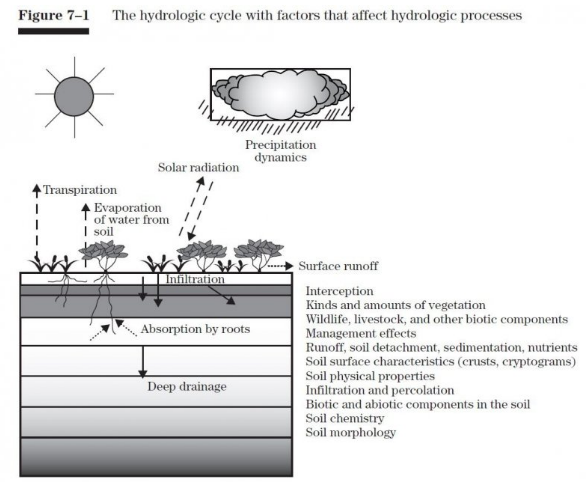

Figure 9.

Soil features

In a representative profile for the Redland ecological site, the soils are shallow, brown or reddish brown, fertile clays, and clay loams. They are underlain by slightly fractured indurated limestone bedrock at depths of 20 inches or less. Plant roots penetrate the crevices, which are usually filled with reddish brown clay. Limestone fragments, cherts, cobbles and stones sometimes occur on the surface and may make up as much as 25 percent of the soil by volume. When dry, the soils crack and take in water rapidly. When wet, the cracks close, and the soils become sticky and plastic and take in water slowly. Light showers are ineffective on the site, which favors the growth of deep-rooted perennial plants. When plant residues are inadequate, soil condition deteriorates and heavy surface crusts develop. In this condition water intake is very slow, runoff is rapid, erosion is a hazard, and grass recovery is slow. The stones on the surface reduce surface evaporation and help protect palatable grasses and forbs from overuse. The mineral content and reaction of these soils enable the site to produce highly nutritious forage. In association with other sites, Redland is usually the preferred grazing area. These sites occur on more stable hillslopes on dissected plateaus.

Due to the scale of mapping, there are inclusions of minor components of other soils within these mapping units. Before performing any inventories, conduct a field evaluation to ensure the soils are correct for the site.

The representative map units associated with the Redland ecological site are:

Hensley association, undulating
Tarpley association, undulating

Table 4. Representative soil features

Parent material	(1) Residuum–limestone
Surface texture	(1) Clay loam (2) Clay (3) Loam
Drainage class	Moderately well drained to well drained
Permeability class	Slow
Soil depth	16–20 in
Surface fragment cover <=3"	0–15%
Surface fragment cover >3"	0–2%
Available water capacity (0-40in)	1.1–3.2 in
Calcium carbonate equivalent (0-40in)	1–5%

Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.1–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–20%
Subsurface fragment volume >3" (Depth not specified)	0–10%

Ecological dynamics

The reference plant community is a post oak (*Quercus stellata*) Texas live oak (*Quercus fusiformis*) blackjack oak (*Quercus marilandica*) savannah, including little bluestem, (*Schizachyrium scoparium*) big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*) and eastern gamagrass (*Tripsacum dactyloides*). This is a very fertile and productive site. Because of the soil chemistry of this site with its neutral to sometimes slightly acidic pH, it is usually a preferred grazing site.

Natural plant mortality is very low with the major species producing seeds and vegetative structure each year in normal years. Litter cover is 100 percent. Physical soil crust is largely absent.

A study of early photographs of this region reveals that today these sites are much denser with woody cover and less covered with grasslike vegetation. Early accounts consistently describe this region as a vast expanse of hills covered with "cedar" from San Antonio to Austin. Accounts also describe an abundance of clean, flowing water and abundant wildlife. These accounts seem to describe heavy wooded areas in mosaic patterns occurring along the highs and lows of the landscape.

The plant communities of this site are dynamic and vary in relation to grazing, fire and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006). Historical records are not specific on the Redland site but do reflect area observations. From the Teran expedition in 1691, “great quantities of buffaloes” were noted in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). Another example is an early settler, Arnold Gugger, who wrote in his journal about the mid to late 1800s in the Helotes, Texas area, “in those days buffaloes were in droves by the hundreds…..and antelopes were three to four hundred in a bunch….and deer and turkeys at any amount” (Massey, 2009).

Many research studies document the interaction of bison grazing and fire (Fuhlendorf, et al., 2008). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This usually long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape both in structure and composition.

Historical fire frequencies for the region are suggested to be 13 to 25 years (Frost, 1998). When fires did occur, they were set either by Native Americans or by lighting. Woody plant control would vary in accordance with the intensity and severity of the fire encountered, which resulted in a mosaic of vegetation types within the same site.

Ashe juniper (*Juniperus ashei*) will increase regardless of grazing. Goats and possibly sheep will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997; Anderson, et al., 2013). The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn.

Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become non-existent under dense juniper canopies. Many times there is a resurgence of the better grasses such as little bluestem when Ashe juniper is controlled and followed by proper grazing management. Seeds and dormant rootstocks of many plant species are contained in the leaf mulch and duff under the junipers.

Currently, cattle, goats, white-tailed deer, sheep and exotic animals are the primary large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which allowed population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Because of their impacts on livestock production, large predators such as red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus) and eventually coyotes (Canis latrins) were reduced in numbers or eliminated (Schmidly, 2002).

The screwworm fly (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker, 1965; Bushland, 1985).

Currently, due to the increased land ownership for recreational purposes and a corresponding reduction in livestock production, predator populations are on the increase. This includes feral hogs (Sus scrofa).

Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition and monitoring of habitat quality has been effective on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of exotic ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium and small sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity.

The plants and topography aided in increasing the infiltration of rainfall into the moderately slowly permeable soil. Any loss of soil organic matter and plant cover has a negative effect on infiltration. More rainfall is directed to overland flow, which causes increased soil erosion and flooding. Soils are also more prone to drought stress since organic matter acts like a sponge aiding in moisture retention for plant growth. Mulch buildup under the Ashe juniper canopy, following brush management and incorporation into the soil, can have a positive effect on increasing infiltration.

This site contains a large diversity of plants and this document does not attempt to cover them all. The intent of this document is to describe ecological processes on representative plants.

European settlement occurred in the mid to late 1800s (Raunick, 2007). This time period also coincided with a stoppage of fire. It was during this time that large-scale fencing was initiated to help the introduction of livestock. Predators were also reduced to protect livestock. In many cases sheep and goats heavily utilized the site. Low successional, unpalatable grasses, forbs and shrubs have taken the place of the more desirable plant species. Non-preferred browse, such as juniper, fared well at the expense of the palatable browse. Juniper is undoubtedly the dominant woody plant over most of the site today.

During the early 1900''s, land managers recognized the soil''s ability to produce annual field crops for added food, forage, and hay. Some of the Redland Sites were put to the plow removing all of the historic species. As land managers decisions changed in the 1970''s thru today, many of the fields were reintroduced with non-native grasses such as bermudagrass (*Cynodon dactylon*), yellow bluestems (Bothriochloa spp.), and kleingrass (*Panicum coloratum*).

Plant Communities and Transitional Pathways (diagram):

A State and Transition Diagram for the Redland Ecological Site (R081CY361TX) is depicted in this report. Descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases.

Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal but can be. Other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are described as are other metrics. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover can drive the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

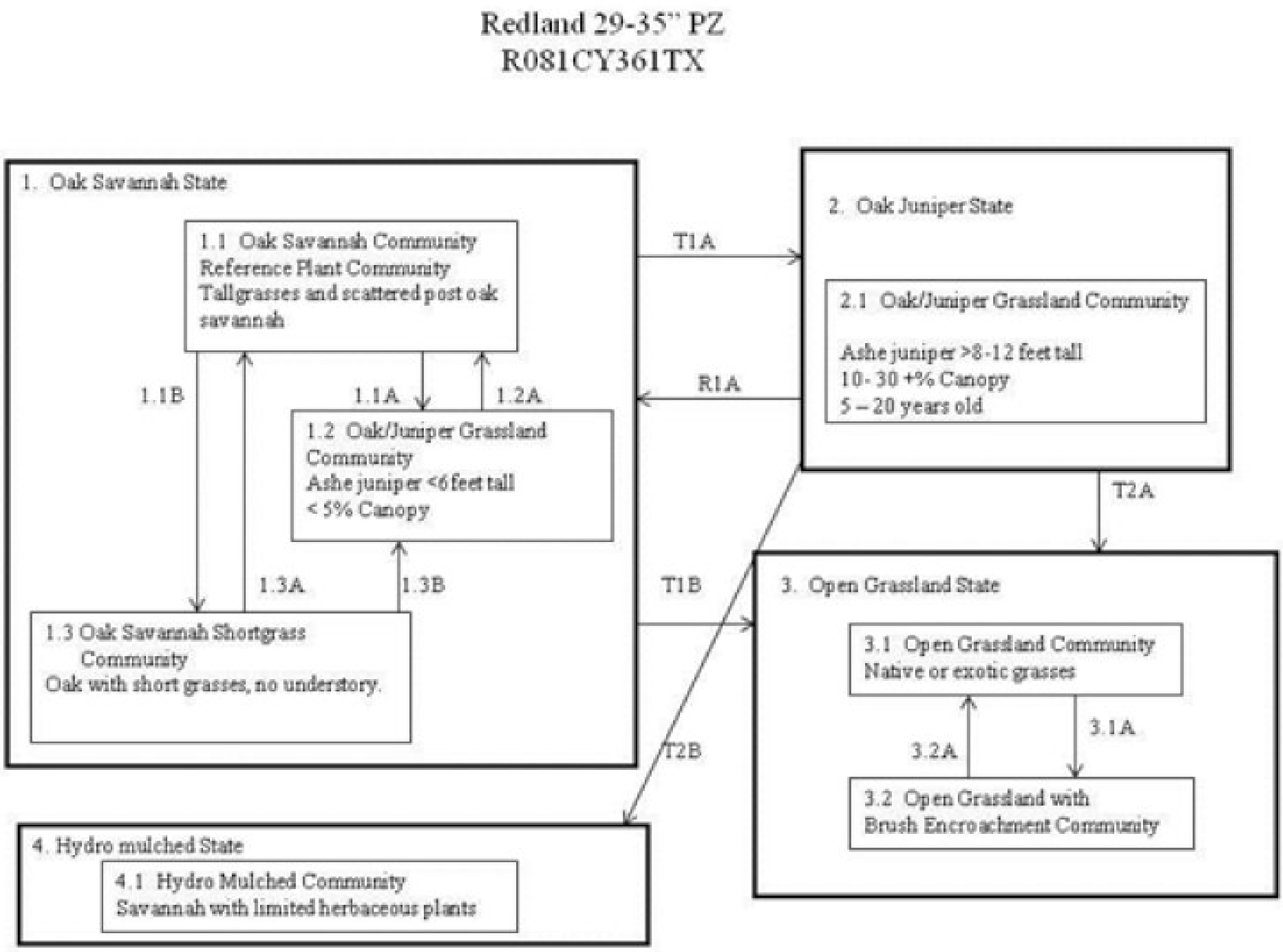

Figure 10. Redland 081CY361TX

State 1
Oak Savannah State

Tallgrasses and scattered post oak savannah.

Community 1.1
Oak Savannah Community

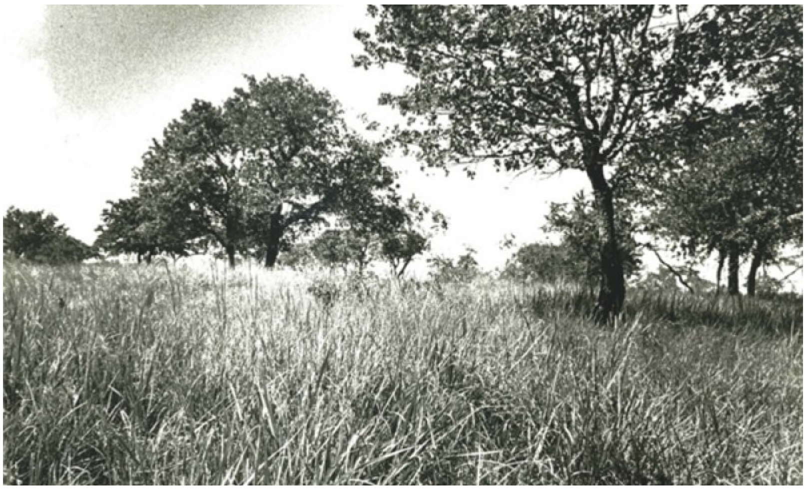

Figure 11. Redlands ecosite in near reference condition. Kendall County, Texas.

Figure 12. A near reference condition location in Blanco County, Texas.

Figure 13. Another near reference condition location in Blanco County, Texas.

The Oak Savannah Community (1.1) is the interpretive plant community. This plant community is a fire/grazing managed savannah composed of tall grasses. The overstory shades around10 percent of the site and consists primarily of post oak, but may include Bigelow oak (*Quercus buckleyi*), Texas red oak (*Quercus texana*), Texas live oak, blackjack oak and several associated species. The post oak and blackjack oak are signature key indicators of the Redland site. Occasionally however there may only be Texas live oak. The role of historic fire and bison grazing was to keep sunlight energy flowing through the deep-rooted trees and grasses, accelerate the mineral and nutrient cycle and to capture the optimum amount of rainfall. The removal or alteration of these ecological disturbances will trigger the plant community to change. The total removal of grazing animals may, in fact, accelerate this change. Juniper is added to the site via droppings from perching birds and small mammals that eat the seeds. Ashe juniper, which is a nonsprouting woody plant easily controlled by fire, and other woody species will increase without fire or some form of brush management. Once Ashe juniper encroachments it can easily be controlled with prescribed fire. When the juniper exceeds about 6 feet in height, fire options become limited. Without intervention, the Ashe juniper will continue to increase and move towards the Oak/Juniper Grassland plant community (1.2). This may occur in as little as five years.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1875	2700	3750
Tree	250	360	500
Forb	250	360	450
Shrub/Vine	125	180	250
Total	**2500**	**3600**	**4950**

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0-1%
Litter	60-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	0-5%

Table 7. Woody ground cover

Downed wood, fine-small (<0.40" diameter; 1-hour fuels)	–
Downed wood, fine-medium (0.40-0.99" diameter; 10-hour fuels)	–
Downed wood, fine-large (1.00-2.99" diameter; 100-hour fuels)	–
Downed wood, coarse-small (3.00-8.99" diameter; 1,000-hour fuels)	–
Downed wood, coarse-large (>9.00" diameter; 10,000-hour fuels)	–
Tree snags** (hard***)	–
Tree snags** (soft***)	–
Tree snag count** (hard***)	20-35 per acre
Tree snag count** (hard***)	

*** Decomposition Classes: N - no or little integration with the soil surface; I - partial to nearly full integration with the soil surface.**

**** >10.16cm diameter at 1.3716m above ground and >1.8288m height--if less diameter OR height use applicable down wood type; for pinyon and juniper, use 0.3048m above ground.**

***** Hard - tree is dead with most or all of bark intact; Soft - most of bark has sloughed off.**

Table 8. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-3%	0-1%
>0.5 <= 1	–	1-3%	3-5%	1-3%
>1 <= 2	–	5-8%	10-15%	3-10%
>2 <= 4.5	–	5-10%	50-60%	–
>4.5 <= 13	–	–	–	–
>13 <= 40	5-20%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 15. Plant community growth curve (percent production by month). TX3760, Warm Season Native Grasses. Native warm season grasses on rangeland with scattered oaks/junipers..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Community 1.2
Oak/Juniper Grassland Community

Figure 16. Young juniper is established. Crossing a threshold is imminent without management.

Figure 17. Young juniper is established mixed with some lower shrubs.

This community still resembles an oak savannah community. However, because of the elimination of fire and/or brush management, woody species begin to invade or increase on the site. This site had a natural variation that probably included some juniper. However, historic fires precluded it from achieving anything other than an occasional tree. The dominant grass species for this plant community are little bluestem, Indiangrass, and sideoats grama (*Bouteloua curtipendula*). The major species to invade this site is Ashe juniper. Juniper in this plant community is still about 6 feet tall and there are sufficient grasses to provide fine fuel loading for a prescribed burn. By implementing vegetative management such as prescribed burning and prescribed grazing, the land manager can shift the plant community towards the Oak Savannah with minimum labor and expense. The sun's energy being captured by the juniper can then be redirected back to the original plants. Mineral cycling, nutrient cycling, and the water cycle are restored as well. A burn or some type of brush management will be needed on a 5- to 10-year return depending upon the size of the juniper. Juniper will increase on this site regardless of grazing. The best option for using animals to control cedar is the prudent and timely grazing/browsing with goats and/or possibly sheep (Taylor, 1997; Anderson, et al., 2013). If the proper vegetation management decisions are not performed, the site is at risk to transition to the Oak/Juniper Grassland State (2) in 10 to 15 years and a significant, high energy intervention will be needed for restoration.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1625	2340	3250
Tree	375	540	750
Forb	250	360	500
Shrub/Vine	250	360	500
Total	**2500**	**3600**	**5000**

Figure 19. Plant community growth curve (percent production by month). TX3760, Warm Season Native Grasses. Native warm season grasses on rangeland with scattered oaks/junipers..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Community 1.3
Oak Savannah Shortgrass Community

Figure 20. Suppressed tall grasses and a browse line result from long-term heavy grazing by mixed livestock

Figure 21. Suppressed tall grasses result from long-term heavy grazing by mixed livestock classes.

This plant community reflects the combined effects of a drought and severe hot weather. The grazing has been a long term mixture of cattle, sheep and goats. Most of the sunlight energy is being captured by plants such as prickly pear, buffalograss and juniper along with the oak. Some mortality of the grasses can be observed. Soil surface temperatures can easily exceed 100 degrees with the sparse ground cover. There will be very little rainfall capture because of the lack of ground cover, especially if high intensity rains come. To restore the herbaceous plant cover will require a long-term effort combining brush management and grazing management. Prescribed burning is not an option until fuel load is built up. This site will progress through a flush of annuals and short lived grasses depending upon the timing and amount of rainfall. Once this recovery stage is done, which restores the hydrologic cycle, then more stable grasses and forbs establish. Prescribed grazing over time will restore the plant cover needed for a healthy hydrologic cycle and continued recovery. Once that is done, brush management can further accelerate the process. If mechanical brush management is done, then the possibility exists of replanting grasses to accelerate the recovery effort. It will still take several years of careful management and favorable rainfall to return to a diverse productive site. Grazing management alone will not suppress the brush unless goats/possibly sheep are used for targeted grazing.

Table 10. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	900	1200	1800
Grass/Grasslike	375	500	750
Forb	150	200	300
Shrub/Vine	75	100	150
Total	**1500**	**2000**	**3000**

Figure 23. Plant community growth curve (percent production by month). TX3760, Warm Season Native Grasses. Native warm season grasses on rangeland with scattered oaks/junipers..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Pathway 1.1A
Community 1.1 to 1.2

Oak Savannah Community

Oak/Juniper Grassland Community

A shift in the composition of the plant community is primarily driven by the lack of managing woody plants, juniper in particular. Juniper and other woody species are introduced from the site primarily through wildlife fecal deposits. Grazing that removes fuel loading for fire is a contributing factor. However juniper can increase regardless of grazing pressure unless goats and possibly sheep are utilized.

Pathway 1.1B
Community 1.1 to 1.3

Oak Savannah Community

Oak Savannah Shortgrass Community

Heavy continuous stocking rates with sheep, cattle, goats and sometimes deer over many years keep sunlight energy from recharging palatable herbaceous grasses, forbs and shrubs. Drought hastens the process. Little rainfall soaks into the ground because of a lack of cover.

Pathway 1.2A
Community 1.2 to 1.1

Oak/Juniper Grassland Community

Oak Savannah Community

This recovery pathway consist of some method of brush management such as fire, mechanical or hand cutting or targeted grazing with goats and/or possibly sheep. Prescribed grazing is essential.

Pathway 1.3A
Community 1.3 to 1.1

Oak Savannah Shortgrass Community

Oak Savannah Community

Restoring the hydrologic cycle and allowing herbaceous plants to harvest sunlight through prescribed grazing will shift the plant community to something close to the reference plant community. Targeted grazing with goats and/or possibly sheep along with selective brush management and/or prescribed burning will allow expression of the reference plant community.

Pathway 1.3B
Community 1.3 to 1.2

Oak Savannah Shortgrass Community

Oak/Juniper Grassland Community

Restoring the hydrologic cycle and sunlight energy with cattle or just long term deferment without fire or brush management will in all likelihood result in a recovery of the herbaceous plants but also juniper and other shrubs.

State 2
Oak Juniper State

Ashe juniper > 8-12 feet tall 10-30+% canopy 5-20 years old

Community 2.1
Oak/Juniper Grassland Community

Figure 24. A mature stand of Ashe juniper exists for the 2.1 plant community on a Tarpley soil.

This community has crossed a threshold from the Oak Savannah State (1). The major woody species to invade is Ashe juniper. Other woody species to commonly invade/increase this site are honey mesquite (*Prosopis glandulosa*), Texas persimmon (*Diospyros texana*), algerita (Mahonia trifoliata), elbowbush (*Forestiera pubescens*), lotebush (*Ziziphus obtusifolia*), Bigelow oak (*Quercus sinuata*), and prickly pear (Opuntia spp.). This site will exhibit Ashe juniper 8 to 12 feet tall with 10 to 30 percent canopies. Foliar cover ranges from 5 to 30 percent. The juniper plants are between 5 and 20 years old. Grasslike vegetation is significantly reduced because of the competition that Ashe juniper and other brush species present regarding sunlight, nutrients and moisture. The dominant grass like species for this plant community are meadow dropseed (*Sporobolus compositus*), silver bluestem (*Bothriochloa saccharoides*), a small amount of sideoats grama, little bluestem, and an occasional Indiangrass. Cool season plant such as Texas wintergrass (*Nassella leucotricha*) and cedar sedge (*Carex planostachys*) occur in the understory. The recovery from an Oak/Juniper Grassland Community (2.1) back to the reference community is still possible but it will involve a considerable investment of time and expense. Implementation of brush management programs involving heavy equipment and/or hand labor makes much higher treatment cost probable. In this state much more sunlight energy is captured in juniper and woody component of the community. There is entrapment of rainfall in the foliage of the juniper which never reaches and enters the soil profile. As much as 20 percent of the annual rainfall is entrapped (Thurow, 1994). The juniper will only get bigger and wider unless intervention is done to prevent it. It is likely that any fires that could burn here under this condition would be wildfires that would also damage the oak community. If left alone for about 20 years, the juniper will attain heights of over 20 feet and crown canopies exceeding 30 percent. At this point the juniper is a threat to the oaks.

Table 11. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1250	1800	2500
Grass/Grasslike	500	720	1000
Shrub/Vine	500	720	1000
Forb	250	360	500
Total	**2500**	**3600**	**5000**

Figure 26. Plant community growth curve (percent production by month).

TX3762, Oak/Juniper Grassland. "Grassland with warm season grasses, oaks, and juniper.".

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	5	8	13	18	12	5	3	12	10	7	4

State 3
Open Grassland State

Open grassland.

Community 3.1
Open Grassland Community

Figure 27. This site has been cleared of trees and replanted to introduced bluestems, on a Tarpley soil.

A threshold has been crossed into the Open Grassland State. The Open Grassland Community (3.1) can be former cropland that has been reseeded or be a result of significant chemical or mechanical brush management. The shallow soils precluded long-term success as cropland. Depending upon the management goals, the site can be seeded to native or exotic species or a combination. Exotic grasses invade without seeding being introduced through hay, livestock or wildlife. Much of the species diversity and site integrity has been lost when compared to the reference plant community. The length of plowing and the intensity of the plowing will dictate the magnitude of deterioration of the soil health and structure. Many of the original soil organisms are missing and soil erosion may have taken place. Soil compaction is usually a problem to be dealt with. This fact makes it difficult to restore completely to the reference plant community. Total tree removal from brush management activities will cause a loss of their root system to the soil resource. This may impact infiltration and organic matter content over the long run. Through the re-introduction of fire and prescribed grazing, plus reseeding of native forbs and grasses, this site can be restored to something resembling the reference plant community as far as the grassland component. It may take many years for natural processes within the soil to restore the oak species. Utilizing native plants in the re-seeding will greatly benefit wildlife species such as deer, turkey, quail, and other birds. This open grassland community may also represent a community of annual and/or perennial seeded species which are non-native and which may occur as monoculture communities. These monoculture type communities may be too dense for gallinaceous wildlife. These communities are typically not very diverse. Seeded or invading grasses include naturalized species such as King Ranch bluestem, bermudagrass, Johnsongrass (*Sorghum halepense*), silky bluestem (*Dichanthium sericeum*), kleingrass and many others. In many cases, hardly any native grasses can be found. There has been a dramatic reduction in the native forb and legume diversity. Total production for this site may be similar to the productive potential of this site in reference condition except the majority of the plant community is grasses. Production can also vary depending upon the amount of purchased fertilizer applied.

Table 12. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2250	3240	4500
Forb	125	180	500
Shrub/Vine	125	180	250
Tree	0	0	0
Total	**2500**	**3600**	**5250**

Table 13. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0-1%
Grass/grasslike foliar cover	15-20%
Forb foliar cover	1-2%
Non-vascular plants	0%
Biological crusts	0%
Litter	90-100%
Surface fragments >0.25" and <=3"	0%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	0-10%

Table 14. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-3%	0-1%
>0.5 <= 1	–	0-3%	3-5%	1-3%
>1 <= 2	–	–	20-50%	3-10%
>2 <= 4.5	–	–	60-100%	–
>4.5 <= 13	–	–	–	–
>13 <= 40	–	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 29. Plant community growth curve (percent production by month). TX3764, Open Grassland. Warm season grasses with minor cool season influence on open grassland..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Community 3.2
Open Grassland with Brush Encroachment Community

Figure 30. Juniper, willow baccharis, and other shrubby species invade on this site once abandoned.

This community is reseeded open grassland which has an encroachment of woody species. Grasslike vegetation is significantly reduced because of the severe competition that Ashe juniper and other woody species present regarding sunlight and moisture as the brush thickens. Ashe juniper can be 20 feet tall and taller, with canopies in excess of 30 percent. Other brushy cover consists of species such as willow baccharis (*Baccharis salicina*), honey mesquite (*Prosopis glandulosa*), algerita, Texas persimmon, elbowbush, and lotebush. Willow baccharis can also be a dominant woody plant. As warm season grass-like species are reduced, bare ground increases because of sunlight limitations. Shade tolerant species such as cedar sedge (*Carex planostachys*) and Texas wintergrass species dominate the understory's void of sunlight. The open sites between canopies may provide opportunities for occasional short grasses such as hairy grama (*Bouteloua hirsuta*), Texas grama (*Bouteloua rigidiseta*), meadow dropseed (*Sporobolus compositus*), and threeawns (Aristida spp.). Once juniper becomes the dominant woody plant, the majority of the soil surface will have a thick mat of cedar leaves and other woody tree and shrub leaf material. The total grasslike production potential for this community is severely restricted. The introduction of an integrated therapy of brush management, prescribed burning and prescribed grazing this site will successfully shift back towards the Open Grassland Community and remain productive. If brush management alternatives are not implemented in a timely manner, this site will become infested with woody species. In as little as 20 years, the brush will be utilizing most of the sunlight and moisture stored in the soil. In addition, rainfall entrapment will deteriorate the hydrologic cycle so that less moisture is absorbed into the rooting zone. Forage productivity will decline accordingly as grazeable acreage decreases.

Table 15. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1250	1800	2500
Grass/Grasslike	1000	1440	2000
Shrub/Vine	125	180	250
Forb	125	180	250
Total	**2500**	**3600**	**5000**

Figure 32. Plant community growth curve (percent production by month). TX3764, Open Grassland. Warm season grasses with minor cool season influence on open grassland..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Pathway 3.1A
Community 3.1 to 3.2

Open Grassland Community

Open Grassland with Brush Encroachment Community

Over time, without any brush management or fire, juniper and other shrubs will establish and begin to capture increasing amounts of sun energy as well as entrapping and utilizing more soil moisture that could be utilized by herbaceous plants.

Pathway 3.2A
Community 3.2 to 3.1

Open Grassland with Brush Encroachment Community

Open Grassland Community

Prescribed burning or selective brush management will restore the grassland. Targeted grazing with goats and/or possibly sheep may arrest the increase of juniper and other shrubs, but cattle grazing alone probably will not, even if stocked properly.

State 4
Mulched State

Savannah with limited herbaceous plants.

Community 4.1
Mulched Community

Figure 33. Hydro mulched juniper on a Tarpley soil.

The Mulched (4.1) plant community is a result of using mechanical mulching to reduce canopy and structure of dense woody species which is usually juniper. The amounts of mulch on the ground and the orientation of the mulch are dependent upon the amount of woody cover treated and the time since treatment. The mulch tends to settle over time and is very resistant to deterioration. This community can structurally appear very similar to the reference plant community but without the herbaceous cover. The understanding of how this plant community reacts over time is unknown but studies are currently underway to monitor. One result is that the soil is protected for a long time. There will be a need for maintenance to treat juniper and other species as they re-establish.

Table 16. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1360	1530	3000
Forb	80	90	175
Grass/Grasslike	80	90	175
Shrub/Vine	80	90	175
Total	**1600**	**1800**	**3525**

Transition T1A
State 1 to 2

A transition occurs because of a lack of brush management with mechanical means, fire or targeted goat/possibly sheep grazing. Grazing deferment alone will not halt the increase of woody species. Hydrologic characteristics are altered by increased woody species. Now, energy flows more through woody plants than herbaceous plants.

Transition T1B
State 1 to 3

Land clearing replanting with grasses represents this transition. Similar reduction in oak species will be expressed with herbicidal treatment. Recovery to the Oak Savannah State is very doubtful, especially if herbaceous exotic plants are utilized. Even though the plants are exotic, many times their hydrologic function is similar to the original native plants.

Restoration pathway R1A
State 2 to 1

The restoration pathway includes some form of brush management. Prescribed burning will also help and prescribed grazing will be essential. In some cases of severe long-term overharvesting of the desired plants, replanting may be necessary.

Transition T2A
State 2 to 3

Land clearing replanting with grasses represents this transition. Similar reduction in oak species will be expressed with herbicidal treatment. Recovery to the Oak Savannah State is very doubtful, especially if herbaceous exotic plants are utilized. Even though the plants are exotic, many times their hydrologic function is similar to the original native plants.

Transition T2B
State 2 to 4

Mechanical conversion of primarily juniper canopy to a mulch cover restores the energy flow to the remaining species, usually oak. The hydrologic cycle retains nearly all the rainfall because of the heavy mulch. Little evaporation takes place.

Additional community tables

Table 17. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrass**			1500–3200	
	little bluestem	SCSC	*Schizachyrium scoparium*	800–1000	–
	Indiangrass	SONU2	*Sorghastrum nutans*	400–800	–

	big bluestem	ANGE	*Andropogon gerardii*	300–600	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	0–400	–
	switchgrass	PAVI2	*Panicum virgatum*	0–200	–
2	**Midgrasses**			300–500	
	sideoats grama	BOCU	*Bouteloua curtipendula*	200–400	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	100–200	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	100–150	–
	vine mesquite	PAOB	*Panicum obtusum*	100–150	–
	composite dropseed	SPCO16	*Sporobolus compositus*	50–100	–
	purpletop tridens	TRFL2	*Tridens flavus*	0–75	–
	slim tridens	TRMU	*Tridens muticus*	25–75	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	25–75	–
3	**Midgrasses**			30–180	
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	50–100	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	50–100	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	25–75	–
4	**Shortgrasses**			30–180	
	buffalograss	BODA2	*Bouteloua dactyloides*	75–100	–
	curly-mesquite	HIBE	*Hilaria belangeri*	75–100	–
	threeawn	ARIST	*Aristida*	25–75	–
	fall witchgrass	DICO6	*Digitaria cognata*	25–50	–
5	**Cool Season Grasses and grasslike**			30–200	
	Texas wintergrass	NALE3	*Nassella leucotricha*	100–150	–
	Canada wildrye	ELCA4	*Elymus canadensis*	50–100	–
	cedar sedge	CAPL3	*Carex planostachys*	50–100	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	25–50	–
Forb					
6	**Annual Forbs**			0	
	prairie broomweed	AMDR	*Amphiachyris dracunculoides*	0–1	–
7	**Forb**			30–200	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	25–100	–
	white sagebrush	ARLU	*Artemisia ludoviciana*	25–100	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	25–100	–
	prairie clover	DALEA	*Dalea*	25–100	–
	bundleflower	DESMA	*Desmanthus*	25–100	–
	ticktrefoil	DESMO	*Desmodium*	25–100	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	25–100	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	50–100	–
	dotted blazing star	LIPU	*Liatris punctata*	25–100	–
	mallow	MALVA	*Malva*	25–100	–
	smartweed leaf-flower	PHPO3	*Phyllanthus polygonoides*	25–100	–
	scurfpea	PSORA2	*Psoralidium*	25–100	–

	scurfpea	PSORA2	*Psoralidium*	25–100	–
	snoutbean	RHYNC2	*Rhynchosia*	25–100	–
	wild petunia	RUELL	*Ruellia*	25–100	–
	annual checkerbloom	SICA	*Sidalcea calycosa*	50–100	–
	fuzzybean	STROP	*Strophostyles*	25–100	–
	vetch	VICIA	*Vicia*	25–100	–
Shrub/Vine					
8	**Shrubs**			20–180	
	eastern redbud	CECA4	*Cercis canadensis*	0–75	–
	snailseed	CODI	*Cocculus diversifolius*	25–75	–
	Texas persimmon	DITE3	*Diospyros texana*	10–75	–
	jointfir	EPHED	*Ephedra*	25–75	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	25–75	–
	stretchberry	FOPU2	*Forestiera pubescens*	25–75	–
	desert-thorn	LYCIU	*Lycium*	25–75	–
	algerita	MATR3	*Mahonia trifoliolata*	25–75	–
	Virginia creeper	PAQU2	*Parthenocissus quinquefolia*	25–75	–
	fragrant sumac	RHAR4	*Rhus aromatica*	0–75	–
	winged sumac	RHCO	*Rhus copallinum*	25–75	–
	evergreen sumac	RHVI3	*Rhus virens*	0–75	–
	gum bully	SILAO	*Sideroxylon lanuginosum ssp. oblongifolium*	25–75	–
	roundleaf greenbrier	SMRO	*Smilax rotundifolia*	25–75	–
	Eve's necklacepod	STAF4	*Styphnolobium affine*	25–75	–
	grape	VITIS	*Vitis*	25–75	–
	twistleaf yucca	YUPA	*Yucca pallida*	25–75	–
Tree					
9	**Trees**			40–200	
	Nuttall oak	QUTE	*Quercus texana*	100–300	–
	post oak	QUST	*Quercus stellata*	0–250	–
	Texas live oak	QUFU	*Quercus fusiformis*	0–250	–
	blackjack oak	QUMA3	*Quercus marilandica*	0–250	–
	hackberry	CELTI	*Celtis*	50–200	–
	bastard oak	QUSIB	*Quercus sinuata var. breviloba*	25–100	–
	elm	ULMUS	*Ulmus*	25–100	–

Animal community

This site is used for the production of domestic livestock and to provide habitat for native wildlife and certain species of exotic wildlife. Cow-calf operations are the primary livestock enterprise although stocker cattle are also grazed. Sheep and goats were formerly raised in large numbers and are still present in reduced numbers. Sustainable stocking rates have declined drastically over the past 100 years because of the deterioration of the historic plant community. Initial starting stocking rates will be determined with the landowner or decision maker. An assessment of vegetation is needed to determine stocking rates. Calculations used to determine an initial starting stocking rate will be based on forage production and on grazeable acres.

A large diversity of wildlife is native to this site. In the historic plant community, large migrating herds of bison, resident herds of pronghorn and large numbers of lesser prairie chickens were the more dominant species. With the demise of these species and the changes in the plant community, the kinds of wildlife have changed.

With the eradication of the screwworm fly, the increase in woody vegetation, and insufficient natural predation, white-tailed deer numbers have increased drastically and are often in excess of natural 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 woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep and goats can be an important consideration in livestock and wildlife management and can cause damage to preferred native 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. 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 Rio Grande turkey, bobwhite quail and mourning dove. Turkey prefer plant communities with substantial amounts of shrubs and trees interspersed with grassland. Quail prefer plant communities with a combination of low shrubs, bunch grass, bare ground and low successional forbs. The different species of songbirds vary in their habitat preferences. In general, a habitat that provides a large variety of grasses, forbs, shrubs, vines and trees and a complex of grassland, savannah, shrubland, and woodland 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. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow and red deer, aoudad sheep and blackbuck antelope. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. Feral hogs are present and can cause damage when their numbers are not managed.

Plant Preference by Animal Kind:
This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition and diet overlap between kinds of herbivores. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. An animal’s preference or avoidance of certain plants is learned over time through grazing experience and maternal learning (http://extension.usu.edu/behave/Grazing/accessed 8/20/13). Preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food are rated. Refer to detailed habitat guides for a more complete description of a species habitat needs.

Legend: P=Preferred D=Desirable U=Undesirable N=Not Consumed T=Toxic X=Used, but not degree of utilization unknown
Preferred – Percentage of plant in animal diet is greater than it occurs on the land
Desirable – Percentage of plant in animal diet is similar to the percentage composition on the land
Undesirable – Percentage of plant in animal diet is less than it occurs on the land
Not Consumed – Plant would not be eaten under normal conditions. It is only consumed when other forages not available. This can also include plants that are unavailable during parts of the year.
Toxic – Rare occurrence in diet and, if consumed in any tangible amounts results in death or severe illness in animal (Hart, 2003). (Note: many plants can be good forage but toxic at certain doses or at certain times of the year. Animals in poor condition are most susceptible.)

Hydrological functions

The water cycle on this site functions according to the existing plant community and the management of that plant community. The water cycle is most functional when the site is dominated by tall bunchgrass and the oak savannah. Rapid rainfall infiltration, high soil organic matter, good soil structure and good porosity are present with a good cover of bunchgrass. When dry, the soils crack and take water in readily. When wet, the cracks close and the soil becomes sticky and plastic taking water in slowly. Light showers are ineffective to this site. Quality of surface runoff will be high and erosion and sedimentation rates will be low. With high rates of infiltration and periods of heavy rainfall, some water will move below the root zone of grasses into the fractures in the limestone. As this water moves downward it contributes to the recharge of aquifers.

When heavy grazing causes loss or reduction of bunchgrass and ground cover, the water cycle becomes impaired. Infiltration is decreased and runoff is increased because of poor ground cover, rainfall splash, soil capping, low organic matter and poor structure. Because of the very high shrink-swell clay soil and the formation of surface cracks in dry periods, rainfall infiltration can still occur even when ground cover is poor. With a combination of a sparse ground cover and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor and sedimentation increased.
As the site becomes dominated by woody species, especially oaks and juniper, the water cycle is further altered. Interception of rainfall by tree canopies is increased which reduces the amount of rainfall reaching the surface. Stem flow is increased, however, because of the funneling effect of the canopy which increases soil moisture at the base of the tree. Increased transpiration, especially when evergreen species such as Texas live oak and juniper dominate, provides less chance for deep percolation into aquifers. As woody species increase, grass cover declines, which causes some of the same results as heavy grazing. Brush management combined with good grazing management can help restore the natural hydrology of the site.

If a mature woodland canopy develops, a buildup of leaf litter occurs which increases the organic litter on the soil, builds structure and retards erosion. The duff, however, can store some moisture and reduce infiltration. Some, but not all values of a properly functioning water cycle are restored on this site when a woodland plant community persists.
The soils of this site are in hydrologic group D.

Recreational uses

This site has the appeal of the wide-open spaces. The abundant tall and mid grasses and scattered oaks produce beautiful fall color variations. The area is also used for hunting, birding, and other Eco-tourism related enterprises.

Wood products

Honey mesquite and oaks can be used for firewood and the specialty wood industry.

Inventory data references

Information provided here has been derived from limited NRCS clipping data and from field observations of range trained personnel. Information has also been interpreted from scientific articles.

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Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high-intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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)	San Angelo ZO
Contact for lead author	325-944-0147
Date	04/08/2013
Approved by	Colin Walden

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:** Some minimal flow patterns may be evident at the juncture of the associated sites.

3. **Number and height of erosional pedestals or terracettes:** None.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** None.

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):** Little or no litter movement or deposition during normal rainfall events.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to wind erosion. Stability range is expected to be 5-6.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 0 to 3.1 inches; brown dry, loam; moderate fine subangular blocky structure; friable, moderately hard, slightly sticky, slightly plastic; 2 percent limestone fragments; noneffervescent by HCl, 1 normal; clear smooth boundary.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The tallgrass/midgrass savanna with abundant forbs, adequate litter, and little bare ground provides for maximum infiltration and negligible runoff.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses

Sub-dominant: Warm-season midgrasses Trees Forbs

Other: Cool Season Grasses Shrubs Warm Season Short Grasses

Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Perennial grasses will naturally exhibit a minor amount (less than 5%) of senescence and some mortality every year.

---

14. **Average percent litter cover (%) and depth (in):** >90 percent litter, 0.5 to 3 inch depth.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 2500 to 5000 pounds per acre.

---

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:** Ashe juniper, baccharis, pricklypear, yucca, tasajillo, pricklyash, lotebush, mesquite, King Ranch bluestem, silky bluestem, and annual broomweed.

---

17. **Perennial plant reproductive capability:** All perennial species should be capable of reproducing every year unless disrupted by extended drought, overgrazing, wildfire, insect damage, or other events occuring immediately prior to, or during the reproductive phase.

USDA Natural Resources Conservation Service

Ecological site R087AY006TX
Sandy

Last updated: 9/23/2019
Accessed: 10/26/2022

General information

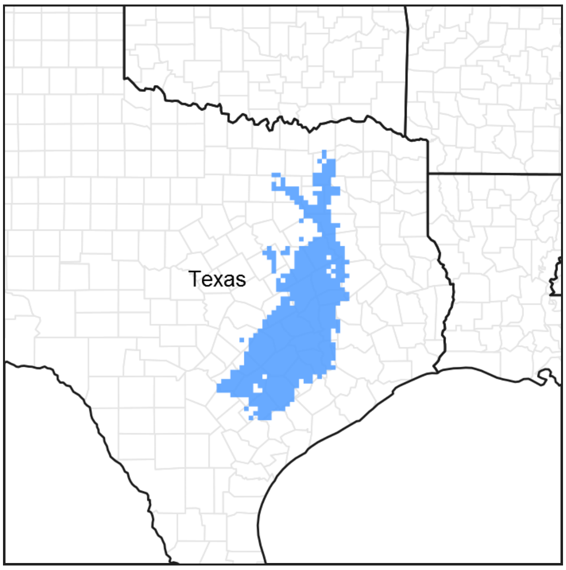


Figure 1. Mapped extent

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): 087A–Texas Claypan Area, Southern Part

This area is entirely in south-central Texas. It makes up about 10,535 square miles (27,295 square kilometers). The towns of Bastrop, Bryan, Centerville, College Station, Ennis, Fairfield, Franklin, Giddings, Gonzales, Groesbeck, La Grange, Madisonville, and Rockdale are in this MLRA. Interstate 45 crosses the northern part of the area, and Interstate 10 crosses the southern part. A number of State Parks are located throughout this area. The parks are commonly associated with reservoirs.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 87A

Ecological site concept

The sites are characterized by a sandy surface layer that extends 20 to 40 inches to a loamy subsurface layer. The sites are more productive and less droughty than soils with deeper sands, but not as productive as soils with a higher clay content.

Associated sites

R087AY001TX	**Gravelly** Gravelly
R087AY002TX	**Sandstone Hill** Sandstone Hill
R087AY003TX	**Claypan Savannah** Claypan Savannah
R087AY004TX	**Deep Redland** Deep Redland
R087AY005TX	**Sandy Loam** Sandy Loam
R087AY007TX	**Deep Sand** Deep Sand
R087AY008TX	**Very Deep Sand** Very Deep Sand
R087AY011TX	**Loamy Bottomland** Loamy Bottomland
R087AY012TX	**Clayey Bottomland** Clayey Bottomland

Similar sites

R087AY008TX	**Very Deep Sand** Very Deep Sand
R087AY007TX	**Deep Sand** Deep Sand

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus marilandica*
Shrub	(1) *Ilex vomitoria* (2) *Callicarpa americana*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Sorghastrum nutans*

Physiographic features

These soils are on gently sloping to strongly sloping ridges and stream terraces. Slopes range from 0 to 12 percent, but are typically between 1 and 8 percent. Some soils have a perched water table up to 30 inches. The water table is highest in later winter and early spring, or during extremely wet precipitation periods.

Table 2. Representative physiographic features

Landforms	(1) Ridge (2) Stream terrace
Flooding frequency	None
Ponding frequency	None
Elevation	200–750 ft
Slope	0–12%
Water table depth	30–80 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 87A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of mild days and cool nights. The average annual precipitation in this area is 41 inches. Most of the rainfall occurs in spring and fall. The freeze-free period averages about 276 days and the frost-free period 241 days.

Table 3. Representative climatic features

Frost-free period (average)	241 days
Freeze-free period (average)	276 days
Precipitation total (average)	41 in

Climate stations used

- (1) CROCKETT [USC00412114], Crockett, TX
- (2) FAIRFIELD 3W [USC00413047], Fairfield, TX
- (3) SOMERVILLE DAM [USC00418446], Somerville, TX
- (4) BARDWELL DAM [USC00410518], Ennis, TX
- (5) FRANKLIN [USC00413321], Franklin, TX
- (6) MADISONVILLE [USC00415477], Madisonville, TX
- (7) BELLVILLE 6NNE [USC00410655], Bellville, TX
- (8) GONZALES 1N [USC00413622], Gonzales, TX
- (9) LA GRANGE [USC00414903], La Grange, TX
- (10) ELGIN [USC00412820], Elgin, TX
- (11) SMITHVILLE [USC00418415], Smithville, TX
- (12) COLLEGE STN [USW00003904], College Station, TX

Influencing water features

A stream or wetland does not influence the plant community of this site.

Soil features

The soils are deep to very deep, fine sands and loamy fine sands with a surface 20 to 40 inches thick over loamy subsoils. Water soaks rapidly into the open soils. Even light showers penetrate below the evaporation zone and are more effective on this site than sites with deeper sands. Water retention is relatively low but the soils give up a high percent of their moisture to growing plants. Although air, water, and plant roots move through the soil with ease, frequent rains are needed to produce optimum plant growth. Inherent low fertility causes these soils to produce forage of lower quantity than associated sites with higher clay content. The site is subject to erosion where adequate herbaceous cover is not maintained and on heavy use areas such as roads and livestock trails. Soils correlated to this site include: Demona, Dutek, Newulm, Nimrod, Rehburg, Robco, Silstid, and Styx.

Table 4. Representative soil features

Parent material	(1) Alluvium–sandstone and shale
Surface texture	(1) Loamy fine sand (2) Fine sand
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Moderate to slow
Soil depth	45–80 in
Surface fragment cover <=3"	0–1%

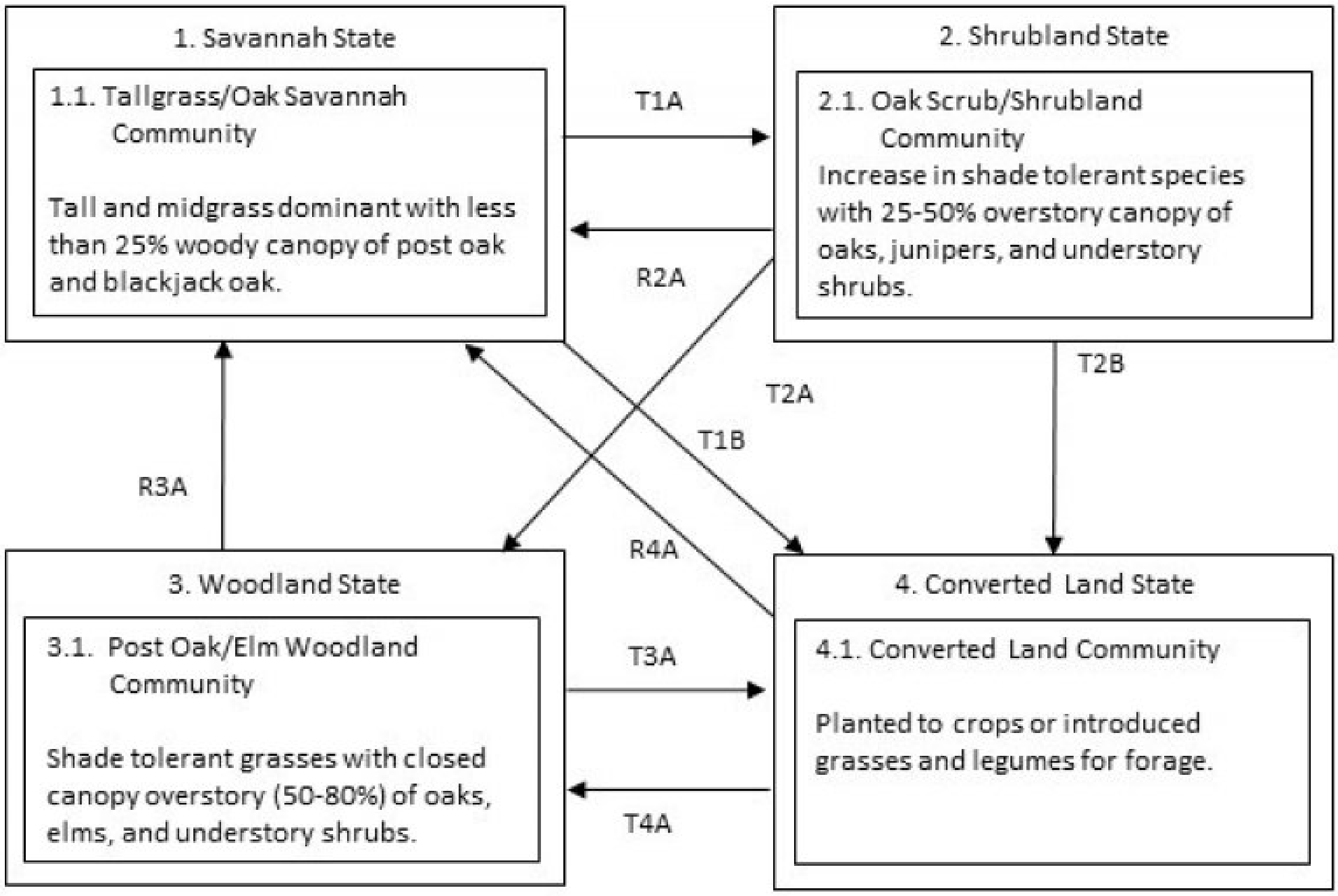
Surface fragment cover >3"	0%
Available water capacity (0-40in)	2–5 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–4
Soil reaction (1:1 water) (0-40in)	4–7.8
Subsurface fragment volume <=3" (Depth not specified)	0–6%
Subsurface fragment volume >3" (Depth not specified)	0–1%

Ecological dynamics

The Sandy site evolved and was maintained by the grazing and herding effects of native wild large ungulates, periodic fires, and extreme climatic fluctuations. Conversion of this site to cropland and the subsequent abandonment of cropping removed the natural native vegetation, organic matter, and fertility and allowed woody species to dominate the site. Continuous grazing by confined domestic livestock and the suppression of fire on non-cropland sites removes little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and preferred forbs such as tephrosia (Tephrosia spp.) and prairie clover (Dalea spp.).

Less productive perennial and annual grasses and forbs will replace these plants. Years of continuous grazing generally lead to periods of prolonged rest for recovery of the perennial herbaceous plant component. These prolonged rest periods with no fire or brush management lead toward a community dominated by woody species such as winged elm (*Ulmus alata*), yaupon (*Ilex vomitoria*), post oak (*Quercus stellata*), and eastern red cedar (*Juniperus virginiana*).

State and transition model



T1A, T2A, T4A	Heavy Continuous Grazing, No Brush Management, Abandonment
T1B, T2B, T3A	Brush Management, Crop Cultivation, Pasture Planting
R2A	Brush Management, Prescribed Grazing, Prescribed Burning
R3A	Brush Management, Range Planting, Prescribed Grazing
R4A	Range Planting, Prescribed Grazing, Prescribed Burning

Figure 6. STM

State 1
Savannah

One community exists in the Savannah State, the 1.1 Tallgrass/Oak Savannah Community. The State is dominated by warm season perennial grasses and the overstory canopy cover is less than 25 percent.

Community 1.1
Tallgrass/Oak Savannah

Figure 7. Tallgrass/Oak Savannah Community

The characteristic plant community of this site is the reference plant community. This site is an open savannah of post oak and blackjack oak (*Quercus marilandica*) trees that shade 20 to 25 percent of the ground. The herbaceous component is mid and tallgrasses and is dominated by little bluestem which usually makes up 50 to 75 percent of the total annual production. Indiangrass, purpletop tridens (*Tridens flavus*), switchgrass, beaked panicum (*Panicum anceps*), sand lovegrass (*Eragrostis trichodes*), brownseed paspalum (*Paspalum plicatulum*), and thin paspalum (*Paspalum setaceum*) also occur. Cool season forage plants are scarce on this site. A variety of shrubs, vines, and forbs occur in this community. Grazing prescriptions that permit acceptable grazing periods and allow adequate rest periods along with prescribed fire every five to seven years are important in the maintenance of the reference herbaceous plant community and the savannah landscape structure. Continuous overgrazing or over rest and the absence of fire tend to allow a vegetative shift towards woody species. Without corrective measures, this shift will continue to the Shrubland State.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2400	2800	3200
Tree	300	350	400
Forb	150	175	200
Shrub/Vine	150	175	200
Total	**3000**	**3500**	**4000**

State 2
Shrubland

One community exists in the Shrubland State, the 2.1 Oak Scrub/Shrubland Community. The herbaceous production is not as great compared to the Savannah State, and overstory canopy has increased between 25 and 50 percent.

Community 2.1
Oak Scrub/Shrubland

Figure 9. Oak Scrub/Shrubland Community

This plant community is a transitional community between the Savannah and Woodland States. It develops in the absence of fire or mechanical or chemical brush management treatments. It is usually the result of abandonment following either cropping or yearly continuous grazing. Trees and shrubs begin to encroach onto pastureland or replace the grassland component of the Tallgrass/Oak Savannah Community. In addition to the naturally occurring oaks, other woody species such as eastern persimmon, winged elm, and eastern red cedar increase in density and canopy coverage (25 to 50 percent). Remnants of little bluestem and Indiangrass may still occur but the herbaceous component of the community becomes dominated by lesser producing grasses and forbs. Initially, species such as brownseed paspalum (*Paspalum plicatulum*), tall dropseed (*Sporobolus compositus*), and fall witchgrass (*Digitaria cognata*) replace the taller grasses. As the site continues to transition, the plants which increase or invade on the site include sandbur (Cenchrus spp.), red lovegrass (*Eragrostis secundiflora*), Yankeeweed (*Eupatorium compositifolium*), bullnettle (*Cnidoscolus texanus*), croton (Croton spp.), snake cotton (Froelichia spp.), prickly pear (Opuntia spp.), queen's delight (*Stillingia texana*), beebalm (Monarda spp.), and baccharis (Baccharis spp.). Prescribed burning on a three to five year interval in conjunction with prescribed grazing may be a viable option for returning this site to the Savannah State providing woody canopy cover is less than 50 percent and adequate herbaceous fine fuel still exists. When this threshold is exceeded, mechanical or chemical brush control becomes necessary to move this transitional community back towards the Savannah State.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1350	1575	1800
Tree	900	1050	1200
Shrub/Vine	600	700	800
Forb	150	175	200
Total	**3000**	**3500**	**4000**

State 3
Woodland

One community exists in the Woodland State, the Post Oak/Elm Woodland Community. The site is characterized by little herbaceous production. The overstory canopy is over 50 percent and shrubs also limit light to the surface.

Community 3.1
Post Oak/Elm Woodland

Figure 11. Post Oak/Elm Woodland Community

This plant community is a closed overstory (50 to 80 percent) woodland dominated by post oak, winged elm, blackjack oak, black hickory (*Carya texana*), and eastern red cedar. Understory shrubs and sub-shrubs include yaupon, farkleberry, possumhaw (*Ilex decidua*), and American beautyberry (*Callicarpa americana*). Woody vines also occur and include poison ivy (*Toxicodendron radicans*), grape (Vitis spp.), greenbriar (Smilax spp.), Virginia creeper (*Parthenocissus quinquefolia*), and peppervine (Ampelopsis arborea). A herbaceous understory is almost nonexistent, but shade-tolerant species including longleaf woodoats (*Chasmanthium sessiliflorum*), cedar sedge (*Carex planostachys*), ironweed (Veronia baldwinii), and goldenrod (Solidago spp.) may occur in small amounts. Prescribed burning in conjunction with prescribed grazing may be used to convert this site back to a Savannah State but generally it takes many consecutive years of burning due to light fine fuel loads comprised mainly of hardwood tree leaves. Weather conditions are rarely condusive to burning this fuel type in this region. Chemical brush control on a large scale is not a viable treatment option on this site due to the resistance of yaupon to broadcast herbicide applications. However, individual plant treatment with herbicides on small acreage is a viable option. Mechanical treatment of this site, along with seeding, is the most viable option for reversion back to the reference community. Although, the economic viability of this option is questionable.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1350	1575	1800
Shrub/Vine	1050	1225	1400
Grass/Grasslike	450	525	600
Forb	150	175	200
Total	**3000**	**3500**	**4000**

State 4
Converted

The Converted Land State contains one community, the 4.1 Converted Land Community. The state is characterized by the land manager farming crops or planted grasses.

Community 4.1
Converted Land

Figure 13. Converted Land Community

Conversion of this site to cropland occurred from the middle 1800's to the early 1900's. Some remains in cropland today, typically cotton (Gossypium spp.), corn (*Zea mays*), sorghum (Sorghum spp.), and soybeans (*Glycine max*). Specifically, this site is used for watermelons, peas, sweet potatoes, and peanuts. Ditching, land leveling, and levee construction has significantly changed the topography and hydrology on many acres of this site. While restoration of this site to a semblance of the reference plant community is possible with seeding and prescribed grazing, complete restoration of the reference community in a reasonable time is very unlikely. Following crop production, this site is often planted to native or introduced grasses and legumes for livestock grazing or hay production. Typical species planted include improved Bermudagrass varieties, bahiagrass, switchgrass, dallisgrass, eastern gamagrass, annual ryegrass (Lolium multiflorum), and white clover. Many of the introduced species (bahiagrass, Bermudagrass, and dallisgrass) are invasive-moving by wind, water, and animals. Once established, they are extremely difficult to remove and will hinder the reestablishment of native species. The establishment and maintenance of these species requires cultivation, fertilization, weed control, and prescribed grazing management.

Transition T1A
State 1 to 2

The Savannah State will transition to the Shrubland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 25 percent and grasses shift composition to more shade-tolerant species.

Transition T1B
State 1 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration back to the Savannah State requires brush management, prescribed grazing and/or prescribed fire. Mechanical or chemical controls can be used to remove the woody overstory species and shrubs. Prescribed grazing may require destocking and/or deferment.

Transition T2A
State 2 to 3

The Shrubland State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Transition T2B

State 2 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration back to the Savannah State requires substantial energy inputs. Brush management and prescribed grazing will be needed to shift the community back to the reference state. Mechanical or chemical controls can be used to remove the woody overstory species back below 25 percent. Prescribed grazing may require destocking and/or deferment to manage the understory grasses back to those found in the reference community. Fire may be an option, but only if adequate amounts of fine fuel exist in the understory.

Transition T3A
State 3 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R4A
State 4 to 1

The restoration to State 1 can occur when the land manager ceases agronomic practices. Range planting of native species found in the reference community will be required to bring back a similar community as the State 1 plant composition. The extent of previous soil disturbances will determine how much seedbed preparation will be needed, as well as the ability to be restored. Proper grazing and brush management will be required to ensure success.

Transition T4A
State 4 to 3

The Converted Land State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			2100–2700	
	little bluestem	SCSC	*Schizachyrium scoparium*	2100–2700	–
	Indiangrass	SONU2	*Sorghastrum nutans*	2100–2700	–
2	**Midgrasses**			175–275	
	sand lovegrass	ERTR3	*Eragrostis trichodes*	175–275	–
	beaked panicgrass	PAAN	*Panicum anceps*	175–275	–
	brownseed paspalum	PAPL3	*Paspalum plicatulum*	175–275	–
	switchgrass	PAVI2	*Panicum virgatum*	175–275	–
3	**Mid/Shortgrasses**			100–150	
	fall witchgrass	DICO6	*Digitaria cognata*	100–150	–
	thin paspalum	PASE5	*Paspalum setaceum*	100–150	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	100–150	–

	purpletop tridens	TRFL2	*Tridens flavus*	100–150	–
4	**Mid/Shortgrasses**			25–75	
	splitbeard bluestem	ANTE2	*Andropogon ternarius*	25–75	–
	woollysheath threeawn	ARLA6	*Aristida lanosa*	25–75	–
	sedge	CAREX	*Carex*	25–75	–
	Hall's panicgrass	PAHA	*Panicum hallii*	25–75	–
Forb					
5	**Forbs**			125–150	
	Atlantic pigeonwings	CLMA4	*Clitoria mariana*	125–150	–
	Virginia dayflower	COVI3	*Commelina virginica*	125–150	–
	ticktrefoil	DESMO	*Desmodium*	125–150	–
	coastal indigo	INMI	*Indigofera miniata*	125–150	–
	lespedeza	LESPE	*Lespedeza*	125–150	–
	littleleaf sensitive-briar	MIMI22	*Mimosa microphylla*	125–150	–
	prairie snoutbean	RHLA5	*Rhynchosia latifolia*	125–150	–
	fuzzybean	STROP	*Strophostyles*	125–150	–
	multibloom hoarypea	TEON	*Tephrosia onobrychoides*	125–150	–
	Virginia tephrosia	TEVI	*Tephrosia virginiana*	125–150	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	125–150	–
6	**Forbs**			25–50	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	25–50	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	25–50	–
	Texas bullnettle	CNTE	*Cnidoscolus texanus*	25–50	–
	hogwort	CRCA6	*Croton capitatus*	25–50	–
	plains snakecotton	FRFL	*Froelichia floridana*	25–50	–
	Carolina woollywhite	HYSCC	*Hymenopappus scabiosaeus var. corymbosus*	25–50	–
	giant goldenrod	SOGI	*Solidago gigantea*	25–50	–
Shrub/Vine					
7	**Shrubs/Vines**			150–200	
	American beautyberry	CAAM2	*Callicarpa americana*	150–200	–
	parsley hawthorn	CRMA5	*Crataegus marshallii*	150–200	–
	yaupon	ILVO	*Ilex vomitoria*	150–200	–
	winged sumac	RHCO	*Rhus copallinum*	150–200	–
	southern dewberry	RUTR	*Rubus trivialis*	150–200	–
	cat greenbrier	SMGL	*Smilax glauca*	150–200	–
	farkleberry	VAAR	*Vaccinium arboreum*	150–200	–
	muscadine	VIRO3	*Vitis rotundifolia*	150–200	–
Tree					
8	**Trees**			300–400	
	blackjack oak	QUMA3	*Quercus marilandica*	300–400	–
	post oak	QUST	*Quercus stellata*	300–400	–

Animal community

The historic savannah provided habitat to bison, deer, turkey, migratory birds and large predators such as wolves, coyotes, mountain lions, and black bear. White-tailed deer, turkey, coyotes, bobcats, and migratory birds find suitable habitat in these savannahs today. Domestic livestock and exotic ungulates are the dominant grazers and browsers on this site. As the savannah transitions through the various vegetative states towards the woodlands, the quality of the habitat may improve for some species and decline for others. Management must be applied to maintain a vegetative state in optimum habitat quality for the desired animal species.

Hydrological functions

Peak rainfall periods occur in May and June from frontal passage thunderstorms and in September and October from tropical systems as well as frontal passages. Rainfall amounts may be high (three to five inches per event) and events may be intense. Extended periods (60 days) of little to no rainfall during the growing season are common. Because of the gently sloping to sloping topography with a rapid intake rate of the surface sands and very rapid permeability of the soils, there is usually little to no runoff on this site. Water from these somewhat excessively drained soils provides groundwater recharge.

Recreational uses

Hunting, camping, bird watching, and equestrian are all common activities.

Wood products

Oaks are used for firewood. Hickory and mesquite are used for barbecue wood. Yaupon is used for landscaping.

Other products

Fruit from dewberries, grapes, and plums are harvested.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

Other references

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Approval

David Kraft, 9/23/2019

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)	Mike Stellbauer, David Polk, and Bill Deauman
Contact for lead author	Mike Stellbauer, Zone RMS, NRCS, Bryan, Texas
Date	06/08/2004
Approved by	Mark Moseley, RMS, NRCS, San Antonio, Texas
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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2. **Presence of water flow patterns:** Water flow patterns are uncommon on this site.

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3. **Number and height of erosional pedestals or terracettes:** Pedestals or terracettes are uncommon for this site when occupied by the reference community.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 25 percent bare ground randomly distributed in small patches.

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5. **Number of gullies and erosion associated with gullies:** No gullies should be present.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site has highly permeable soils with high infiltration rates. Only small-sized litter will move short distances with intense storms.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Soil Stability class range is expected to be 3 to 5.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface structure is 0 to 40 inches thick with colors from pale brown fine sand to dark brown loamy fine sand and generally weak fine granular structure. SOM is less than one percent.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The savannah of trees, shrubs, vines, grasses and forbs, along with adequate litter and little bare ground, provides for maximum infiltration and little runoff under normal rainfall events.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses >>

    Sub-dominant: Warm-season midgrasses >

    Other: Trees > Shrubs/Vines > Forbs

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups.

14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 3,000 pounds per acre for below average moisture years to 4,000 pounds per acre for above average moisture years.

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:** Potential invasive species include bahiagrass, common Bermudagrass, post oak, yaupon, eastern persimmon, and winged elm.

17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing except during periods of prolonged drought conditions, heavy natural herbivory or intense wildfires.

Ecological site R087AY005TX
Sandy Loam

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

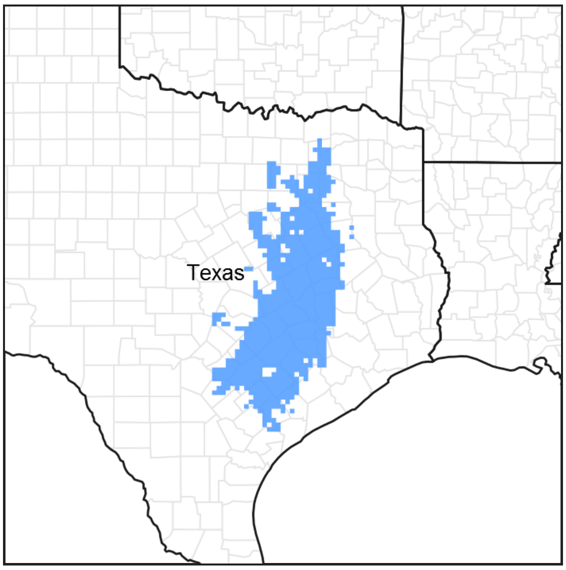


Figure 1. Mapped extent

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): 087A–Texas Claypan Area, Southern Part

This area is entirely in south-central Texas. It makes up about 10,535 square miles (27,295 square kilometers). The towns of Bastrop, Bryan, Centerville, College Station, Ennis, Fairfield, Franklin, Giddings, Gonzales, Groesbeck, La Grange, Madisonville, and Rockdale are in this MLRA. Interstate 45 crosses the northern part of the area, and Interstate 10 crosses the southern part. A number of State Parks are located throughout this area. The parks are commonly associated with reservoirs.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 87A

Ecological site concept

The Sandy Loam site are upland sites with sandy surface soils over loamy subsoils. The surface soils are usually less than 10 inches deep. The site is one of most vegetatively productive uplands sites in the MLRA.

Associated sites

R087AY002TX	**Sandstone Hill** Sandstone Hill
R087AY003TX	**Claypan Savannah** Claypan Savannah
R087AY006TX	**Sandy** Sandy
R087AY011TX	**Loamy Bottomland** Loamy Bottomland
R087AY012TX	**Clayey Bottomland** Clayey Bottomland

Similar sites

R087AY003TX	**Claypan Savannah** Claypan Savannah
R087AY004TX	**Deep Redland** Deep Redland

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Ulmus alata*
Shrub	(1) *Ilex vomitoria* (2) *Callicarpa americana*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Sorghastrum nutans*

Physiographic features

The topography of this site is nearly level to undulating with slopes ranging from 0 to 15 percent, but are mainly 1 to 8 percent.

Table 2. Representative physiographic features

Landforms	(1) Stream terrace
Flooding frequency	None
Ponding frequency	None
Elevation	200–750 ft
Slope	0–15%
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 87A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of mild days and cool nights. The average annual precipitation in this area is 41 inches. Most of the rainfall occurs in spring and fall. The freeze-free period averages about 276 days and the frost-free period 241 days.

Table 3. Representative climatic features

Frost-free period (average)	241 days
Freeze-free period (average)	276 days

Precipitation total (average)	41 in

Climate stations used

- (1) BARDWELL DAM [USC00410518], Ennis, TX
- (2) CROCKETT [USC00412114], Crockett, TX
- (3) ELGIN [USC00412820], Elgin, TX
- (4) SOMERVILLE DAM [USC00418446], Somerville, TX
- (5) FRANKLIN [USC00413321], Franklin, TX
- (6) BELLVILLE 6NNE [USC00410655], Bellville, TX
- (7) GONZALES 1N [USC00413622], Gonzales, TX
- (8) LA GRANGE [USC00414903], La Grange, TX
- (9) MADISONVILLE [USC00415477], Madisonville, TX
- (10) SMITHVILLE [USC00418415], Smithville, TX
- (11) FAIRFIELD 3W [USC00413047], Fairfield, TX
- (12) COLLEGE STN [USW00003904], College Station, TX

Influencing water features

The plant community of this site is not influenced by a stream or wetland.

Soil features

The soils are moderately deep to very deep fine sandy loams and loamy fine sands with a minimum thickness of 10 inches. The sandy surface is underlain by clay, clay loam, or sandy clay loam subsoil. Moisture from light showers is readily absorbed by the surface soil, and the subsoil takes in water moderately well. Fertility and water holding capacity are moderate in the surface and high in the subsoil. Air, water, and plant roots move through the soil readily. The soils give up water generously to growing plants. Surface crusts, slower water intake, and increased runoff are characteristics of the soils in a deteriorated condition. Soils correlated to this site include: Alum, Bastrop, Chazos, Dubina, Gasil, Gause, Gholson, Hammond, Inez, Marquez, Minerva, Personville, Rosanky, Shiro, Silawa, Spiller, and Travis.

Table 4. Representative soil features

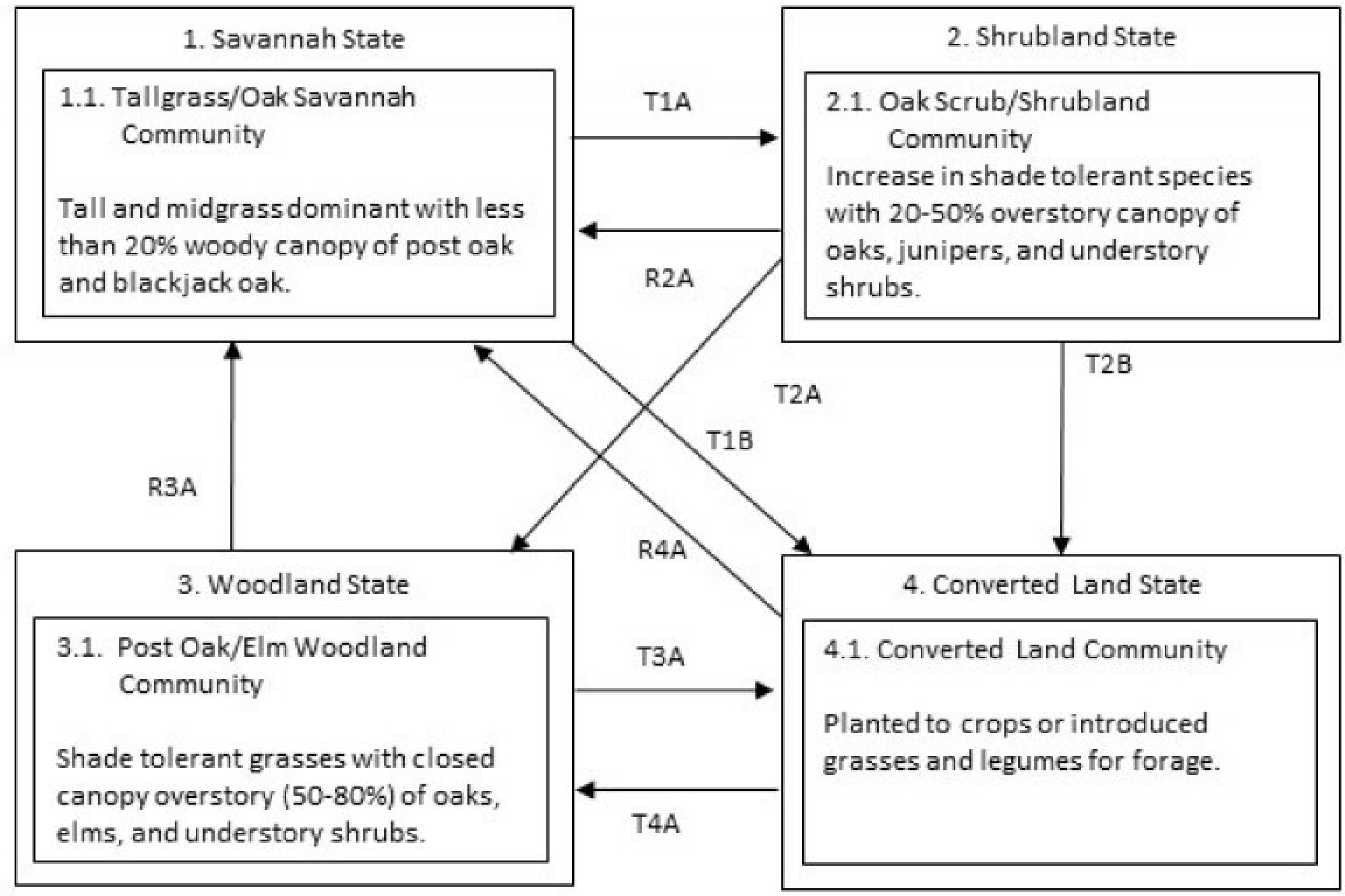
Parent material	(1) Residuum–sandstone and shale (2) Alluvium–mudstone
Surface texture	(1) Fine sandy loam (2) Loamy fine sand (3) Very fine sandy loam
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Moderately slow to very slow
Soil depth	30–80 in
Surface fragment cover <=3"	0–8%
Surface fragment cover >3"	0%
Available water capacity (0-40in)	3–6 in
Calcium carbonate equivalent (0-40in)	0–10%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–10

Soil reaction (1:1 water) (0-40in)	4.5–7.8
Subsurface fragment volume <=3" (Depth not specified)	0–20%
Subsurface fragment volume >3" (Depth not specified)	0–5%

Ecological dynamics

The sandy loam site evolved and was maintained by the grazing and herding of native wild large ungulates, periodic fires, and climatic fluctuations. Conversion of this site to cropland and the subsequent abandonment of cropping removed the native vegetation, organic matter and fertility, and allowed woody species to dominate the site. Continuous grazing by domestic livestock and the suppression of fire on non-cropland sites removes little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and preferred forbs such as Engelmann daisy (Engelmannia pinnitifida) and gayfeather (Liatris spp.). Less productive perennial grasses, annual grasses, and forbs will replace these plants. Years of continuous grazing generally lead to periods of prolonged rest or recovery of the perennial herbaceous plant component. These prolonged rest periods with no fire or brush management lead toward a community dominated by woody species such as winged elm (*Ulmus alata*), eastern persimmon (*Diospyros virginiana*), mesquite (*Prosopis glandulosa*), yaupon (*Ilex vomitoria*), post oak (Querus stellata), and eastern red cedar (*Juniperus virginiana*).

State and transition model



T1A, T2A, T4A	Heavy Continuous Grazing, No Brush Management, Abandonment
T1B, T2B, T3A	Brush Management, Crop Cultivation, Pasture Planting
R2A	Brush Management, Prescribed Grazing, Prescribed Burning
R3A	Brush Management, Range Planting, Prescribed Grazing
R4A	Range Planting, Prescribed Grazing, Prescribed Burning

Figure 6. STM

State 1
Savannah

One community exists in the Savannah State, the 1.1 Tallgrass/Oak Savannah Community. The State is dominated by warm season perennial grasses and the overstory canopy cover is less than 20 percent.

Community 1.1
Tallgrass/Oak Savannah

The interpretive plant community of this site is the reference plant community. This site is a fire-driven savannah of post oak and blackjack oak (*Quercus marilandica*) trees that shade 15 to 20 percent of the ground. The herbaceous component of tall and midgrasses and is dominated by little bluestem, Indiangrass, and brownseed paspalum (*Paspalum plicatulum*), which usually make up 50 to 75 percent of the total annual yield. Purpletop tridens (*Tridens flavus*), Florida paspalum (*Paspalum floridanum*), switchgrass, tall dropseed (*Sporobolus compositus*), and thin paspalum (*Paspalum setaceum*) also occur. Cool season plants occuring on the site include Canada wildrye (*Elymus canadensis*), Engelmann's daisy (Engelmannia pinnatifida), and sedges (Carex spp.). A variety of shrubs, vines, and forbs occur in this community. Grazing prescriptions that permit acceptable grazing periods and allow adequate rest periods along with prescribed fire every three to five years are important in the maintenance of the reference herbaceous plant community and the savannah landscape structure. Continuous overgrazing, over rest, and the absence of fire tend to allow a vegetative shift towards woody species such as eastern persimmon (*Diospyros virginiana*), eastern red cedar (*Juniperus virginiana*), and winged elm (*Ulmus alata*). Without corrective measures, this shift will continue to the Shrubland State.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2800	3600	4400
Tree	350	450	550
Shrub/Vine	175	225	275
Forb	175	225	275
Total	**3500**	**4500**	**5500**

State 2
Shrubland

One community exists in the Shrubland State, the 2.1 Oak Scrub/Shrubland Community. The herbaceous production is not as great compared to the Savannah State, and overstory canopy has increased between 20 and 50 percent.

Community 2.1
Oak Scrub/Shrubland

This plant community is a transitional community between the Savannah and Woodland State. It develops in the absence of fire or brush control treatments. It is usually the result of abandonment following cropping or yearly continuous grazing. Trees and shrubs begin to replace the grassland component of the savannah community. In addition to the naturally occuring post oak and blackjack oak - winged elm, water oak (*Quercus nigra*), mesquite (*Prosopis glandulosa*), eastern persimmon, bumelia (*Sideroxylon lanuginosum*), eastern red cedar, yaupon (*Ilex vomitoria*), and greenbriar (Smilax spp.) increase in density and canopy coverage (20 to 50 percent). Species whose seed is windblown (elm) or animal dispersed (persimmon, mesquite, eastern red cedar, bumelia) are the first to colonize and dominate the site. Remnants of little bluestem and Indiangrass may still occur but the herbaceous component of the community becomes dominated by lesser producing grasses and forbs. Silver bluestem (*Bothriochloa laguroides*), tall dropseed, arrowfeather threeawn (*Aristida purpurascens*), Scribner's panicum (Dicanthelium oliganthes), thin paspalum, Hall's panicum (*Panicum hallii*), western ragweed (*Ambrosia psilostachya*), croton (Croton spp.), and narrowleaf sumpweed (*Iva angustifolia*) commonly occur. Prescribed burning on a three to five year interval in conjunction with prescribed grazing is a viable option for returning this site to a community that resembles the reference community, provided the woody canopy cover is less than 50 percent and adequate herbaceous fine fuel exists. When this threshold is exceeded, mechanical or chemical brush control becomes necessary to move this transitional community back towards the Savannah State.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1120	1440	1760
Tree	560	720	880
Shrub/Vine	475	600	750
Forb	230	300	360
Total	**2385**	**3060**	**3750**

State 3
Woodland

One community exists in the Woodland State, the Post Oak/Elm Woodland Community. The site is characterized by little herbaceous production. The overstory canopy is over 50 percent and shrubs also limit light to the surface.

Community 3.1
Post Oak/Elm Woodland

This plant community is a closed overstory (50 to 80 percent) woodland dominated by post oak, winged elm, blackjack oak, black hickory (*Carya texana*), eastern red cedar, and water oak. Understory shrubs and sub-shrubs include yaupon, farkleberry (*Vaccinium arboreum*), possumhaw (*Ilex decidua*), and American beautyberry (*Callicarpa americana*). Woody vines also occur including, Alabama supplejack (*Berchemia scandens*), poison ivy (Toxicondendron radicans), grape (Vitis spp.), greenbriar (Smilax spp.), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and peppervine (Ampelopsis arborea). An herbaceous understory is almost nonexistent but shade-tolerant species including longleaf woodoats (*Chasmanthium sessiliflorum*), broadleaf woodoats (*Chasmanthium latifolium*), cedar sedge (*Carex planostachys*), ironweed (Veronia baldwinii), and goldenrod (Solidago spp.) may occur in small amounts. Prescribed fire may be used to convert this community back to the tallgrass savannah but may take many consecutive years of burning due to light fine fuel loads. Chemical brush control on a large scale is usually not a treatment option on this site due to the herbicide resistance of yaupon. Individual plant treatment with herbicides on small acreage may be a viable option. Mechanical treatment of this site, along with seeding, is the most viable option for reversion back to the reference community. Although, the economic feasibility of this option is questionable.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1960	2520	3100
Shrub/Vine	300	500	700
Grass/Grasslike	100	250	400
Forb	100	150	200
Total	**2460**	**3420**	**4400**

State 4
Converted

The Converted Land State contains one community, the 4.1 Converted Land Community. The state is characterized by the land manager farming crops or planted grasses.

Community 4.1
Converted Land

Conversion of this site to cropland occurred from the middle 1800's to the early 1900's. Some remains in cropland today, typically cotton (Gossypium spp.), corn (*Zea mays*), sorghum (Sorghum spp.), and soybeans (*Glycine max*). Ditching, land leveling, and levee construction has significantly changed the topography and hydrology on many acres of this site. While restoration of this site to a semblance of the reference plant community is possible with seeding and prescribed grazing, complete restoration of the reference community in a reasonable time is very unlikely. Following crop production, this site is often planted to native or introduced grasses and legumes for livestock grazing or hay production. Typical species planted include improved Bermudagrass varieties, bahiagrass, switchgrass, dallisgrass, eastern gamagrass, annual ryegrass (Lolium multiflorum), and white clover. Many of the introduced species (bahiagrass, Bermudagrass, and dallisgrass) are invasive-moving by wind, water, and animals. Once established, they are extremely difficult to remove and will hinder the reestablishment of native species. The establishment and maintenance of these species requires cultivation, fertilization, weed control, and prescribed grazing management.

Transition T1A
State 1 to 2

The Savannah State will transition to the Shrubland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 20 percent and grasses shift composition to more shade-tolerant species.

Transition T1B
State 1 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration back to the Savannah State requires brush management, prescribed grazing and/or prescribed fire. Mechanical or chemical controls can be used to remove the woody overstory species and shrubs. Prescribed grazing may require destocking and/or deferment.

Transition T2A
State 2 to 3

The Shrubland State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Transition T2B
State 2 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration back to the Savannah State requires substantial energy inputs. Brush management and prescribed grazing will be needed to shift the community back to the reference state. Mechanical or chemical controls can be used to remove the woody overstory species back below 20 percent. Prescribed grazing may require destocking and/or deferment to manage the understory grasses back to those found in the reference community. Fire may be an option, but only if adequate amounts of fine fuel exist in the understory.

Transition T3A
State 3 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R4A
State 4 to 1

The restoration to State 1 can occur when the land manager ceases agronomic practices. Range planting of native species found in the reference community will be required to bring back a similar community as the State 1 plant composition. The extent of previous soil disturbances will determine how much seedbed preparation will be needed, as well as the ability to be restored. Proper grazing and brush management will be required to ensure success.

Transition T4A
State 4 to 3

The Converted Land State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrass**			1400–2200	
	little bluestem	SCSC	*Schizachyrium scoparium*	1400–2200	–
2	**Tallgrasses**			700–1100	
	big bluestem	ANGE	*Andropogon gerardii*	700–1100	–
	Florida paspalum	PAFL4	*Paspalum floridanum*	700–1100	–
	switchgrass	PAVI2	*Panicum virgatum*	700–1100	–
	Indiangrass	SONU2	*Sorghastrum nutans*	700–1100	–
3	**Midgrasses**			420–660	
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	420–660	–
	longleaf woodoats	CHSE2	*Chasmanthium sessiliflorum*	420–660	–
	Canada wildrye	ELCA4	*Elymus canadensis*	420–660	–
	beaked panicgrass	PAAN	*Panicum anceps*	420–660	–
	brownseed paspalum	PAPL3	*Paspalum plicatulum*	420–660	–

	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	420–660	–
	purpletop tridens	TRFL2	*Tridens flavus*	420–660	–
4	**Shortgrasses**			280–440	
	arrowfeather threeawn	ARPU8	*Aristida purpurascens*	280–440	–
	sedge	CAREX	*Carex*	280–440	–
	fall witchgrass	DICO6	*Digitaria cognata*	280–440	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	280–440	–
	Hall's panicgrass	PAHA	*Panicum hallii*	280–440	–
	thin paspalum	PASE5	*Paspalum setaceum*	280–440	–
Forb					
5	**Forbs**			175–275	
	Illinois bundleflower	DEIL	*Desmanthus illinoensis*	175–275	–
	ticktrefoil	DESMO	*Desmodium*	175–275	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	175–275	–
	lespedeza	LESPE	*Lespedeza*	175–275	–
	pinkscale blazing star	LIEL	*Liatris elegans*	175–275	–
	littleleaf sensitive-briar	MIMI22	*Mimosa microphylla*	175–275	–
	yellow puff	NELU2	*Neptunia lutea*	175–275	–
	prairie snoutbean	RHLA5	*Rhynchosia latifolia*	175–275	–
	fuzzybean	STROP	*Strophostyles*	175–275	–
	multibloom hoarypea	TEON	*Tephrosia onobrychoides*	175–275	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	175–275	–
	Atlantic pigeonwings	CLMA4	*Clitoria mariana*	175–275	–
	Virginia dayflower	COVI3	*Commelina virginica*	175–275	–
	croton	CROTO	*Croton*	0–15	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–15	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	0–15	–
Shrub/Vine					
6	**Shrubs/Vines**			175–275	
	Alabama supplejack	BESC	*Berchemia scandens*	175–275	–
	American beautyberry	CAAM2	*Callicarpa americana*	175–275	–
	parsley hawthorn	CRMA5	*Crataegus marshallii*	175–275	–
	yaupon	ILVO	*Ilex vomitoria*	175–275	–
	winged sumac	RHCO	*Rhus copallinum*	175–275	–
	southern dewberry	RUTR	*Rubus trivialis*	175–275	–
	cat greenbrier	SMGL	*Smilax glauca*	175–275	–
	muscadine	VIRO3	*Vitis rotundifolia*	175–275	–
Tree					
7	**Trees**			350–550	
	black hickory	CATE9	*Carya texana*	350–550	–
	blackjack oak	QUMA3	*Quercus marilandica*	350–550	–

	water oak	QUNI	*Quercus nigra*	350–550	–
	post oak	QUST	*Quercus stellata*	350–550	–
	gum bully	SILAL3	*Sideroxylon lanuginosum ssp. lanuginosum*	350–550	–
	winged elm	ULAL	*Ulmus alata*	350–550	–
	Alabama supplejack	BESC	*Berchemia scandens*	175–275	–
	American beautyberry	CAAM2	*Callicarpa americana*	175–275	–
	parsley hawthorn	CRMA5	*Crataegus marshallii*	175–275	–
	yaupon	ILVO	*Ilex vomitoria*	175–275	–
	winged sumac	RHCO	*Rhus copallinum*	175–275	–
	southern dewberry	RUTR	*Rubus trivialis*	175–275	–
	cat greenbrier	SMGL	*Smilax glauca*	175–275	–
	muscadine	VIRO3	*Vitis rotundifolia*	175–275	–

Animal community

The historic savannah provided habitat to bison, deer, turkey, migratory birds and large predators such as wolves, coyotes, mountain lions, and black bear. White-tailed deer, turkey, coyotes, bobcats, and resident and migratory birds fine suitable habitat in these savannahs today. Domestic livestock and exotic ungulates are the dominant grazers and browsers of this site. As the savannah transitions through the various vegetative states towards oak woodlands, the quality of the habitat may improve for some species and decline for others. Management must be applied to maintain a vegetative state in optimum habitat quality for the desired animal species.

Hydrological functions

Peak rainfall periods occur in May and June from frontal passage thunderstorms and in September and October from tropical weather systems as well as frontal passages. Rainfall amounts may be high (three to five inches per envent) and events may be intense. The site is subject to erosion where adequate herbaceous cover is not maintaned and on heavy use areas such as roads and livestock trails. Extended periods (60 days) of little to no rainfall during the growing season are common. The hydrology of this site may be manipulated through management to yield higher runoff volumes or greater infiltration to groundwater. Management for less herbaceous cover will favor higher surface runoff while dense herbaceous cover and litter will favor ground water recharge. Potential pollution from sediment, pesticides, and both organic and inorganic fertilizers should always be considered when managing for higher volumes of surface runoff.

Recreational uses

Hunting, hiking, camping, equestrian, bird watching, and off road vehicle use such as atv, dirt bikes, and mountain biking are common activities.

Wood products

Oaks are used for firewood. Hickory and mesquite are used for barbecue wood. Eastern red cedar is used for posts. Yaupon is used for landscaping.

Other products

Fruits from dewberries, grapes, and plums are harvested.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

Other references

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Approval

David Kraft, 5/06/2020

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)	Mike Stellbauer, David Polk, and Bill Deauman
Contact for lead author	Mike Stellbauer, Zone RMS, NRCS, Bryan, Texas
Date	06/08/2004
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:** Some water flow patterns may be present on this site due to landscape position and slopes.

3. **Number and height of erosional pedestals or terracettes:** Pedestals or terracettes are uncommon for this site when occupied by the reference community.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 20 percent bare ground randomly distributed in small patches.

5. **Number of gullies and erosion associated with gullies:** Some gullies associated with seeps, springs and intermittent streams may be present. Head and side slopes should be vegetated and stable.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site has slowly permeable subsoils. Small to medium-sized litter will move short distances with intense storms.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Soil Stability class range is expected to be 3 to 5.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface structure is less than 10 inches thick with colors from brown fine sandy loam to dark brown loamy fine sand and generally weak fine granular structure. SOM is less than one percent.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The savannah of trees, vines, shrubs, grasses, and forbs, along with adequate litter and little bare ground, provides for maximum infiltration and little runoff under normal rainfall events.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses >

Sub-dominant: Warm-season midgrasses >

Other: Trees > Shrubs/Vines > Forbs

Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups.

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14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 3,500 pounds per acre for below average moisture years to 5,500 pounds per acre for above average moisture years.

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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:** Potential invasive species include bahiagrass, common Bermudagrass, yellow bluestem, elm, post oak, yaupon, huisache, mesquite, eastern persimmon, and eastern red cedar.

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17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing except for periods of prolonged drought conditions, heavy natural herbivory and intense wildfires.

Ecological site R087AY006TX
Sandy

Last updated: 9/23/2019
Accessed: 10/26/2022

General information

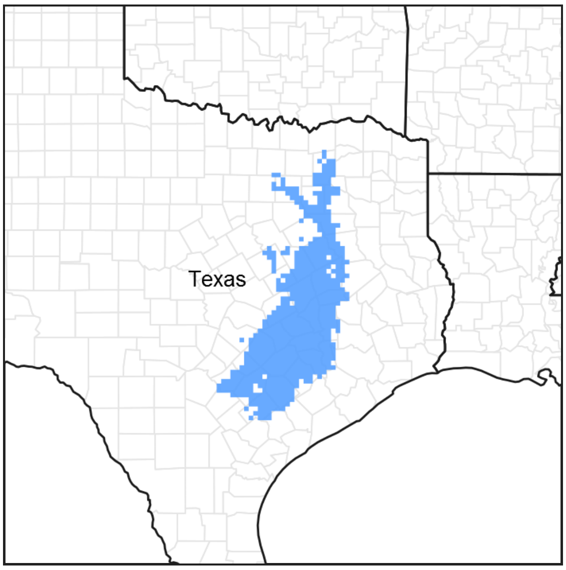


Figure 1. Mapped extent

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): 087A–Texas Claypan Area, Southern Part

This area is entirely in south-central Texas. It makes up about 10,535 square miles (27,295 square kilometers). The towns of Bastrop, Bryan, Centerville, College Station, Ennis, Fairfield, Franklin, Giddings, Gonzales, Groesbeck, La Grange, Madisonville, and Rockdale are in this MLRA. Interstate 45 crosses the northern part of the area, and Interstate 10 crosses the southern part. A number of State Parks are located throughout this area. The parks are commonly associated with reservoirs.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 87A

Ecological site concept

The sites are characterized by a sandy surface layer that extends 20 to 40 inches to a loamy subsurface layer. The sites are more productive and less droughty than soils with deeper sands, but not as productive as soils with a higher clay content.

Associated sites

R087AY001TX	**Gravelly** Gravelly
R087AY002TX	**Sandstone Hill** Sandstone Hill
R087AY003TX	**Claypan Savannah** Claypan Savannah
R087AY004TX	**Deep Redland** Deep Redland
R087AY005TX	**Sandy Loam** Sandy Loam
R087AY007TX	**Deep Sand** Deep Sand
R087AY008TX	**Very Deep Sand** Very Deep Sand
R087AY011TX	**Loamy Bottomland** Loamy Bottomland
R087AY012TX	**Clayey Bottomland** Clayey Bottomland

Similar sites

R087AY008TX	**Very Deep Sand** Very Deep Sand
R087AY007TX	**Deep Sand** Deep Sand

Table 1. Dominant plant species

Tree	(1) *Quercus stellata* (2) *Quercus marilandica*
Shrub	(1) *Ilex vomitoria* (2) *Callicarpa americana*
Herbaceous	(1) *Schizachyrium scoparium* (2) *Sorghastrum nutans*

Physiographic features

These soils are on gently sloping to strongly sloping ridges and stream terraces. Slopes range from 0 to 12 percent, but are typically between 1 and 8 percent. Some soils have a perched water table up to 30 inches. The water table is highest in later winter and early spring, or during extremely wet precipitation periods.

Table 2. Representative physiographic features

Landforms	(1) Ridge (2) Stream terrace
Flooding frequency	None
Ponding frequency	None
Elevation	200–750 ft
Slope	0–12%
Water table depth	30–80 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 87A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of mild days and cool nights. The average annual precipitation in this area is 41 inches. Most of the rainfall occurs in spring and fall. The freeze-free period averages about 276 days and the frost-free period 241 days.

Table 3. Representative climatic features

Frost-free period (average)	241 days
Freeze-free period (average)	276 days
Precipitation total (average)	41 in

Climate stations used

- (1) CROCKETT [USC00412114], Crockett, TX
- (2) FAIRFIELD 3W [USC00413047], Fairfield, TX
- (3) SOMERVILLE DAM [USC00418446], Somerville, TX
- (4) BARDWELL DAM [USC00410518], Ennis, TX
- (5) FRANKLIN [USC00413321], Franklin, TX
- (6) MADISONVILLE [USC00415477], Madisonville, TX
- (7) BELLVILLE 6NNE [USC00410655], Bellville, TX
- (8) GONZALES 1N [USC00413622], Gonzales, TX
- (9) LA GRANGE [USC00414903], La Grange, TX
- (10) ELGIN [USC00412820], Elgin, TX
- (11) SMITHVILLE [USC00418415], Smithville, TX
- (12) COLLEGE STN [USW00003904], College Station, TX

Influencing water features

A stream or wetland does not influence the plant community of this site.

Soil features

The soils are deep to very deep, fine sands and loamy fine sands with a surface 20 to 40 inches thick over loamy subsoils. Water soaks rapidly into the open soils. Even light showers penetrate below the evaporation zone and are more effective on this site than sites with deeper sands. Water retention is relatively low but the soils give up a high percent of their moisture to growing plants. Although air, water, and plant roots move through the soil with ease, frequent rains are needed to produce optimum plant growth. Inherent low fertility causes these soils to produce forage of lower quantity than associated sites with higher clay content. The site is subject to erosion where adequate herbaceous cover is not maintained and on heavy use areas such as roads and livestock trails. Soils correlated to this site include: Demona, Dutek, Newulm, Nimrod, Rehburg, Robco, Silstid, and Styx.

Table 4. Representative soil features

Parent material	(1) Alluvium–sandstone and shale
Surface texture	(1) Loamy fine sand (2) Fine sand
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Moderate to slow
Soil depth	45–80 in
Surface fragment cover <=3"	0–1%

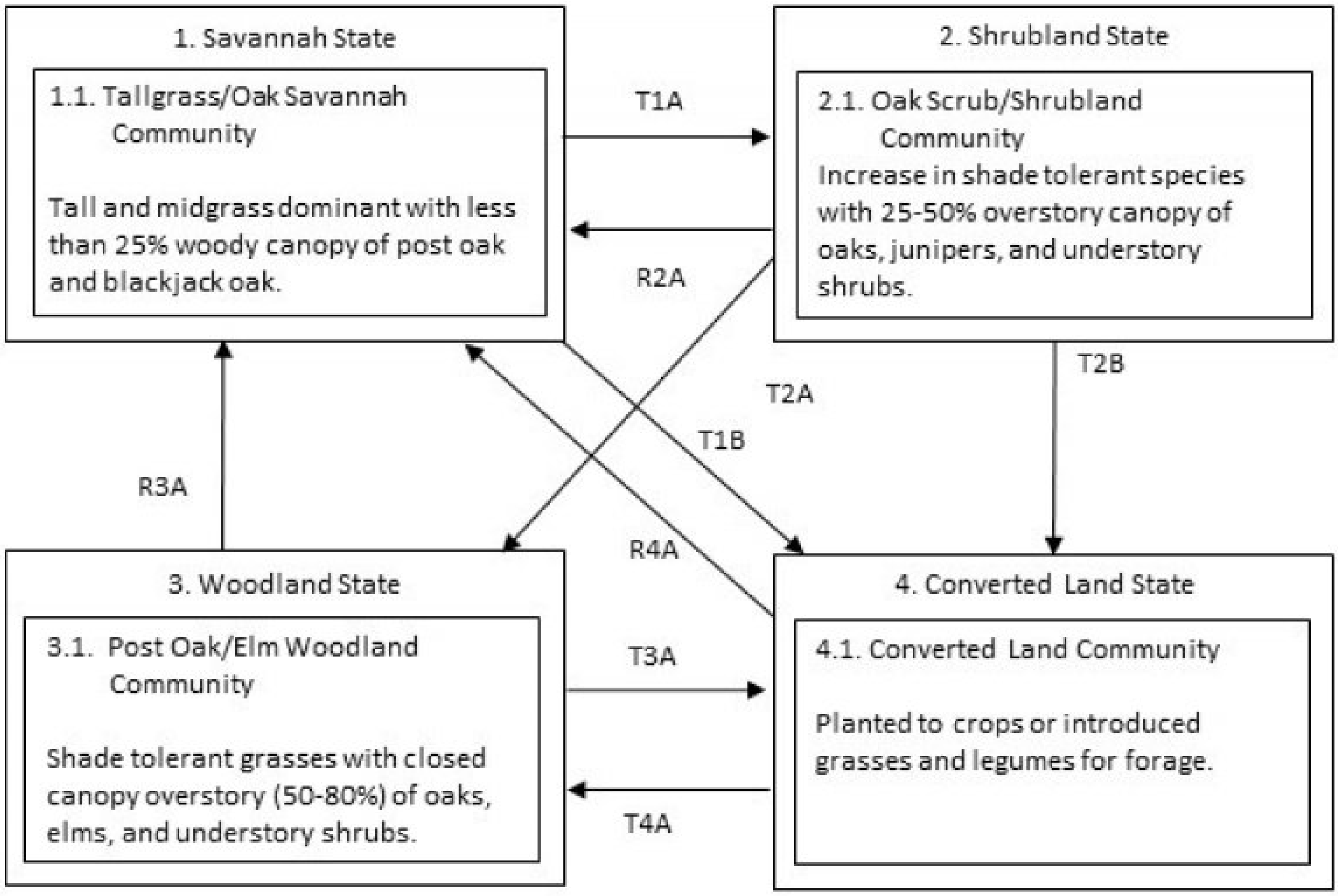
Surface fragment cover >3"	0%
Available water capacity (0-40in)	2–5 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–4
Soil reaction (1:1 water) (0-40in)	4–7.8
Subsurface fragment volume <=3" (Depth not specified)	0–6%
Subsurface fragment volume >3" (Depth not specified)	0–1%

Ecological dynamics

The Sandy site evolved and was maintained by the grazing and herding effects of native wild large ungulates, periodic fires, and extreme climatic fluctuations. Conversion of this site to cropland and the subsequent abandonment of cropping removed the natural native vegetation, organic matter, and fertility and allowed woody species to dominate the site. Continuous grazing by confined domestic livestock and the suppression of fire on non-cropland sites removes little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and preferred forbs such as tephrosia (Tephrosia spp.) and prairie clover (Dalea spp.).

Less productive perennial and annual grasses and forbs will replace these plants. Years of continuous grazing generally lead to periods of prolonged rest for recovery of the perennial herbaceous plant component. These prolonged rest periods with no fire or brush management lead toward a community dominated by woody species such as winged elm (*Ulmus alata*), yaupon (*Ilex vomitoria*), post oak (*Quercus stellata*), and eastern red cedar (*Juniperus virginiana*).

State and transition model



T1A, T2A, T4A	Heavy Continuous Grazing, No Brush Management, Abandonment
T1B, T2B, T3A	Brush Management, Crop Cultivation, Pasture Planting
R2A	Brush Management, Prescribed Grazing, Prescribed Burning
R3A	Brush Management, Range Planting, Prescribed Grazing
R4A	Range Planting, Prescribed Grazing, Prescribed Burning

Figure 6. STM

State 1
Savannah

One community exists in the Savannah State, the 1.1 Tallgrass/Oak Savannah Community. The State is dominated by warm season perennial grasses and the overstory canopy cover is less than 25 percent.

Community 1.1
Tallgrass/Oak Savannah

Figure 7. Tallgrass/Oak Savannah Community

The characteristic plant community of this site is the reference plant community. This site is an open savannah of post oak and blackjack oak (*Quercus marilandica*) trees that shade 20 to 25 percent of the ground. The herbaceous component is mid and tallgrasses and is dominated by little bluestem which usually makes up 50 to 75 percent of the total annual production. Indiangrass, purpletop tridens (*Tridens flavus*), switchgrass, beaked panicum (*Panicum anceps*), sand lovegrass (*Eragrostis trichodes*), brownseed paspalum (*Paspalum plicatulum*), and thin paspalum (*Paspalum setaceum*) also occur. Cool season forage plants are scarce on this site. A variety of shrubs, vines, and forbs occur in this community. Grazing prescriptions that permit acceptable grazing periods and allow adequate rest periods along with prescribed fire every five to seven years are important in the maintenance of the reference herbaceous plant community and the savannah landscape structure. Continuous overgrazing or over rest and the absence of fire tend to allow a vegetative shift towards woody species. Without corrective measures, this shift will continue to the Shrubland State.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2400	2800	3200
Tree	300	350	400
Forb	150	175	200
Shrub/Vine	150	175	200
Total	**3000**	**3500**	**4000**

State 2
Shrubland

One community exists in the Shrubland State, the 2.1 Oak Scrub/Shrubland Community. The herbaceous production is not as great compared to the Savannah State, and overstory canopy has increased between 25 and 50 percent.

Community 2.1
Oak Scrub/Shrubland

Figure 9. Oak Scrub/Shrubland Community

This plant community is a transitional community between the Savannah and Woodland States. It develops in the absence of fire or mechanical or chemical brush management treatments. It is usually the result of abandonment following either cropping or yearly continuous grazing. Trees and shrubs begin to encroach onto pastureland or replace the grassland component of the Tallgrass/Oak Savannah Community. In addition to the naturally occurring oaks, other woody species such as eastern persimmon, winged elm, and eastern red cedar increase in density and canopy coverage (25 to 50 percent). Remnants of little bluestem and Indiangrass may still occur but the herbaceous component of the community becomes dominated by lesser producing grasses and forbs. Initially, species such as brownseed paspalum (*Paspalum plicatulum*), tall dropseed (*Sporobolus compositus*), and fall witchgrass (*Digitaria cognata*) replace the taller grasses. As the site continues to transition, the plants which increase or invade on the site include sandbur (Cenchrus spp.), red lovegrass (*Eragrostis secundiflora*), Yankeeweed (*Eupatorium compositifolium*), bullnettle (*Cnidoscolus texanus*), croton (Croton spp.), snake cotton (Froelichia spp.), prickly pear (Opuntia spp.), queen's delight (*Stillingia texana*), beebalm (Monarda spp.), and baccharis (Baccharis spp.). Prescribed burning on a three to five year interval in conjunction with prescribed grazing may be a viable option for returning this site to the Savannah State providing woody canopy cover is less than 50 percent and adequate herbaceous fine fuel still exists. When this threshold is exceeded, mechanical or chemical brush control becomes necessary to move this transitional community back towards the Savannah State.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1350	1575	1800
Tree	900	1050	1200
Shrub/Vine	600	700	800
Forb	150	175	200
Total	**3000**	**3500**	**4000**

State 3
Woodland

One community exists in the Woodland State, the Post Oak/Elm Woodland Community. The site is characterized by little herbaceous production. The overstory canopy is over 50 percent and shrubs also limit light to the surface.

Community 3.1
Post Oak/Elm Woodland

Figure 11. Post Oak/Elm Woodland Community

This plant community is a closed overstory (50 to 80 percent) woodland dominated by post oak, winged elm, blackjack oak, black hickory (*Carya texana*), and eastern red cedar. Understory shrubs and sub-shrubs include yaupon, farkleberry, possumhaw (*Ilex decidua*), and American beautyberry (*Callicarpa americana*). Woody vines also occur and include poison ivy (*Toxicodendron radicans*), grape (Vitis spp.), greenbriar (Smilax spp.), Virginia creeper (*Parthenocissus quinquefolia*), and peppervine (Ampelopsis arborea). A herbaceous understory is almost nonexistent, but shade-tolerant species including longleaf woodoats (*Chasmanthium sessiliflorum*), cedar sedge (*Carex planostachys*), ironweed (Veronia baldwinii), and goldenrod (Solidago spp.) may occur in small amounts. Prescribed burning in conjunction with prescribed grazing may be used to convert this site back to a Savannah State but generally it takes many consecutive years of burning due to light fine fuel loads comprised mainly of hardwood tree leaves. Weather conditions are rarely condusive to burning this fuel type in this region. Chemical brush control on a large scale is not a viable treatment option on this site due to the resistance of yaupon to broadcast herbicide applications. However, individual plant treatment with herbicides on small acreage is a viable option. Mechanical treatment of this site, along with seeding, is the most viable option for reversion back to the reference community. Although, the economic viability of this option is questionable.

Table 7. Annual production by plant type

Plant Type	**Low (Lb/Acre)**	**Representative Value (Lb/Acre)**	**High (Lb/Acre)**
Tree	1350	1575	1800
Shrub/Vine	1050	1225	1400
Grass/Grasslike	450	525	600
Forb	150	175	200
Total	**3000**	**3500**	**4000**

State 4
Converted

The Converted Land State contains one community, the 4.1 Converted Land Community. The state is characterized by the land manager farming crops or planted grasses.

Community 4.1
Converted Land

Figure 13. Converted Land Community

Conversion of this site to cropland occurred from the middle 1800's to the early 1900's. Some remains in cropland today, typically cotton (Gossypium spp.), corn (*Zea mays*), sorghum (Sorghum spp.), and soybeans (*Glycine max*). Specifically, this site is used for watermelons, peas, sweet potatoes, and peanuts. Ditching, land leveling, and levee construction has significantly changed the topography and hydrology on many acres of this site. While restoration of this site to a semblance of the reference plant community is possible with seeding and prescribed grazing, complete restoration of the reference community in a reasonable time is very unlikely. Following crop production, this site is often planted to native or introduced grasses and legumes for livestock grazing or hay production. Typical species planted include improved Bermudagrass varieties, bahiagrass, switchgrass, dallisgrass, eastern gamagrass, annual ryegrass (Lolium multiflorum), and white clover. Many of the introduced species (bahiagrass, Bermudagrass, and dallisgrass) are invasive-moving by wind, water, and animals. Once established, they are extremely difficult to remove and will hinder the reestablishment of native species. The establishment and maintenance of these species requires cultivation, fertilization, weed control, and prescribed grazing management.

Transition T1A
State 1 to 2

The Savannah State will transition to the Shrubland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 25 percent and grasses shift composition to more shade-tolerant species.

Transition T1B
State 1 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration back to the Savannah State requires brush management, prescribed grazing and/or prescribed fire. Mechanical or chemical controls can be used to remove the woody overstory species and shrubs. Prescribed grazing may require destocking and/or deferment.

Transition T2A
State 2 to 3

The Shrubland State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Transition T2B

State 2 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration back to the Savannah State requires substantial energy inputs. Brush management and prescribed grazing will be needed to shift the community back to the reference state. Mechanical or chemical controls can be used to remove the woody overstory species back below 25 percent. Prescribed grazing may require destocking and/or deferment to manage the understory grasses back to those found in the reference community. Fire may be an option, but only if adequate amounts of fine fuel exist in the understory.

Transition T3A
State 3 to 4

The transition to the Converted State occurs when the site is plowed for planting crops or pasture. The driver for the transition is the land manager's decision to farm the site.

Restoration pathway R4A
State 4 to 1

The restoration to State 1 can occur when the land manager ceases agronomic practices. Range planting of native species found in the reference community will be required to bring back a similar community as the State 1 plant composition. The extent of previous soil disturbances will determine how much seedbed preparation will be needed, as well as the ability to be restored. Proper grazing and brush management will be required to ensure success.

Transition T4A
State 4 to 3

The Converted Land State will transition to the Woodland State when continued heavy grazing pressure, no brush management, and/or field abandonment continues. The transition is evident when woody species canopy cover exceeds 50 percent and grasses shift composition to more shade-tolerant species.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			2100–2700	
	little bluestem	SCSC	*Schizachyrium scoparium*	2100–2700	–
	Indiangrass	SONU2	*Sorghastrum nutans*	2100–2700	–
2	**Midgrasses**			175–275	
	sand lovegrass	ERTR3	*Eragrostis trichodes*	175–275	–
	beaked panicgrass	PAAN	*Panicum anceps*	175–275	–
	brownseed paspalum	PAPL3	*Paspalum plicatulum*	175–275	–
	switchgrass	PAVI2	*Panicum virgatum*	175–275	–
3	**Mid/Shortgrasses**			100–150	
	fall witchgrass	DICO6	*Digitaria cognata*	100–150	–
	thin paspalum	PASE5	*Paspalum setaceum*	100–150	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	100–150	–

	purpletop tridens	TRFL2	*Tridens flavus*	100–150	–
4	**Mid/Shortgrasses**			25–75	
	splitbeard bluestem	ANTE2	*Andropogon ternarius*	25–75	–
	woollysheath threeawn	ARLA6	*Aristida lanosa*	25–75	–
	sedge	CAREX	*Carex*	25–75	–
	Hall's panicgrass	PAHA	*Panicum hallii*	25–75	–
Forb					
5	**Forbs**			125–150	
	Atlantic pigeonwings	CLMA4	*Clitoria mariana*	125–150	–
	Virginia dayflower	COVI3	*Commelina virginica*	125–150	–
	ticktrefoil	DESMO	*Desmodium*	125–150	–
	coastal indigo	INMI	*Indigofera miniata*	125–150	–
	lespedeza	LESPE	*Lespedeza*	125–150	–
	littleleaf sensitive-briar	MIMI22	*Mimosa microphylla*	125–150	–
	prairie snoutbean	RHLA5	*Rhynchosia latifolia*	125–150	–
	fuzzybean	STROP	*Strophostyles*	125–150	–
	multibloom hoarypea	TEON	*Tephrosia onobrychoides*	125–150	–
	Virginia tephrosia	TEVI	*Tephrosia virginiana*	125–150	–
	prairie spiderwort	TROC	*Tradescantia occidentalis*	125–150	–
6	**Forbs**			25–50	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	25–50	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	25–50	–
	Texas bullnettle	CNTE	*Cnidoscolus texanus*	25–50	–
	hogwort	CRCA6	*Croton capitatus*	25–50	–
	plains snakecotton	FRFL	*Froelichia floridana*	25–50	–
	Carolina woollywhite	HYSCC	*Hymenopappus scabiosaeus var. corymbosus*	25–50	–
	giant goldenrod	SOGI	*Solidago gigantea*	25–50	–
Shrub/Vine					
7	**Shrubs/Vines**			150–200	
	American beautyberry	CAAM2	*Callicarpa americana*	150–200	–
	parsley hawthorn	CRMA5	*Crataegus marshallii*	150–200	–
	yaupon	ILVO	*Ilex vomitoria*	150–200	–
	winged sumac	RHCO	*Rhus copallinum*	150–200	–
	southern dewberry	RUTR	*Rubus trivialis*	150–200	–
	cat greenbrier	SMGL	*Smilax glauca*	150–200	–
	farkleberry	VAAR	*Vaccinium arboreum*	150–200	–
	muscadine	VIRO3	*Vitis rotundifolia*	150–200	–
Tree					
8	**Trees**			300–400	
	blackjack oak	QUMA3	*Quercus marilandica*	300–400	–
	post oak	QUST	*Quercus stellata*	300–400	–

Animal community

The historic savannah provided habitat to bison, deer, turkey, migratory birds and large predators such as wolves, coyotes, mountain lions, and black bear. White-tailed deer, turkey, coyotes, bobcats, and migratory birds find suitable habitat in these savannahs today. Domestic livestock and exotic ungulates are the dominant grazers and browsers on this site. As the savannah transitions through the various vegetative states towards the woodlands, the quality of the habitat may improve for some species and decline for others. Management must be applied to maintain a vegetative state in optimum habitat quality for the desired animal species.

Hydrological functions

Peak rainfall periods occur in May and June from frontal passage thunderstorms and in September and October from tropical systems as well as frontal passages. Rainfall amounts may be high (three to five inches per event) and events may be intense. Extended periods (60 days) of little to no rainfall during the growing season are common. Because of the gently sloping to sloping topography with a rapid intake rate of the surface sands and very rapid permeability of the soils, there is usually little to no runoff on this site. Water from these somewhat excessively drained soils provides groundwater recharge.

Recreational uses

Hunting, camping, bird watching, and equestrian are all common activities.

Wood products

Oaks are used for firewood. Hickory and mesquite are used for barbecue wood. Yaupon is used for landscaping.

Other products

Fruit from dewberries, grapes, and plums are harvested.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

Other references

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Approval

David Kraft, 9/23/2019

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)	Mike Stellbauer, David Polk, and Bill Deauman
Contact for lead author	Mike Stellbauer, Zone RMS, NRCS, Bryan, Texas
Date	06/08/2004
Approved by	Mark Moseley, RMS, NRCS, San Antonio, Texas
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:** Water flow patterns are uncommon on this site.

3. **Number and height of erosional pedestals or terracettes:** Pedestals or terracettes are uncommon for this site when occupied by the reference community.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 25 percent bare ground randomly distributed in small patches.

5. **Number of gullies and erosion associated with gullies:** No gullies should be present.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site has highly permeable soils with high infiltration rates. Only small-sized litter will move short distances with intense storms.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Soil Stability class range is expected to be 3 to 5.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface structure is 0 to 40 inches thick with colors from pale brown fine sand to dark brown loamy fine sand and generally weak fine granular structure. SOM is less than one percent.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** The savannah of trees, shrubs, vines, grasses and forbs, along with adequate litter and little bare ground, provides for maximum infiltration and little runoff under normal rainfall events.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses >>

    Sub-dominant: Warm-season midgrasses >

    Other: Trees > Shrubs/Vines > Forbs

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups.

14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 3,000 pounds per acre for below average moisture years to 4,000 pounds per acre for above average moisture years.

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:** Potential invasive species include bahiagrass, common Bermudagrass, post oak, yaupon, eastern persimmon, and winged elm.

17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing except during periods of prolonged drought conditions, heavy natural herbivory or intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R081BY343TX
Shallow 23-31 PZ

Last updated: 9/20/2019
Accessed: 10/26/2022

General information

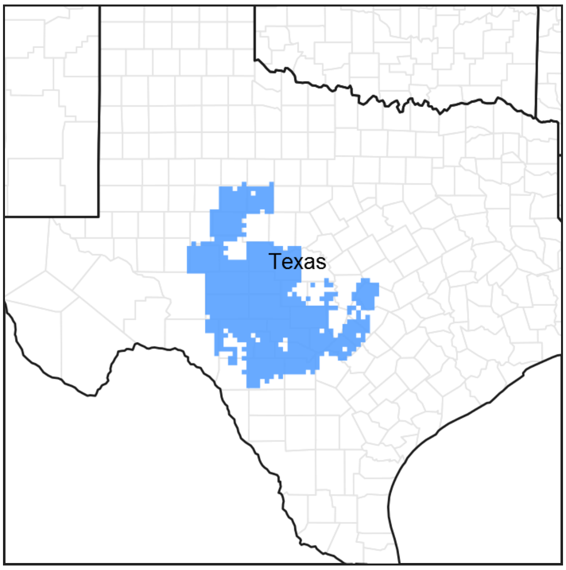


Figure 1. Mapped extent

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): 081B–Edwards Plateau, Central Part

This area is entirely in south-central Texas. It makes up about 11,125 square miles (28,825 square kilometers). The towns of Fredericksburg, Junction, Menard, Rocksprings, and Sonora are in this MLRA. Interstate 10 crosses the middle part of the area. A few State parks and State historic sites are in this MLRA.

Classification relationships

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

Ecological site concept

The Shallow ecological site is located on uplands with soils 10 to 20 inches deep over a petrocalcic horizon.

Associated sites

R081BY326TX	**Clay Loam 23-31 PZ** The Clay Loam site may be encountered on adjacent slopes.
R081BY335TX	**Loamy Bottomland 23-31 PZ** The Loamy Bottomland site may be encountered downslope from the Shallow site.

R081BY350TX	**Steep Rocky 23-31 PZ** The Steep Rocky site may be encountered upslope.
R081BY593TX	**Limestone Hill 19-23 PZ** The Limestone Hill site may be encountered uphill.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

The Shallow ecological site consists of nearly level to gently sloping soils on uplands. Slope ranges from 0 to 8 percent. This site is usually found on stream terraces, alluvial fans, hills, ridges, divides, and foot slopes. The elevation ranges from 899 feet to 2,500 feet above sea level. These soils are on nearly level to gently sloping uplands. The majority of the site is used for rangeland due to the shallow soils. However, there are some areas that are used for permanent pastureland and small grains.

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Ridge (3) Interfluve
Flooding frequency	None
Ponding frequency	None
Elevation	899–2,500 ft
Slope	0–8%
Aspect	Aspect is not a significant factor

Climatic features

The climate in the MLRA 81B is subtropical subhumid on the eastern portion and subtropical steppe on the western portion of the MLRA. Winters are dry, and the summers are hot and humid. The precipitation increases from west to east and the temperatures increase from north to south. The area usually receives 65 to 70 percent sunshine each year. The majority of the rainfall occurs during the warm months of April to October. Most precipitation comes from thunderstorms that vary in the amount of water received and the areas covered. Spring is characterized by fluctuating patterns, but mild temperatures prevail. July and August are relatively dry and hot with little weather variability day-to-day. As summer progresses through fall, an increase of precipitation usually occurs in the eastern portions while a decrease of precipitation occurs to the west. Winter temperatures are mild, but polar Canadian air masses bring rapid drops in temperature. These cold spells last 2 or 3 days. Prevailing winds are southerly with March and April the windiest months.

Table 3. Representative climatic features

Frost-free period (characteristic range)	190-202 days
Freeze-free period (characteristic range)	209-227 days
Precipitation total (characteristic range)	25-28 in
Frost-free period (actual range)	179-210 days
Freeze-free period (actual range)	194-238 days
Precipitation total (actual range)	24-30 in
Frost-free period (average)	195 days

Freeze-free period (average)	219 days
Precipitation total (average)	27 in

Climate stations used

- (1) FT MCKAVETT [USC00413257], Fort Mc Kavett, TX
- (2) ROCKSPRINGS 1S [USC00417706], Rocksprings, TX
- (3) BRADY [USC00411017], Brady, TX
- (4) EDEN [USC00412741], Eden, TX
- (5) FREDERICKSBURG [USC00413329], Fredericksburg, TX
- (6) HUNT 10 W [USC00414375], Hunt, TX
- (7) JUNCTION 4SSW [USC00414670], Junction, TX
- (8) JUNCTION KIMBLE CO AP [USW00013973], Junction, TX
- (9) MENARD [USC00415822], Menard, TX
- (10) SAN SABA [USC00417992], San Saba, TX

Influencing water features

The sites are located on uplands and are not influenced by a stream or wetland.

Soil features

In a representative profile, the parent material is limestone and alluvium derived from limestone. The surface layer is dark grayish-brown, calcareous loam about 6 to 9 inches thick. The soil depth to bedrock or a petrocalcic horizon ranges from 8 to 20 inches. Cemented limestone and caliche fragments are usually below 10 inches in depth, but may be present in the surface horizon. Texture modifiers such as gravels and cobbles compose up to 40 percent on the surface and seventy percent in the subsurface. Internal drainage is well drained and permeability is moderate to moderately slow. Runoff is low to high due to the gently sloping nature. The available water capacity is low and calcium carbonate makes up 70 percent in the soil profile. Soils correlated to this site include: Doss, Kavett, Meretta, Prade, and Purves.

Table 4. Representative soil features

Surface texture	(1) Stony silty clay (2) Cobbly clay (3) Loam
Family particle size	(1) Clayey (2) Loamy (3) Clayey-skeletal
Drainage class	Well drained
Permeability class	Very slow
Soil depth	10–20 in
Surface fragment cover <=3"	0–20%
Surface fragment cover >3"	0–20%
Available water capacity (0-40in)	1–3 in
Calcium carbonate equivalent (0-40in)	2–70%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0

Soil reaction (1:1 water) (0-40in)	7.9–8.4
Subsurface fragment volume <=3" (Depth not specified)	5–40%
Subsurface fragment volume >3" (Depth not specified)	0–35%

Ecological dynamics

The Shallow Ecological Site is a fire influenced midgrass prairie with scattered oak (Quercus spp.) mottes. Pre-settlement influences included grazing or browsing by endemic pronghorn antelope, deer and migratory bison, severe droughts, and frequent fires. Wildfires occurred at 7 to 12 years intervals or less maintaining woody species at less than 10 percent canopy on this relatively level site. The soils of the site vary from very shallow clays to shallow clay loams with pockets and crevices of deeper soils. Productivity of the site varies with these fluctuations and decreases with precipitation from east to west. Moisture holding capacity is relatively limited and often limits productivity. Long-term droughts, occurring three to four times per century, may cause shifts in vegetation by causing woody plant mortality.

Tallgrasses, such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), and Indiangrass (Sorgastrum nutans), dominated the grassland community in the eastern boundary of the MLRA originally. Sideoats grama (*Bouteloua curtipendula*) and little bluestem were the co-dominants on the drier western boundary. There was a large component of midgrasses including several feathery bluestems (Bothriochloa spp.). The frequent fires favored grasses over woody plants and forbs, but there were a wide variety of forbs, including legumes, present. Trees, primarily live oak and hackberry (*Celtis laevigata*) occupied rock crevices and deeper soil pockets on areas protected from wildfires, covering less than 10 percent of the ground area.

The Mid and Tallgrass Prairie Community is relatively stable and resilient within the climate, soil, and fire regime until European settlement. Not understanding the limits of rangeland productivity, the settlers overstocked the land with domesticated livestock almost universally. As overgrazing occurred, there was a reduction of late seral tallgrasses, decline in mulch, organic matter, and reduction in intensity and frequency of fires. The shift in plant cover and decline in soil properties favored woody plant encroachment. The woody and grassland vegetation invaders were generally endemic species released from competition. The plant community resulted in a Midgrass/Oak Savannah Community. In this community, midgrasses such as sideoats grama, feathery bluestems, plains lovegrass (*Eragrostis intermedia*), and low palatability forbs began replacing the preferable tallgrasses and forbs. In this phase, grasses still dominate primary production, but the encroaching woody species contributes an increasing amount. The higher percentage of woody species is more favorable to browsing animals. While observing the woody species use by browsing animals, early settlers stocked the area with large numbers of cattle, sheep, and goats than the site was able to sustain.

When the Midgrass/Oak Savannah Community is continually overgrazed and fire is excluded, the process of succession proceeds toward woody plant dominants and replacement of the more preferred midgrasses with shortgrasses. As grass cover declines, litter and soil organic matter decline and bare ground, erosion and other desertification processes increase. The microclimate in the grassland areas becomes more arid. Increasing woody dominants are primarily Ashe juniper (*Juniperus ashei*) in the eastern half of the MLRA and mesquite (*Prosopis glandulosa*) in the western half. When the woody plant community exceeds 20 to 25 percent canopy, rest from grazing generally will not restore the grassland community. When this transition occurs, the site develops the Oak/Juniper Shortgrass Community. This plant community also marks the beginning of the Woodland State.

Oaks (Quercus spp.) and juniper dominate the Oak/Mixedbrush Shortgrass Community in the east side of the MLRA while oaks and juniper and/or mesquite dominate in the western half. The grass component is a mixture of midgrasses, shortgrasses, and low-quality forbs. With continued livestock overgrazing, the more desirable shortgrasses, such as buffalograss (*Bouteloua dactyloides*) and curlymesquite (*Hilaria belangeri*), are replaced by less palatable species such as three-awns (Aristida spp.) and broom snakeweed (*Gutierrezia sarothrae*). Cool-season grasses such as Texas wintergrass (*Nassella leucotricha*) also increase in this phase. During this phase, the process of deterioration can be reversed with brush control and improved grazing management. If these conservation practices are not applied, the woody canopy will continue to increase in size and density and another woody plant dominated community develops.

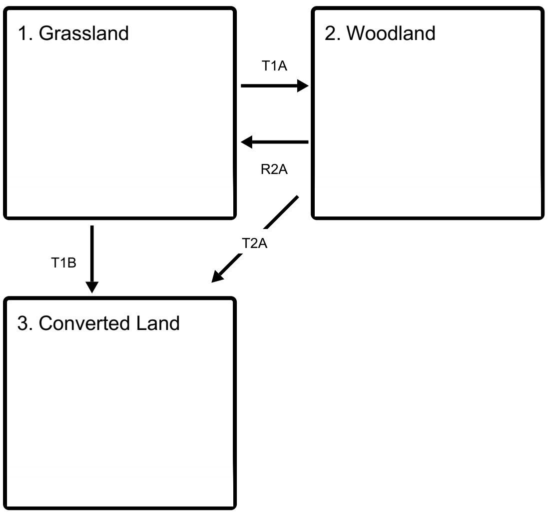
The Oak/Juniper/Mesquite Woodland Community is dominated by live oak, Ashe juniper and mesquite to the exclusion of most climax herbaceous species except within the small interspaces. Once ground cover exceeds 35 to 40 percent understory, forage production is very limited being generally made up of unpalatable shrubs, grasses, and forbs. Shortgrasses and cool-season grasses and forbs are in weakened condition due to shading and competition from the woody plants. Desertification, including erosion, continues in the interspaces until maximum ground cover by woody species is approached. The microclimate becomes drier as interception losses increase with canopy cover. Once canopy cover reaches potential, however, the hydrologic processes, energy flow and nutrient cycling stabilize under the woodland environment.

The Oak/Juniper/Mesquite Woodland Community is poor for livestock and low quality deer habitat providing only cover and low quality browse. However, this plant community provides good habitat for songbirds and woodland mammals, particularly predators. Major expense and energy are necessary to restore the Oak/Juniper/Mesquite Woodland Community to a grassland community. Generally, broadcast mechanical or herbicidal treatments, such as dozing, range planting followed by grazing deferment, prescribed grazing and prescribed burning, are essential for the site to return to the reference plant community. Erosion during the retrogression process may preclude return to reference condition.

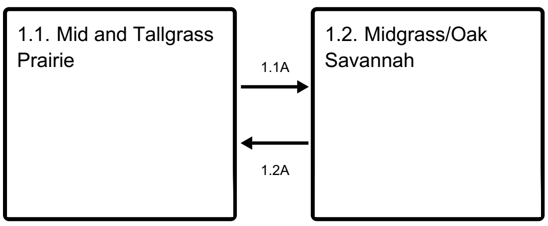
During the settlement period of the late 1800’s, the site was often plowed to cropland. Much of the site was plowed for food, fiber, and hay. Although some winter cereal crops are planted today, most of the fields in the site are planted in native or non-native grasses such as bermudagrass (*Cynodon dactylon*) or Kleingrass (*Panicum coloratum*). Some areas originally planted to crops have been abandoned and let “Go Back” to native pasture. These generally re-establish with seed from adjacent areas, especially brush species. If these invaders are not controlled with brush management, woody species will eventually dominate the plant community.

State and transition model

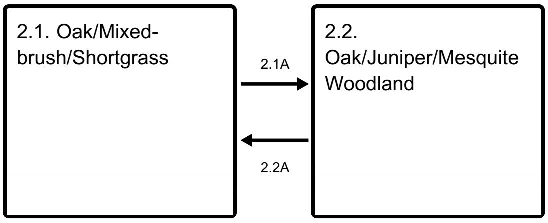
Ecosystem states



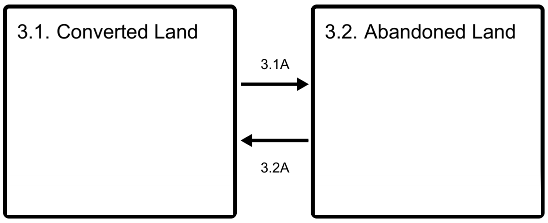
State 1 submodel, plant communities



State 2 submodel, plant communities



State 3 submodel, plant communities



State 1
Grassland

Community 1.1
Mid and Tallgrass Prairie

Figure 8. 1. Mid and Tallgrass Prairie Community

The reference plant community for this site is a fire induced mid and tallgrass prairie. Live oak was widely scattered on ridges and along draws, but made up less than three percent canopy. Woody plant production consisted mostly of shrubs. Little bluestem (*Schizachyrium scoparium*) was the dominant grass on the east side of the MLRA. Big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*) occupied favorable micro-sites and were locally dominant. In the western half, sideoats grama (*Bouteloua curtipendula*) and little bluestem were the co-dominants and big bluestem and Indiangrass were seldom present. Also occurring on the site but in smaller amounts were meadow dropseed (Sporobolus asper var. asper), feathery bluestems (Bothriochloa spp.), Texas wintergrass (*Nassella leucotricha*), Texas cupgrass (*Eriochloa sericea*), and a number of shortgrasses. Typical forbs were Maximilian sunflower (*Helianthus maximiliani*), Engelmann’s daisy (*Engelmannia peristenia*), wooly-white (Hymenopappus spp.), half-shrub sundrop (*Calylophus serrulatus*), catclaw sensitivebriar (*Mimosa nuttallii*), and bundleflower (Desmanthus spp.). Shrubs included sumacs (Rhus spp.), Texas kidneywood (*Eysenhardtia texana*), greenbriar (Smilax spp.), and bumelia (Sideroxylon spp.). Live oak (*Quercus virginiana*), hackberry (Celtis spp.), Texas redbud (*Cercis canadensis* var. texensis), and mesquite (Prosopsis glandulosa) were typical tree species. The Mid and Tallgrass Prairie Community (1.1) produced approximately 1,800 to 3,500 pounds of biomass annually, depending upon the amount of precipitation. Annual production declines from east to west due to decline in precipitation. Grasses made up to 85 to 90 percent of the total annual production. The mid and tallgrasses aided in the infiltration of rainfall into the slowly permeable soil and reduced runoff. The Mid and Tallgrass Community (1.1) furnished good habitat for grass and forb eaters such as bison and pronghorn antelope.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1530	2023	2975
Shrub/Vine	108	168	210
Forb	108	168	210
Tree	54	84	105
Total	**1800**	**2443**	**3500**

Figure 10. Plant community growth curve (percent production by month). TX3622, Mid and Shortgrass Savannah, 10% canopy. Mid and shortgrasses dominate the site with less than 20 percent forbs, shrubs, and woody plants..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	3	5	13	23	15	4	5	15	7	5	3

Community 1.2
Midgrass/Oak Savannah

Figure 11. 1.2 Midgrass/Oak Savannah Community.

The Midgrass/Oak Savannah Community (1.2) is a midgrass dominated grassland being encroached by indigenous or invading woody species that had been held at low densities by repeated fires and competition from a vigorous grass component. The overstory is primarily live oak. Numerous brushy species, including juniper and mesquite, are increasing in density because overgrazing by livestock has reduced grass cover, exposed some soil and reduced fine fuel for fire. In this phase, the increasing woody species are generally less than five feet tall and are subject to control by fire and improved grazing management. The woody canopy varies between 10 and 25 percent depending on severity of grazing, time since last burned and availability of invading species. Typically, oaks increase in size and mesquite and/or juniper increase in density. Less preferred brushy species such as bumelia, Texas persimmon (*Diospyros texana*), spiny hackberry (Celtis pallida), sumacs (Sumac spp.), condalia (Condalia spp.), elbowbush (*Forestiera pubescens*), and feather dalea (Dalea spp.) also increase. The prairie becomes a savannah being encroached by woody species. The preferred tall grasses are being replaced by the more grazing resistant midgrasses, although little bluestem persists. Important grasses are sideoats grama, tall dropseed, meadow dropseed, vine mesquite (*Panicum obtusum*), plains lovegrass (*Eragrostis intermedia*), Texas cupgrass (*Eriochloa sericea*), and feathery bluestems (Bothriochloa spp.). Most of the reference forbs still exist. Annual primary production ranges from 1,600 to 3,500 pounds per acre depending on precipitation amounts and the soil series, with production generally decreasing from the eastern boundary of the MLRA to the western boundary of the MLRA. Forage production is predominantly grass species. Heavy abusive grazing by livestock and wildlife has reduced plant cover, litter and mulch and has increased bare ground exposing the soil to some erosion. There could be some mulch and litter movement during rainstorms but due to gentle slopes, little soil movement would take place in this vegetation phase.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	500	1250	1500
Shrub/Vine	160	280	350
Tree	80	140	175
Forb	80	140	175
Total	**820**	**1810**	**2200**

Pathway 1.1A
Community 1.1 to 1.2

Mid and Tallgrass Prairie

Midgrass/Oak Savannah

With overgrazing, decrease in intensity and frequency of fires and no brush management, this plant community transitions very quickly into the Midgrass/Oak Savannah Community.

Pathway 1.2A
Community 1.2 to 1.1

Midgrass/Oak Savannah

Mid and Tallgrass Prairie

With brush management, proper grazing, and prescribed burning, the Midgrass/Oak Savannah will transition back to the Mid and Tallgrass Prairie Community.

State 2
Woodland

Community 2.1
Oak/Mixed-brush/Shortgrass

Figure 13. 2.1 Oak/Mixed-brush/Shortgrass Community.

The Oak/Mixedbrush Plant community presents a 25 percent or greater woody plant canopy dominated by live oak with mixed brush, especially Ashe juniper and/or mesquite increasing in density and size. It is the result of selective overgrazing by livestock and deer and the differential response of plants to defoliation. There is a decline in diversity of the grassland component and an increase in woody species and unpalatable forbs. Primary production has decreased due to decline in soil structure and organic matter and has shifted toward the woody component. All, except the more palatable woody species, have increased in size. Mesquite was an early increaser throughout the MLRA. Ashe juniper spreads throughout the eastern boundary and some redberry juniper (*Juniperus pinchotii*) is found in the western boundary. Many of the climax shrubs are present. Typically, algerita (Mahonia trifoliata), Texas persimmon, prickly pear (Opuntia spp.), condalia (Condalia spp.), shin oak (*Quercus sinuata*), and sumac (Sumac spp.) form thickets. Remnants of reference condition grasses and forbs and unpalatable invaders occupy the interspaces between trees and shrubs. Cool-season grasses such as Texas wintergrass can be found under and around woody plants. Because of grazing pressure and competition for nutrients and water from the woody plants, the grassland component shows lack of plant vigor and productivity. Common herbaceous species are three-awns (Aristida spp.), hairy tridens (*Erioneuron pilosum*), hairy grama (*Bouteloua hirsuta*), sedges (Carex spp.), Queen's delight (*Stillingia sylvatica*), prairie coneflower (*Ratibida columnifera*), Texas grama (*Bouteloua rigidiseta* var. rigidiseta), and red grama (*Bouteloua trifida*). As the grassland vegetation declines, more soil is exposed to crusting and erosion. During this phase, soil and water erosion can be high. High interception losses by the increasing woody canopy combined with evaporation and runoff can reduce the effectiveness of rainfall. Soil organic matter and structure decline in the interspaces but conditions may improve under woody plant cover. Some soil loss could occur during heavy rainfall events. Annual primary production is approximately 1,000 to 3,000 pounds per acre. In this stage, production is balanced between herbaceous plants and woody plants. Browsing animals such as goats and deer find fair food value if browsing has not been excessive. Forage quality for cattle is low. Unless brush management and good grazing management are applied at this stage, the transition toward dense woodland community will continue. The trend cannot be reversed with good grazing management practices alone.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	500	1250	1500
Tree	250	625	750
Shrub/Vine	150	325	450
Forb	100	250	300
Total	**1000**	**2450**	**3000**

Community 2.2
Oak/Juniper/Mesquite Woodland

Figure 15. 2.2 Oak/Juniper/Mesquite Woodland Community.

Oak, juniper and/or mesquite dominate the Oak/Juniper/Mesquite Woodland Community. Juniper is more prevalent in the eastern portion of the MLRA. With the associated brushy understory shrubs, the woody canopy can approach 100 percent ground cover with continued heavy grazing. Common understory shrubs are pricklypear (Opuntia spp.), algerita (Mahonia trifoliata), condalia (Condalia spp.), yucca (Yucca spp.), Texas persimmon (*Diospyros* *texana*), elbowbush (*Forestiera pubescens*), pricklyash (Zanthoxylum spp.), and tasajillo (Opuntia leptocaulis). Shortgrasses and low quality annual and perennial forbs occupy the tree interspaces. Characteristic grasses are Texas wintergrass, curlymesquite, buffalograss, Hall's panicum (*Panicum hallii* var. hallii), rough tridens (*Tridens muticus* var. muticus), slim tridens (*Tridens muticus*), tobosagrass (*Pleuraphis mutica*), and fall witchgrass (*Digitaria cognata*). Grasses and forbs make up 25 percent or less of the annual biomass production. Common forbs include dotted gayfeather (*Liatris punctata* var. punctata), orange zexmenia (Wedelia hispida), croton (Croton spp.), western ragweed (*Ambrosia psilostachya*), prairie coneflower (*Ratibida columnifera*), and broomweed (Gutierrezia spp.). The tree and shrub canopy acts to intercept rainfall and increase evapotranspiration losses, creating a more xeric microclimate. Soil fauna and litter are reduced exposing more soil surface to erosion in the few interstitial spaces. However, within the woody canopy hydrologic processes stabilize and soil organic matter and mulch begin to increase and eventually stabilize under the woodland. Without major brush control and management inputs, this plant community cannot be reversed. Without proper management, the site will continue to thicketize until it stabilizes with the climate and soil. Although this state provides good habitat cover for wildlife, only limited preferred forage or browse is available for livestock or wildlife.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	400	1000	1500
Grass/Grasslike	200	500	750
Shrub/Vine	160	400	600
Forb	40	100	150
Total	**800**	**2000**	**3000**

Pathway 2.1A
Community 2.1 to 2.2


Oak/Mixed-brush/Shortgrass


Oak/Juniper/Mesquite Woodland

With heavy abusive grazing, no fire, no brush management, and invasion of brush species, the Mixed-brush/Shortgrass Community will shift to the Mixed-brush Shrubland Community.

Pathway 2.2A
Community 2.2 to 2.1


Oak/Juniper/Mesquite Woodland


Oak/Mixed-brush/Shortgrass

With prescribed grazing, prescribed burning, and brush management (IPT) conservation practices, the Mixed-brush Shrubland Community can revert back to Mixed-brush/Shortgrass Community.

State 3
Converted Land

Community 3.1
Converted Land

Figure 17. 3.1 Converted Land Community.

Early settlers of the MLRA, having farming background, cultivated small fields for vegetable crops, grain, forage sorghum, and winter cereals for livestock forage. Many of the Shallow sites were converted to cropland. In Edwards Plateau summer crops succeed only one in every four or five years, so farming is not sustainable. Cropping small acreages is still practiced, however, for summer annual forage crops or winter small grain grazing. Cropland fields are used for livestock grazing, grain harvesting or wildlife food plots on many ranches. Many fields, however, have been abandoned and let ‘go back’ to native range or planted to native or introduced grasses for pasture. Abandoned cropland areas, or woodland areas, are often cleared and plowed for seeding to native or introduced species such as Kleingrass (*Panicum coloratum*), blue panicum (*Panicum antidotale*), or weeping lovegrass (*Eragrostis curvula*). Herbage production on those seeded to adapted introduced grasses or native grasses reach peak production within a few years, if a full stand is established. In this case, herbage production will equal the reference community if species such as little bluestem or sideoats grama are seeded. Adapted introduced species plantings such as Kleingrass may surpass reference community production. The practice of including adapted legumes or other forbs will enhance productivity and usefulness, especially for wildlife.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	2200	3000	4500
Forb	100	300	400
Total	**2300**	**3300**	**4900**

Community 3.2
Abandoned Land

The Abandoned Land Community describes cropland fields that have been abandoned and are undergoing secondary succession. The ‘go back land’ results from abandoning cropped land and leaving it idle without seeding or brush management. Settlers cultivated many areas of the Shallow Ecological Site because of their gentle slopes, loamy soils and location. Many cropland fields have since been abandoned. The abandoned cropland will be invaded by brush from the adjacent rangeland. The initial composition of abandoned fields on the Shallow site is composed of annual, biennial and weak perennial grasses and forbs. The species depends on the seed source from adjacent rangeland. The rate of succession depends on grazing management and drought frequency, but reestablishment of reference community species takes many years. Without grazing management and brush management practices, brush species such as pricklypear, mesquite, and juniper will dominate the site before a grass community can become established. Biomass production will be limited in the early seral stage and increase as the reference community is approached. Brush management and grazing management are necessary to allow the field to ‘go back’ near reference community conditions.

Table 10. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	550	990	1320
Forb	300	540	720
Shrub/Vine	100	180	240
Tree	50	90	120
Total	**1000**	**1800**	**2400**

Pathway 3.1A
Community 3.1 to 3.2

Invasion of the seeded fields by brush is common in this MLRA. Drought and reduced soil cover due to cropping and grazing and a nearby seed source trigger the invasions. The shrub seedlings that appear in seeded or abandoned fields are true seedlings established by seeds brought in by animals, water, or wind. The invading brush must be controlled with grazing management, prescribed burning or other brush management methods or the woody invaders will again dominate.

Pathway 3.2A
Community 3.2 to 3.1

With the implementation of various conservation practices such as prescribed grazing, range/pasture/cropland management, pasture planting, range planting, and crop cultivation, the Abandoned Land Community can be reverted to the Converted Land Community.

Transition T1A
State 1 to 2

The changes in species composition are small initially, but unless proper grazing and prescribed burning are applied; the woody species continue to increase in size and density. When the canopy of the woody plants becomes dense enough (25 percent) and tall enough (greater than five feet) to suppress grass growth and resist fire damage, a threshold in ecological succession is crossed. The Midgrass/Oak Savannah Community transitions into the Oak/Mixedbrush Shortgrass Community. Normal range management practices, such as proper grazing and prescribed burning, cannot reverse the trend to tallgrass dominance.

Transition T1B
State 1 to 3

Brush management, pasture planting, range planting, and crop cultivation are some conservation practices that can shift from the Grassland State to the Converted Land State.

Restoration pathway R2A
State 2 to 1

With reclamation, prescribed grazing, prescribed burning, brush management, and range planting, the Woodland State can shift to the Grassland State.

Transition T2A
State 2 to 3

Brush management, pasture planting, range planting, and crop cultivation are some conservation practices that can shift from the Grassland State to the Converted Land State.

Additional community tables

Table 11. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**tallgrass**			450–875	
	little bluestem	SCSC	*Schizachyrium scoparium*	450–875	–
2	**tallgrasses**			270–525	
	big bluestem	ANGE	*Andropogon gerardii*	270–525	–
	Indiangrass	SONU2	*Sorghastrum nutans*	270–525	–
3	**midgrasses**			540–1050	
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	540–1050	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	540–1050	–
	tall grama	BOHIP	*Bouteloua hirsuta var. pectinata*	540–1050	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	540–1050	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	540–1050	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	540–1050	–
	green sprangletop	LEDU	*Leptochloa dubia*	540–1050	–
	vine mesquite	PAOB	*Panicum obtusum*	540–1050	–
	Reverchon's bristlegrass	SERE3	*Setaria reverchonii*	540–1050	–
	plains bristlegrass	SEVU2	*Setaria vulpiseta*	540–1050	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	540–1050	–
	Drummond's dropseed	SPCOD3	*Sporobolus compositus var. drummondii*	540–1050	–
	slim tridens	TRMU	*Tridens muticus*	540–1050	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	540–1050	–
4	**shortgrasses**			180–350	
	threeawn	ARIST	*Aristida*	180–350	–
	buffalograss	BODA2	*Bouteloua dactyloides*	180–350	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	180–350	–
	Texas grama	BORI	*Bouteloua rigidiseta*	180–350	–
	red grama	BOTR2	*Bouteloua trifida*	180–350	–
	fall witchgrass	DICO6	*Digitaria cognata*	180–350	–
	hairy woollygrass	ERPI5	*Erioneuron pilosum*	180–350	–
	curly-mesquite	HIBE	*Hilaria belangeri*	180–350	–
5	**cool-season grasses**			90–175	
	cedar sedge	CAPL3	*Carex planostachys*	90–175	–
	Canada wildrye	ELCA4	*Elymus canadensis*	90–175	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	90–175	–
Forb					
6	**forbs**			108–210	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	108–210	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	108–210	–
	aster	ASTER	*Aster*	108–210	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	108–210	–

	croton	CROTO	*Croton*	108–210	–
	prairie clover	DALEA	*Dalea*	108–210	–
	bundleflower	DESMA	*Desmanthus*	108–210	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	108–210	–
	beeblossom	GAURA	*Gaura*	108–210	–
	starviolet	HEDYO2	*Hedyotis*	108–210	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	108–210	–
	trailing krameria	KRLA	*Krameria lanceolata*	108–210	–
	dotted blazing star	LIPU	*Liatris punctata*	108–210	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	108–210	–
	yellow puff	NELU2	*Neptunia lutea*	108–210	–
	narrowleaf Indian breadroot	PELI10	*Pediomelum linearifolium*	108–210	–
	beardtongue	PENST	*Penstemon*	108–210	–
	smartweed leaf-flower	PHPO3	*Phyllanthus polygonoides*	108–210	–
	wild petunia	RUELL	*Ruellia*	108–210	–
	white rosinweed	SIAL	*Silphium albiflorum*	108–210	–
	awnless bushsunflower	SICA7	*Simsia calva*	108–210	–
	fuzzybean	STROP	*Strophostyles*	108–210	–
	queen's-delight	STSY	*Stillingia sylvatica*	108–210	–
	creepingoxeye	WEDEL	*Wedelia*	108–210	–
Shrub/Vine					
7	**shrubs/vines**			108–210	
	acacia	ACACI	*Acacia*	108–210	–
	snakewood	CONDA	*Condalia*	108–210	–
	featherplume	DAFO	*Dalea formosa*	108–210	–
	Texas crabgrass	DITE	*Digitaria texana*	108–210	–
	jointfir	EPHED	*Ephedra*	108–210	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	108–210	–
	stretchberry	FOPU2	*Forestiera pubescens*	108–210	–
	western white honeysuckle	LOAL	*Lonicera albiflora*	108–210	–
	algerita	MATR3	*Mahonia trifoliolata*	108–210	–
	plum	PRUNU	*Prunus*	108–210	–
	fragrant sumac	RHAR4	*Rhus aromatica*	108–210	–
	littleleaf sumac	RHMI3	*Rhus microphylla*	108–210	–
	sumac	RHUS	*Rhus*	108–210	–
	bully	SIDER2	*Sideroxylon*	108–210	–
	greenbrier	SMILA2	*Smilax*	108–210	–
	grape	VITIS	*Vitis*	108–210	–
Tree					
8	**trees**			54–105	
	eastern redbud	CECA4	*Cercis canadensis*	54–105	–
	hackberry	CELTI	*Celtis*	54–105	–
	juniper	JUNIP	*Juniperus*	54–105	–

	juniper	JUNIP	*Juniperus*	54–105	–
	mesquite	PROSO	*Prosopis*	54–105	–
	live oak	QUVI	*Quercus virginiana*	54–105	–

Animal community

Many types of grassland insects, reptiles, birds, and mammals use the Shallow Ecological Site, either as their base habitat or from the adjacent sites. Small mammals include many kinds of rodents, jackrabbit, cottontail rabbit, raccoon, skunk, opossum, and armadillo. Predators include coyote, red fox, gray fox, bobcat, and occasionally mountain lion. Game birds, songbirds, and birds of prey are indigenous or frequent users. Bison and pronghorn antelope, however, are no longer present, but white-tailed and many species of exotic deer utilize the Shallow site. Deer, turkey, and quail particularly favor the habitat. Deer, turkey, quail, and dove hunting is an important sport, or commercial enterprise, providing considerable income to landowners.

The site is suitable for the production of livestock, including cattle, sheep, and goats. The site in reference condition is very suited to primary grass eaters such as cattle. As retrogression occurs and woody plants invade it becomes better habitat for sheep, goats, deer, and other wildlife because of the browse and cool-season grasses. Cattle, sheep, and goats should be stocked in proportion to the available grass, forb, and browse forage, keeping deer competition for forbs and browse in mind. If the animal numbers are not kept in balance with herbage and browse production through grazing management and good wildlife population management, the late mixed-brush shrubland phase will have little to offer as habitat except cover.

Hydrological functions

The Shallow Ecological Site is a well-drained, very shallow upland with nearly level to gentle slopes. Most soils are 10 to 20 inches deep with pockets and crevices of deeper soils included. A hard limestone or caliche layer below the surface horizon limits soil moisture holding capacity. Runoff is slow due to gentle slopes. However, soil crusting can cause erosion from bare ground on steeper slopes. Under reference conditions, the grassland vegetation intercepted and utilized much of the incoming rainfall in the soil solum. Only during extended rains or heavy thunderstorms was there much runoff. Litter and soil movement was slight. Standing plant cover, duff, and organic matter decrease and surface runoff increases as the Mid and Tallgrass Prairie Community transitions to the Midgrass/Oak Savannah Community. These processes continue in the interstitial spaces in the Oak/Mixed-brush Shortgrass Community.

Once the Oak/Juniper/Mesquite Woodland Community canopy surpasses 50 percent the hydrology and ecological processes, nutrient cycling and energy flow, stabilize within the woody plant canopy. Evaporation and interception losses are higher, however, resulting in less moisture reaching the soil. If overgrazing continues, the plant community deteriorates further and desertification processes continue. Herbage production has shifted from primarily grasses to primarily woody plants. The deeper-rooted woody plants are able to extract water from greater depths than grasses, so less water will be available for down-slope movement. The woody plants compete for moisture with the remaining grasses and forbs further reducing production and ground cover in openings, which in the advanced woodland state occur only on very shallow soil areas. Decreased litter and more bare ground allow erosion from soils in openings between trees.

Recreational uses

The Shallow site is well suited for many outdoor recreational uses including recreational hunting, hiking, camping, equestrian, and bird watching. This site along with adjacent upland sites and Loamy Bottomland sites also provide diverse scenic beauty and many opportunities for recreation and hunting.

Wood products

Posts and specialty wood products are made from juniper, mesquite, oak, and many shrubs. Mesquite and oak are used for firewood and charcoal.

Other products

Jams and jellies are made from many fruit-bearing species. Seeds are harvested from many plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from the many flowering plants.

Inventory data references

Information presented here has been derived from the revised Shallow Site, literature, limited NRCS clipping data (417s), field observations and personal contacts with range-trained personnel. Photos by J. L. Schuster.

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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.

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Approved by	Mark Moseley, RMS, NRCS, Boerne, Texas
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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2. **Presence of water flow patterns:** None to few. Erosion which might cause rills, flow patterns and pedestals and terracettes would have occurred only if intense rainstorms occurred during extended drought or shortly after an intense wildfire.

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3. **Number and height of erosional pedestals or terracettes:** None to few.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Less than 10 percent bare ground. Small and non-connected areas. Lower slopes would have less bare ground.

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5. **Number of gullies and erosion associated with gullies:** None to rare. Drainages are stable with adequate vegetative cover to reduce erosive action of runoff. Rare gullies would be vegetated and stabilized.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** None to slight. Wind erosion hazard of soil is slight.

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7. **Amount of litter movement (describe size and distance expected to travel):** Minimal movement of litter for short distances. Litter is fairly uniformly distributed.

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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):** Erosion Stability Values estimated at 5 to 6. and water erosion is slight.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Surface layer is dark grayish brown clay 11 to 14 inches thick. Structure is moderate, fine and medium blocky. There are many fine and medium roots throughout soil profile. SOM is high.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Tall and midgrasses having good distribution and ground cover provide excellent infiltration and slow runoff. Except on steeper slopes, runoff is essentially nil but when rainfall exceeds site's ability to hold water, the run off is free of erosive action.

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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. Rock layer at 14 inches restricts water and root penetration.

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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 tallgrasses

    Sub-dominant: Warm-season midgrasses Warm-season shortgrasses

    Other: Forbs = Shrub/Vines Cool-season grasses Trees

    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal. Grasses will almost always show some mortality and decadence, especially during drought conditions.

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14. **Average percent litter cover (%) and depth (in):** Interspaces between plant canopies essentially covered with various sizes of litter and mulch. Wildfires, natural herbivory and/or extended drought might reduce litter to none. Recovery will take 2 to 5 years.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1,800 pounds per acre in years with below average moisture, 2,800 pounds per acre in years with average moisture and 3,500 pounds per acre in above average moisture years.

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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:** Mesquite, pricklypear, broom snakeweed, agarito, acacia, sumacs, junipers, Texas persimmon, and condalia.

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17. **Perennial plant reproductive capability:** Good. All species should be capable of reproducing except during periods of prolonged drought, heavy natural herbivory or intense fire. Recovery from these disturbances will take 2 to 5 years.

USDA Natural Resources Conservation Service

Ecological site R086AY011TX
Southern Blackland

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

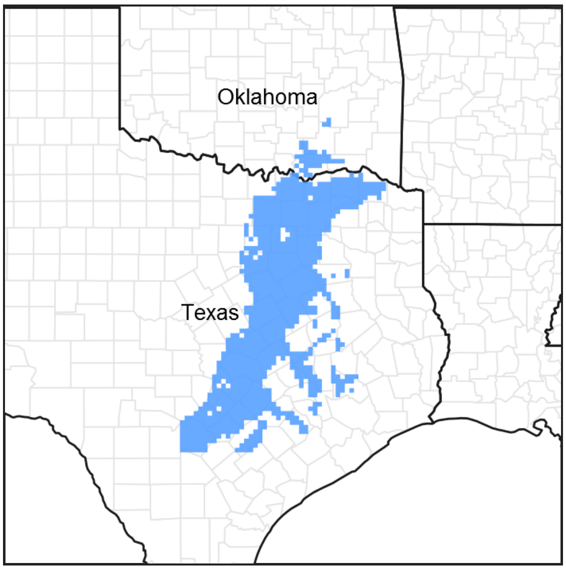


Figure 1. Mapped extent

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): 086A–Texas Blackland Prairie, Northern Part

MLRA 86A, The Northern Part of Texas Blackland Prairie is entirely in Texas. It makes up about 15,110 square miles (39,150 square kilometers). The cities of Austin, Dallas, San Antonio, San Marcos, Temple, and Waco are located within the boundaries. Interstate 35, a major thoroughfare for commerce and travel, traverses the length of the MLRA from San Antonio to Dallas. The area supports tall and mid-grass prairies, but improved pasture, croplands, and urban development account for the majority of the acreage.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 86A

Ecological site concept

The Blackland ecological site is a true tallgrass prairie. Reference sites show an intact grass community with small clumped dispersal of woody species. The soils are moderately deep to very deep, richly black in color, and characterized by their shrink-swell nature. The sites are widely distributed across the uplands and terraces throughout the region.

Associated sites

R086AY002TX	**Southern Chalky Ridge** The Chalky Ridge site is often upslope from the Blackland. It differs from the site by having shallow soils and low soil fertility.
R086AY004TX	**Southern Claypan Prairie** The Claypan Prairie site is often adjacent to the Blackland. It differs from the site by having a fine sandy loam surface soil layer over clay subsoils.
R086AY009TX	**Southern Eroded Blackland** The Eroded Blackland site is often adjacent to the Blackland site. It differs from the site by having extensive erosion indicated by a partial or lost A horizon, active rills and/or gullies, and lower production.

Similar sites

R086AY010TX	**Northern Blackland** The Northern Blackland site is similar to the Southern Blackland site by having similar physiographic features and representative soil features. It differs from the site by receiving more effective precipitation.
R086AY009TX	**Southern Eroded Blackland** The Eroded Blackland site is similar to the Blackland site by having similar soil types and topography. It differs from the site by having extensive erosion indicated by a partial or lost A horizon, active rills and/or gullies, and lower production.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

These are uplands and terraces with nearly level to moderate slopes. Slope gradients range from 0 to 8 percent but are usually less than 5 percent. There is no flooding or ponding with a low to high runoff, greatly depending on soil saturation and slope.

Table 2. Representative physiographic features

Landforms	(1) Terrace (2) Ridge (3) Plain
Flooding frequency	None
Ponding frequency	None
Elevation	300–600 ft
Slope	0–8%
Water table depth	60–80 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 86A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. Tropical maritime air controls the climate during spring, summer and fall. In winter and early spring, frequent surges of Polar Canadian air cause sudden drops in temperatures and add considerable variety to the daily weather. When these cold air masses stagnate and are overrun by moist air from the south, several days of cold, cloudy, and rainy weather follow. Generally, these occasional cold spells are of short duration with rapid clearing following cold frontal passages. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of sunny skies, mild days, and cool nights. The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time during the summer and 50 percent in winter. The prevailing wind direction is from the south and highest wind speeds occur during the spring months. Rainfall during the spring and summer months generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. High-intensity rains of short duration are likely to produce rapid runoff almost anytime during the year. The predominantly anticyclonic atmospheric circulation over Texas in summer and the exclusion of cold fronts from North Central Texas result in a decrease in rainfall during midsummer. The amount of rain that falls varies considerably from month-to-month and from year-to-year.

Table 3. Representative climatic features

Frost-free period (average)	244 days
Freeze-free period (average)	276 days
Precipitation total (average)	36 in

Climate stations used

- (1) SAN MARCOS [USC00417983], San Marcos, TX
- (2) AUSTIN-CAMP MABRY [USW00013958], Austin, TX
- (3) NEW BRAUNFELS [USC00416276], New Braunfels, TX
- (4) SAN ANTONIO 8NNE [USC00417947], San Antonio, TX
- (5) WACO DAM [USC00419417], Waco, TX
- (6) LULING [USC00415429], Luling, TX
- (7) TAYLOR 1NW [USC00418862], Taylor, TX
- (8) TEMPLE [USC00418910], Temple, TX
- (9) CAMERON [USC00411348], Cameron, TX
- (10) CEDAR CREEK 5 S [USC00411541], Cedar Creek, TX
- (11) GRANGER DAM [USC00413686], Granger, TX
- (12) RED ROCK [USC00417497], Red Rock, TX
- (13) SAN ANTONIO INTL AP [USW00012921], San Antonio, TX
- (14) AUSTIN BERGSTROM AP [USW00013904], Austin, TX

Influencing water features

The site has a water table that can exist at a depth of 60 inches in the soil profile.

Soil features

The site consists of moderately deep to very deep, moderately well to well drained soils that are slow to very slowly permeable. The upland soils formed in calcareous marl and marine sediments, high in smectitic clays. The terrace soils formed in clayey alluvial sediments. A few of the upland soils may have weathered and soft bedrock at a depth of more than 24 inches below the soil surface. The majority of this site is used for cropland due to the very deep, highly productive soils. There are some areas that are used for pasture or rangeland.

In a representative profile, the surface layer is black clay about 24 inches thick. The clay extends below 24 inches and to depths of more than 80 inches. The subsoil is clay that grades from very dark gray to light olive brown as depth increases. Available water capacity to a depth of 60 inches is moderate, and shrink swell potential is very high.

The dominant associated soil series for the Blackland ecological site includes:
Barbosa, Behring, Branyon, Burleson, Chatt, Dalco, Deport, Fairlie, Ferris, Heiden, Houston Black, and Leson.

Table 4. Representative soil features

Parent material	(1) Residuum–mudstone

Surface texture	(1) Clay (2) Gravelly clay (3) Stony clay
Family particle size	(1) Clayey
Drainage class	Moderately well drained to well drained
Permeability class	Slow to very slow
Soil depth	24–80 in
Surface fragment cover <=3"	0–40%
Surface fragment cover >3"	0–10%
Available water capacity (0-40in)	5–11 in
Calcium carbonate equivalent (0-40in)	0–55%
Electrical conductivity (0-40in)	0–4 mmhos/cm
Sodium adsorption ratio (0-40in)	0–2
Soil reaction (1:1 water) (0-40in)	5.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–25%
Subsurface fragment volume >3" (Depth not specified)	0–15%

Ecological dynamics

Introduction – The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background – Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Florida paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsuta*), and dropseeds (Sporobolus spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak (*Quercus virginiana*) and hackberry (Celtis spp.) trees are also native to the region. In some areas, cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), and honey locust (*Gleditsia triacanthos*) are abundant. In the Northern Blackland Prairie oaks (Quercus spp.) are common increasers, but in the Southern Blackland Prairie oaks are less prevalent. Junipers are common invaders, particularly in the northern part of the region.

During the first half of the nineteenth century, row crop agriculture lead to over 80 percent of the original vegetation lost. During the second half, urban development has caused even an even greater decline in the remaining prairie. Today, less than one percent of the original tallgrass prairie remains. The known remaining blocks of intact prairie range from 10 to 2,400 acres. Some areas are public, but many are privately owned and have conservation easements.

Current State – Much of the area is classified as prime farmland and has been converted to cropland. Most areas where native prairie remains have histories of long-term management as native hay pastures. Tallgrasses remain dominant when haying of warm-season grasses is done during the dormant season or before growing points are elevated, meadows are not cut more than once, and the cut area is deferred from grazing until frost.

Due to the current-widespread farming, the Northern Blackland Prairie is still relatively free from the invasion of brush that has occurred in other parts of Texas. In contrast, many of the more sloping have experienced heavy brush encroachment, and the continued increase of brush encroachment is a concern. The shrink-swell and soil cracking characteristics of the soils favor brush species with tolerance for soil movement.

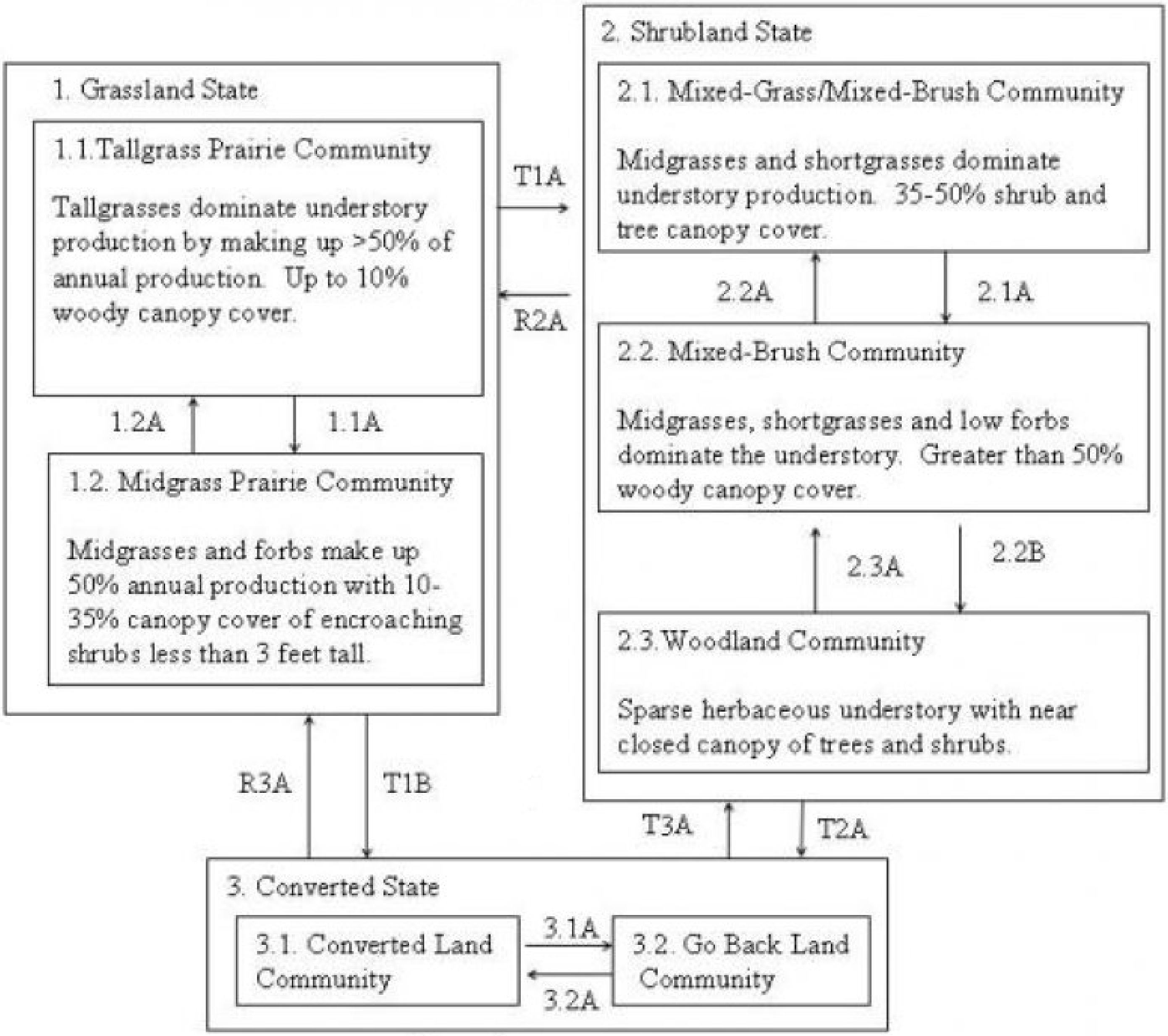
Current Management – Rangeland and pastureland are grazed primarily by beef cattle. Horse numbers are increasing rapidly in the region, and in recent years goat numbers have increased significantly. There are some areas where dairy cattle, poultry, goats, and sheep are locally important. Whitetail deer, wild turkey, bobwhite quail, and dove are the major wildlife species, and hunting leases are a major source of income for many landowners in this area.

Introduced pasture has been established on many acres of old cropland and in areas with deeper soils. Coastal bermudagrass (*Cynodon dactylon*) and kleingrass (*Panicum coloratum*) are by far the most frequently used introduced grasses for forage and hay. Hay has also been harvested from a majority of the prairie remnants, where long-term mowing at the same time of year has possibly changed the relationships of the native species. Cropland is found in the valleys, bottomlands, and deeper upland soils. Wheat (Triticum spp.), oats (Avena spp.), forage and grain sorghum (Sorghum spp.), cotton (Gossypium spp.), and corn (*Zea mays*) are the major crops in the region.

Fire Regimes – The prairies were a disturbance-maintained system. Prior to European settlement (pre-1825), fire and infrequent, but intense, short-duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes - Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases. Wet periods allow tallgrasses to increase in dominance. These natural disturbances cause shifts in the states and communities of the ecological sites.

State and transition model



Legend

1.1A Improper Grazing Management, No Fire, No Brush Management, Drought
1.2A Proper Grazing Management, Prescribed Burning, Brush Management
T1A Improper Grazing Management, No Fire, No Brush Management, Drought
R2A Proper Grazing, Brush Management, Range Planting, Prescribed Burning
2.1A Improper Grazing Management, No Fire, No Brush Management, Drought
2.2A Proper Grazing Management, Prescribed Burning, Brush Management, Range Planting
2.2B Improper Grazing Management, No Fire, No Brush Management, Drought
2.3A Proper Grazing Management, Prescribed Burning, Brush Management, Range Planting
T1B Brush Management, Crop Cultivation, Pasture Planting, Nutrient Management, Pest Management
T2A Brush Management, Crop Cultivation, Pasture Planting, Nutrient Management, Pest Management
3.1A Heavy Continuous Grazing, No Brush Management, No Pest Management, No Fire
3.2A Proper Grazing Management, Brush Management, Pest Management, No Fire
R3A Proper Grazing Management, Range Planting, Brush Management, Prescribed Burning
T3A Improper Grazing Management, No Brush Management, No Fire

Figure 6. STM

State 1
Grassland

Two communities exist in the Grassland State: the 1.1 Tallgrass Prairie Community and the 1.2 Midgrass Plant Community. Community 1.1 is characterized by tallgrasses dominating the understory and comprising greater than 50 percent of the annual production. Woody species cover less than 10 percent of the area. Community 1.2 is characterized by greater than 50 percent annual production from grasses, but the woody species cover is 10 to 35 percent, with some species attaining heights of three feet.

Community 1.1
Tallgrass Prairie

The Tallgrass Prairie Plant Community (1.1) is the reference community. It is characterized by deeper soils dominated by warm-season, perennial tallgrasses, with warm-season, perennial midgrasses filling most of the remaining species composition. The warm-season, perennial forb component varies between 5 and 15 percent depending on climatic patterns and local precipitation. Woody species make up a minor component of the community, five percent by weight, even in the short-term absence of fire (two to five years). Indiangrass, big bluestem, eastern gamagrass, and switchgrass dominate the site. Little bluestem and Florida paspalum act as increasers when improper grazing management causes less grazing tolerant grasses to lose vigor. Other important grasses included Virginia wildrye, sideoats grama, silver bluestem (*Bothriochloa laguroides*), Texas wintergrass, and Texas cupgrass (*Eriochloa sericea*). Forbs commonly found on the site include Engelmann’s daisy (*Engelmannia peristenia*), Maximilian sunflower (*Helianthus maximiliani*), blacksamson (*Echinacea angustifolia*), button snakeroot (*Eryngium yuccifolium*), halfshrub sundrop (*Calylophus serrulatus*), sensitive-briar (Mimosa spp.), and yellow neptunia (*Neptunia lutea*). Typical but infrequent shrub and tree species include species of oak, hackberry, and elm (Ulmus spp.), along with bumelia (Sideroxylon spp.) and coralberry (*Symphoricarpos orbiculatus*). The reference grassland community will transition to a midgrass-dominated community under the stresses of improper grazing management. The first species to decrease in dominance will be the most palatable and/or least grazing tolerant grasses and forbs (e.g. eastern gamagrass, switchgrass, Indiangrass, big bluestem, and Engelmann’s daisy). This will initially result in an increase in composition of little bluestem and Florida paspalum. If improper grazing management continues, little bluestem and Florida paspalum will decrease and midgrasses such as silver bluestem and sideoats grama will increase in composition. Less palatable forbs will increase at this stage. Because the woody species that dominate in the Shrubland State are native species that occur as part of the Grassland State, the transition to the Shrubland State is a linear process with shrubs starting to increase soon after fire or brush control. Unless some form of brush control takes place, woody species will increase to the 35 percent canopy cover level that indicates a state change. This is a continual process that is always in effect. Managers need to detect the increase in woody species when canopy is less than 35 percent and take management action before the state change occurs. There is not a 10-year window before shrubs begin to increase followed by a rapid transition to the Shrubland State. The drivers of the transition (lack of fire and lack of brush control) constantly pressure the system towards the Shrubland State. Canopy cover drives the transitions between community and states because of the influence of shade and interception of rainfall. Species composition by weight remains an important descriptor of the herbaceous community and of the community as a whole. Woody species are included in species composition for the site. This plant community has very little bare ground. Plant basal cover and litter make up almost 100 percent ground cover. Infiltration is rapid and runoff is very low when the soils are dry and open. Once soils have swelled to the point of sealing shut, infiltration is slow and runoff can occur.

Soils with heavy plant cover contribute to increasing organic matter and soil building. The nearly level areas have gilgai. Sloping soils also have gilgai which create microridges and valleys extending up and down the slopes. Soil erosion is very low if tallgrasses and the water trapping gilgai are present. As much as six inches of water could be temporarily trapped in these gilgai microreliefs before runoff begins. Plowing removes the gilgai; it may take 20 years or more after plowing stops for the gilgai to reform.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	3200	4400	5600
Forb	600	825	1050
Shrub/Vine	200	275	350
Total	**4000**	**5500**	**7000**

Community 1.2
Midgrass Prairie

The Midgrass Prairie Plant Community (1.2) is the result of improper cattle grazing management or improper haying practices over a long period of time. Tallgrasses in the reference community decrease in vigor and production, allowing midgrasses and forbs to increase to the point that they make up more than 50 percent of species composition. Indigenous or invading woody species may increase depending on fire and brush control methods. In the Tallgrass Prairie Community (1.1), repeated fires and competition from a vigorous grass component keep woody canopy cover low. When the Midgrass Prairie Plant Community (1.2) is continually overgrazed and fire is excluded, the community crosses a threshold to the Grass/Mixed-Brush Plant Community (2.1) that is dominated by woody plants. Important grasses found in this community include little bluestem, sideoats grama, silver bluestem, paspalums, Texas wintergrass, and tridens (Tridens spp.). Some of the reference community perennial forbs persist, but less palatable forbs will increase. Woody canopy may be as high as 35 percent, depending on the type of grazing animal, fire interval, brush control, and/or availability of increaser shrub species. Numerous shrub and tree species will encroach because overgrazing by livestock has reduced grass cover, exposed more soil, and reduced grass fuel for fire. Typically, trees such as oak, elm, and hackberry will increase in size, while other woody species such as honey mesquite (*Prosopis glandulosa*), bumelia, coralberry, honey locust and elbowbush (*Forestiera pubescens*) will increase in density. Aggressive, introduced pasture species may begin to invade the Midgrass Prairie Community, particularly if they have been seeded in nearby pastures. These include introduced paspalums, such as bahiagrass (*Paspalum notatum*), Old World bluestems (Bothriochloa spp.), and Johnsongrass (*Sorghum halepense*). Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to crusting and erosion. Some mulch and litter movement may occur during rainstorms, but little soil movement occurs due to gentle slopes in this vegetation type. Litter and mulch will move off site as plant cover declines. Increasing woody dominants are oak, hackberry, elm, juniper, and honey mesquite. Once shrubs reach a height of about three feet, they become more resistant to being killed by fires. When woody species exceed 35 percent canopy cover, the site crosses a threshold (T1A) into the Shrubland State (2) and the Grass/Mixed-Brush Plant Community (2.1). Until the Midgrass Prairie Plant Community (1.2) crosses the threshold into the Grass/Mixed-Brush Community (2.1), this community can be managed back toward the reference community (1.1) through the use of cultural practices including prescribed grazing, prescribed burning, and strategic brush control. It may take several years to achieve this, depending upon climate and the aggressiveness of the manager. Once woody species begin to establish, returning fully to the reference community is difficult, but it is possible to return to a similar plant community. If improper grazing management continues but shrubs are held in check through fire, brush control, browsing, or mowing, the Midgrass Prairie Plant Community will continue to degrade. Tallgrasses will continue to decrease in species composition, and midgrasses will begin to decrease. Grazing-resistant shortgrasses, annuals, and forbs will represent more of species composition. These species may increase in relative composition due to the loss of tall and midgrasses. The site will have reduced production and poor ecological processes.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1800	2400	3000
Forb	600	800	1000
Shrub/Vine	600	800	1000
Total	**3000**	**4000**	**5000**

Pathway 1.1A
Community 1.1 to 1.2

Tallgrass Prairie

Midgrass Prairie

The Tallgrass Prairie Plant Community will shift to the Midgrass Prairie Plant Community when there is continued growing-season stress on reference grass species. These stresses include improper grazing management that creates insufficient critical growing-season deferment, excess intensity of defoliation, repeated, long-term growing-season defoliation, long-term drought, and/or other repeated critical growing-season stress. Increaser species (midgrasses and woody species) are generally endemic species released by disturbance. Woody species canopy exceeding 20 percent and/or dominance of tallgrasses falling below 50 percent of species composition indicate a transition to the Midgrass Prairie Plant Community. The reference community can be maintained through implementation of brush management combined with properly managed grazing that provides adequate growing-season deferment to allow establishment of tall grass propagules and/or the recovery of vigor of stressed plants. The driver for community shift 1.1A for the herbaceous component is improper grazing management. The driver for the woody component is lack of fire and/or brush control.

Pathway 1.2A
Community 1.2 to 1.1

Midgrass Prairie

Tallgrass Prairie

The Midgrass Prairie Plant Community will return to the Tallgrass Prairie Plant Community under grazing management that provides sufficient critical growing-season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. The understory component may return to dominance by tallgrasses in the absence of fire or brush control. However, reduction of the woody component to 10 percent or less canopy cover will require inputs of fire or brush control. The understory and overstory components can act independently when canopy cover is less than 35 percent. Meaning, an increase in shrub canopy cover can occur while proper grazing management creates an increase in desirable herbaceous species. The driver for community shift 1.2A for the herbaceous component is proper grazing management. The driver for the woody component is fire and/or brush control.

State 2
Shrubland

The Shrubland State has three communities: 2.1 Mixed-Grass/Mixed-Brush Community, 2.2 Mixed-Brush Community, and 2.3 Woodland Community. The 2.1 community has a woody species overstory canopy of 35 to 50 percent, the 2.2 community over 50 percent, and the 2.3 community has a closed canopy. As tree and brush canopy increases, the herbaceous understory production decreases due to lack of light availability.

Community 2.1
Mixed-Grass/Mixed-Brush

The Grass/Mixed-Brush Plant Community (2.1) presents a 35 to 50 percent woody plant canopy, with oak, hackberry, elm, mesquite, or juniper as dominant woody species. This community can occur as a result of continuous improper grazing management combined with lack of fire or brush control. It can also occur where there has been proper grazing management without brush control or fire. Improper grazing management speeds the process. Although it is rarely found, it is possible for the herbaceous component to include substantial production from tallgrasses. Palatable woody species tend to decrease and unpalatable woody species tend to increase, particularly where there is heavy browsing from deer or goats. Honey mesquite is an early increaser throughout the MLRA. Ashe juniper (*Juniperus ashei*) invaded from the south, and eastern red cedar is found more frequently in the northern portion of the MLRA. Many of the reference (1.1) shrubs are still present. Sideoats grama and other reference (1.1) midgrasses decrease, but still remain the dominant component of composition, while shortgrasses such as buffalograss (*Bouteloua dactyloides*) increase. Remnants of the reference community (1.1) grasses and forbs along with unpalatable invaders occupy the interspaces between shrubs. Cool-season species such as Texas wintergrass and sedges (Carex spp.), plus other grazing-resistant species, can be found under and around woody plants. Plant vigor and productivity of the grassland component is reduced due to grazing pressure and competition for sunlight, nutrients, and water from woody plants. Common herbaceous species include threeawns (Aristada spp.), dropseeds, and dotted gayfeather (*Liatris punctata*). Tumblegrass (*Schedonnardus paniculatus*), Texas grama (*Bouteloua rigidiseta*), western ragweed (*Ambrosia psilostachya*), Indian paintbrush (Castilleja spp.), Texas bluebonnet (*Lupinus texensis*), curly-mesquite (*Hilaria belangeri*), and annual species are persistent increasers until shrub density reaches maximum canopy. This community can dominated by a mix of forbs and short stature shrubs when there is continued growing season stress on reference and midgrass species. This transition usually results from heavy, long-term continuous grazing and is often associated with farm lots and horse pastures. Invasive species often dominate the site, including invasive forbs, shrubs, and grasses. As the grassland vegetation declines, more soil is exposed, leading to crusting and erosion. In this vegetation type, erosion can be severe. Higher rainfall interception losses by the increasing woody canopy combined with evaporation and runoff can reduce the effectiveness of rainfall. Soil organic matter and soil structure decline within the interspaces, but soil conditions improve under the woody plant cover. Some soil loss can occur during rainfall events. Annual primary production is approximately 2,000 to 4,500 pounds per acre. In this plant community, annual production is balanced between herbaceous plants and woody species, with herbaceous production still the dominant component of annual production. Browsing animals such as goats and deer can find fair food value if browse plants have not been grazed excessively. Forage quantity and quality for cattle is low. Unless brush management and good grazing management are applied at this stage, woody species canopy will exceed 50 percent, causing the community to convert to the Mixed-Brush Plant Community (2.2). The trend cannot be reversed with proper grazing management alone.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	800	1300	1800
Grass/Grasslike	800	1300	1800
Forb	400	650	900
Total	**2000**	**3250**	**4500**

Community 2.2

Mixed Brush

The Mixed-Brush Plant Community (2.2) has 50 to 80 percent woody canopy cover and is the result of many years of improper grazing, lack of periodic fires, and/or a lack of proper brush management. Reference community woody species or increasers such as honey mesquite and/or juniper dominate the Mixed-Brush Plant Community (2.2). The site can now have the appearance of a dense shrubland or savannah of interspersed shrubland and grassland areas. Common understory shrubs are pricklypear (Opuntia spp.), agarito (*Mahonia trifoliolata*), and sumac (Rhus spp.). Woody shrubs seem to increase more rapidly in the southern portion of the site. With continued lack of brush control, the trees and shrubs can exceed 80 percent canopy cover, which indicates the transition to the Woodland Community (2.3). Remnant midgrasses and opportunistic shortgrasses, annuals, and perennial forbs occupy the woody plant interspaces. Characteristic grasses are curly-mesquite, buffalograss, and tumblegrass. Texas wintergrass and annuals are found in and around tree/shrub cover. Grasses and forbs make up 50 percent or less of the annual herbage production. Common forbs include dotted gayfeather, halfshrub sundrop, croton, western ragweed, verbena (Verbena spp.), snow-on-the-prairie (*Euphorbia bicolor*), Mexican sagewort (*Artemisia ludoviciana* ssp. mexicana), and sensitive-briar. The shrub canopy acts to intercept rainfall and increase evapotranspiration losses, creating a more xeric microclimate. Soil fauna and organic mulch are reduced, exposing more of the soil surface to erosion in interspaces. The exposed soil crusts readily. However, within the woody canopy, hydrologic processes stabilize and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. The Mixed-Brush Plant Community (2.2) can provide good cover habitat for wildlife, but only limited forage or browse is available for livestock or wildlife. At this stage, highly intensive restoration practices are needed to return the shrubland to grassland. Alternatives for restoration include brush control and range planting with proper stocking, prescribed grazing, and prescribed burning following restoration to maintain the desired community.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	1050	1400	1750
Grass/Grasslike	225	300	375
Forb	225	300	375
Total	**1500**	**2000**	**2500**

Community 2.3
Woodland

The Woodland Community (2.3) has more than 80 percent woody canopy cover as the result of lack of periodic fires, and/or a lack of proper brush management. Reference woody species or increasers such as honey mesquite and/or juniper dominate the Woodland Community (2.3) with little herbaceous understory. The site has the appearance of a dense shrubland or woodland. Herbaceous understory plants are limited to shade-tolerant grasses, sedges, and forbs. Under the woody canopy, hydrologic processes stabilize, and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. The Woodland Community (2.3) can provide good habitat for wildlife that favor woodland habitat. Highly intensive restoration practices are needed to return the woodland to grassland. Alternatives for restoration include brush control and range planting with proper stocking, prescribed grazing, and prescribed burning following restoration to maintain the desired community.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	1800	2700	3600
Forb	150	225	300
Grass/Grasslike	50	75	100
Total	**2000**	**3000**	**4000**

Pathway 2.1A
Community 2.1 to 2.2

Without some form of brush control, woody density and canopy cover will increase in the Grass/Mixed-Brush Plant Community until it converts into the Mixed-Brush Plant Community. Improper grazing management and/or long-term drought (or other growing season stress) will accelerate this transition. Woody species canopy exceeding 50 percent indicates this transition. Herbaceous understory may be similar to any of the Grassland State Plant Communities. Improper grazing or other long-term growing season stress can increase the composition of less productive grasses and low-growing (or unpalatable) forbs in the herbaceous component. Even with proper grazing, in the absence of fire the woody component will increase to the point that the herbaceous component will decline in production and shift in composition toward sedges, grasses, and forbs suited to growing in shaded conditions with reduced available soil moisture. The driver for community shift 2.1A is lack of fire and/or brush control.

Pathway 2.2A
Community 2.2 to 2.1

Brush management and/or fire can reduce the woody component of the Mixed-Brush Plant Community to below the transition level of 50 percent brush canopy. Continued fire and/or brush management will be required to maintain woody density and canopy below 50 percent. If the herbaceous component has transitioned to shortgrasses and low forbs, proper grazing management (combined with favorable moisture conditions and adequate seed source) will be necessary to facilitate the shift of the understory component in the Mixed-Brush Plant Community to a midgrass-dominated Grass/Mixed-Brush Plant Community. Range planting may accelerate the transition of the herbaceous community, particularly when combined with favorable growing conditions. Range planting is more commonly associated with restoration efforts associated with Restoration Pathway R2A. The driver for community shift 2.2A is fire and/or brush control.

Pathway 2.2B
Community 2.2 to 2.3

Without fire (natural or human-caused) and/or brush control, woody density and canopy cover will increase in the Mixed-Brush Plant Community until it converts into the Woodland Community. Woody species canopy exceeding approaching closed canopy (greater than 80 percent) and a decline of herbaceous understory species composition of less than 20 percent indicate this transition. Herbaceous understory will be sparse and comprised of sedges, grasses, and forbs suited to growing in shaded conditions with reduced available soil moisture. The driver for community shift 2.2B is lack of fire and/or brush control.

Pathway 2.3A
Community 2.3 to 2.2

Brush management and/or fire can reduce the woody component of the Woodland Community below the transition level of 80 percent woodland canopy. Continued fire and/or brush management will be required to maintain woody density and canopy below 80 percent. Range planting may accelerate the transition of the herbaceous community, particularly when combined with favorable growing conditions. Range planting is more common with restoration efforts associated with Restoration Pathway R2A. The driver for community shift 2.3A is removal of canopy cover to allow limited recovery of understory species.

State 3
Converted

Two communities exist in the Converted State: 3.1 Converted Land Community and the 3.2 Go-Back Land Community. The 3.1 Community is characterized by agricultural production. The site may be planted to improved pasture for hay or grazing. The site may otherwise be planted to row crops. The 3.2 community represents an agricultural state that has not been managed. The land is colonized by first successional species.

Community 3.1
Converted Land

The Converted State (3) occurs when the prairie, either the Grassland State (1) or Shrubland State (2), is plowed for planting to cropland, hayland, tame pasture, or use as non-agricultural land. The Converted State includes cropland, tame pasture, and go-back land. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. Many or all native species are replaced by seeding crops or introduced species into the plowed soil. The native component of the prairie is usually lost in this state, and even with reseeding, the ecological processes defining the past states of the site can be permanently changed. Common introduced species include coastal Bermudagrass and kleingrass, which are used in hayland and tame pastures. Wheat, oats, forage sorghum, grain sorghum, cotton, and corn are the major crop species. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. Without agronomic inputs, the site will eventually return to either the Grassland or Shrubland State. Weed and shrub control will be required because seeds remain in the soil or are transported to the site. Return to native prairie communities in the Grassland State is more likely to be successful if soil chemistry and structure have not been severely altered. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions. Restoration to native prairie will require seedbed preparation and seeding of native species. Without active restoration the site is not likely to return to reference conditions due to the presence of introduced forbs and grasses. Protocols and plant materials for restoring prairie communities are a developing portion of restoration science.

Community 3.2
Go-Back Land

Without agronomic inputs, the site will eventually return to either the Grassland or Shrubland State. The site is considered go-back land when active management for pasture ceases. Heavily disturbed soils usually return to the Shrubland State but could return to a Grassland State if shrub seeds are not present. Long-term cropping creates changes in soil chemistry, microflora and structure that make restoration to the reference state very difficult and/or expensive. Moreover, the residual seedbank is usually depleted depending upon the length of time the site has been in the converted state. Restoration to near native prairie is possible. It will nearly always require seedbed preparation, suppression of shrubs and seeding of native species. Otherwise, it would take a very long time to reestablish from natural processes. Protocols and plant materials for restoring prairie communities are a developing portion of restoration science.

Pathway 3.1A
Community 3.1 to 3.2

Converted Land

Go-Back Land

The driver for this transition is lack of agricultural management. Without practices to suppress forbs and woody species, the land will eventually grow first successional species. Annual forbs and grasses are common colonizers and first provide ground cover and soil stability. Eventually, woody species will encroach and begin rapid expansion.

Pathway 3.2A
Community 3.2 to 3.1

Go-Back Land

Converted Land

The driver for this transition is a reestablishment of agricultural management. Depending on what the Go-Back Land looks like depends on the prescription. Proper grazing, brush management, herbicides, and/or fire are all potential practices the landowner can use to create more agricultural production on the site.

Transition T1A
State 1 to 2

Shrubs make up a portion of the plant community in the Grassland State, hence woody propagules are present. The Grassland State is not resistant to shrub dominance in the absence of fire. The mean fire return interval in the Grassland State is two to five years. Even with proper grazing and favorable climate conditions, lack of fire or brush control for 10 to 15 years will allow woody species to increase in canopy to reach the 35 percent threshold level.

Improper grazing management, prolonged drought, and a warming climate will provide disturbance conditions which will accelerate this process. This transition can occur from any of the Grassland State Communities. The driver for Transition T1A is lack of fire and/or brush control. The Grassland State is always at risk for this transition because woody species are present in the grassland plant community. Introduction of aggressive woody invader species (i.e. juniper) increases the risk that this state transition will occur and accelerates the rate at which it is likely to occur.

Transition T1B
State 1 to 3

The transition to the Converted State from the Grassland State occurs when the prairie is plowed for planting to cropland or hayland. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered go-back land during the period between cessation of active cropping, fertilization, and weed control and the return to States 1 or 2. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management's decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration of the Shrubland State to the Grassland State requires substantial energy input. Mechanical or herbicidal brush control treatments can be used to remove woody species. A long-term prescribed fire program may sufficiently reduce brush density to a level below the threshold of the Grassland State, particularly if the woody component is dominated by species that are not re-sprouters following top removal. However, fire may not be sufficient to remove mature trees. A mixed program consisting of mechanical, chemical, and fire measures may be used. Brush control in combination with prescribed fire, proper grazing management, and favorable growing conditions may be the most economical means of creating and maintaining the desired plant community. Proper grazing management will be required to promote recovery of the understory towards a tallgrass community. If remnant populations of tallgrasses, midgrasses, and desirable forbs are not present at sufficient levels, range planting will be necessary to restore the grassland plant community. Depending on the understory community and inputs of seed, the restoration pathway can result in return to any of the Grassland State Communities. The driver for Restoration Pathway R2A is fire and/or brush control combined with restoration of the herbaceous community and proper grazing management. Restoration may require aggressive treatment of invader species.

Transition T2A
State 2 to 3

The transition to the Converted State from the Shrubland State (T2A) occurs when the prairie is plowed for planting to cropland or hayland. The size and density of brush in the Shrubland State will require heavy equipment and energy-intensive practices (e.g. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered "go-back land" during the period between cessation of active cropping, fertilization, and weed control and the return to the "native" states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management's decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration from the Converted State can occur in the short-term through active restoration or over the long-term due to cessation of agronomic practices. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. If the soil chemistry and structure have not been overly disturbed (which is most likely to occur with tame pasture) the site can be restored to the Grassland State. Heavily disturbed soils are more likely to return to the Shrubland State. Without continued disturbance from agriculture the site can eventually return to either the Grassland or Shrubland State. The level of disturbance while in the converted state determines whether the site restoration pathway is likely to be R3A (a return to the Grassland State) or T3A (a return to the Shrubland State). Return to native prairie communities in the Grassland State is more likely to be successful if soil chemistry and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions. Converted sites can be returned to the Grassland State through active restoration, including seedbed preparation and seeding of native grass and forb species. Protocols and plant materials for restoring prairie communities are a developing part of restoration science. The driver for both of these restoration pathways is the cessation of agricultural disturbances.

Transition T3A
State 3 to 2

Transition to the Shrubland State (2) occurs with the cessation of agronomic practices. The site will move from the Abandoned Land Community when woody species begin to invade. After shrubs and trees have established over 35 percent, and reached a height greater than three feet, the threshold has been crossed. The driver for the change is lack of agronomic inputs, improper grazing, no brush management, and no fire.

Additional community tables

Table 10. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			2000–3500	
	big bluestem	ANGE	*Andropogon gerardii*	500–2750	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	500–2750	–
	switchgrass	PAVI2	*Panicum virgatum*	250–1750	–
	Indiangrass	SONU2	*Sorghastrum nutans*	250–1750	–
	little bluestem	SCSC	*Schizachyrium scoparium*	250–1600	–
	Florida paspalum	PAFL4	*Paspalum floridanum*	250–1100	–
2	**Tall/Midgrasses**			1200–2100	
	sideoats grama	BOCU	*Bouteloua curtipendula*	200–1600	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	100–1100	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	100–1100	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	50–800	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	50–800	–
	prairie Junegrass	KOMA	*Koeleria macrantha*	50–800	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	100–800	–
	panicgrass	PANIC	*Panicum*	50–800	–
	vine mesquite	PAOB	*Panicum obtusum*	50–800	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	50–800	–
	Drummond's dropseed	SPCOD3	*Sporobolus compositus var. drummondii*	50–800	–
	Silveus' dropseed	SPSI2	*Sporobolus silveanus*	50–800	–
	white tridens	TRAL2	*Tridens albescens*	50–800	–
	longspike tridens	TRST2	*Tridens strictus*	50–800	–
	sedge	CAREX	*Carex*	50–800	–
	cylinder jointtail grass	COCY	*Coelorachis cylindrica*	50–800	–
	fall witchgrass	DICO6	*Digitaria cognata*	50–800	–
	purple threeawn	ARPU9	*Aristida purpurea*	50–800	–
Forb					

3	**Forbs**			600–1050	
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	0–900	–
	beardtongue	PENST	*Penstemon*	0–900	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	0–900	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	0–900	–
	button eryngo	ERYU	*Eryngium yuccifolium*	0–900	–
	prairie clover	DALEA	*Dalea*	0–750	–
	larkspur	DELPH	*Delphinium*	0–750	–
	bundleflower	DESMA	*Desmanthus*	0–750	–
	ticktrefoil	DESMO	*Desmodium*	0–750	–
	prairie acacia	ACANH	*Acacia angustissima var. hirta*	0–750	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	0–750	–
	Indian paintbrush	CASTI2	*Castilleja*	0–750	–
	American star-thistle	CEAM2	*Centaurea americana*	0–750	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	0–750	–
	coastal indigo	INMI	*Indigofera miniata*	0–750	–
	dotted blazing star	LIPU	*Liatris punctata*	0–750	–
	sensitive plant	MIMOS	*Mimosa*	0–750	–
	yellow puff	NELU2	*Neptunia lutea*	0–750	–
	beeblossom	GAURA	*Gaura*	0–750	–
	vetch	VICIA	*Vicia*	0–750	–
	scurfpea	PSORA2	*Psoralidium*	0–750	–
	snoutbean	RHYNC2	*Rhynchosia*	0–750	–
	fuzzybean	STROP	*Strophostyles*	0–750	–
	vervain	VERBE	*Verbena*	0–500	–
	skullcap	SCUTE	*Scutellaria*	0–500	–
	prairie parsley	POLYT	*Polytaenia*	0–500	–
	Chalk Hill hymenopappus	HYTE2	*Hymenopappus tenuifolius*	0–500	–
	croton	CROTO	*Croton*	0–500	–
	ragweed	AMBRO	*Ambrosia*	0–500	–
	milkweed	ASCLE	*Asclepias*	0–500	–
	purple poppymallow	CAIN2	*Callirhoe involucrata*	0–500	–
	snow on the prairie	EUBI2	*Euphorbia bicolor*	0–500	–
Shrub/Vine					
4	**Shrubs and Trees**			200–350	
	live oak	QUVI	*Quercus virginiana*	0–350	–
	elm	ULMUS	*Ulmus*	0–300	–
	common hackberry	CEOC	*Celtis occidentalis*	0–300	–
	gum bully	SILA20	*Sideroxylon lanuginosum*	0–175	–
	coralberry	SYOR	*Symphoricarpos orbiculatus*	0–175	–

Animal community

The animal community in the Blackland differs depending on what state the site is currently in. Northern Bobwhite prefer the reference state. They require dense bunchgrasses for nesting and cover. As the site transitions into State 2, white-tailed deer will become more prevalent. Deer are woodland and edge species, with their primary diet consisting of browse. Mourning dove need open areas with semi-clear ground and forbs with desirable seed sources. Go-back land and communities with shortgrasses and forbs provide the best habitat for dove.

Hydrological functions

Rills and gullies are rare in the reference state. This site has potential for gullies to heal when in functioning condition. Drainage ways should be vegetated and stable. Water flow patterns are very short (less than two feet) if visible. Pedestals or terracettes do not occur in the reference community. Bare ground is essentially non-existent. Soils on this site are permeable when dry, infiltration is rapid, and runoff is slight. When soils are wet and have sealed over, soils are impermeable, infiltration is slow to very slow, and runoff is likely. Soils on this site have high shrink-swell values. This site has slowly permeable soils. Due to density of vegetation, even on sloping sites, small to medium-sized litter will move very little during intense storms. The soil surface under reference conditions is highly resistant to erosion; the soil stability class range is expected to be 6. This prairie site is dominated by tallgrasses and forbs having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events. The nearly level areas have a microrelief of knolls and depressions called gilgai. Sloping soils also have gilgai, which create microridges and valleys extending up and down the slopes. Soil erosion is very low if the tall grasses and the water trapping gilgai are present. Gilgai develops pools of standing water during wet weather. As much as six inches of water can be temporarily trapped in these gilgai microreliefs before runoff begins.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Honey mesquite, eastern red cedar, and some oak are used for posts, firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as agarito. Seeds are harvested from many reference plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

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Approval

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Rangeland health reference sheet

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

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Date	05/01/2008
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:** Some water flow patterns are normal for this site due to landscape position and slope but should be vegetated and stable. Water flow patterns are very short (less than two feet) if visible.

3. **Number and height of erosional pedestals or terracettes:** None.

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

5. **Number of gullies and erosion associated with gullies:** No gullies should be present. Drainage ways should be stable and covered with vegetation.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site has slowly permeable soils. On sloping sites, small to medium-size litter will move short distances during intense storms.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Stability class range is expected to be 5 to 6.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface is greater than 60 inches in depth. Colors range from black to very dark brown and moderately fine to medium subangular blocky structure. SOM is 1 to 3 percent.

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** This prairie site is dominated by tallgrasses and forbs having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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 tallgrasses >>

    Sub-dominant: Warm-season midgrasses > Forbs

    Other: Cool-season grasses > Trees > Shrubs/Vines

Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Grasses and forbs due to their growth habit will exhibit some mortality and decadence, though very slight. Open spaces from disturbance are quickly filled by new plants through seedlings and reproductive reproduction (tillering).

14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 4,000 pounds per acre for below average moisture to 7,000 pounds per acre for above average moisture.

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:** Potential invasives for this site include yellow bluestems, Bermudagrass, mesquite, elm, huisache and eastern red cedar.

17. **Perennial plant reproductive capability:** All perennial plants should be capable of producing except during periods of prolonged drought conditions, heavy natural herbivory and intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R086AY002TX
Southern Chalky Ridge

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

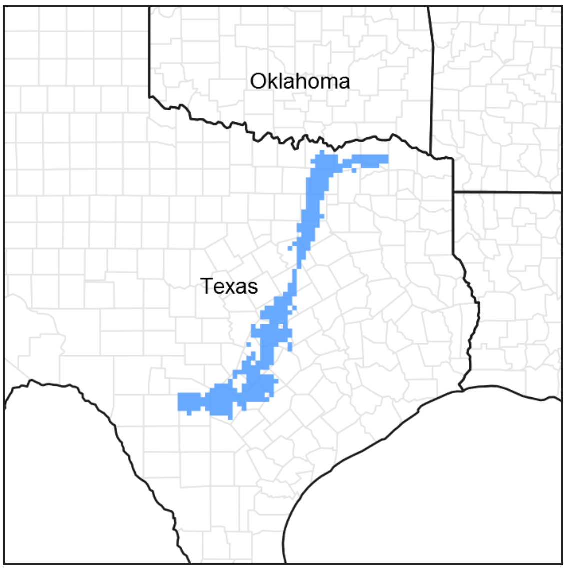

Figure 1. Mapped extent

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): 086A–Texas Blackland Prairie, Northern Part

MLRA 86A, The Northern Part of Texas Blackland Prairie is entirely in Texas. It makes up about 15,110 square miles (39,150 square kilometers). The cities of Austin, Dallas, San Antonio, San Marcos, Temple, and Waco are located within the boundaries. Interstate 35, a major thoroughfare for commerce and travel, traverses the length of the MLRA from San Antonio to Dallas. The area supports tall and midgrass prairies, but improved pasture, croplands, and urban development account for the majority of the acreage.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 86A

Ecological site concept

The Chalky Ridge site is a true tallgrass prairie. The sites are characterized by very shallow to moderately deep soils that are high in calcium carbonate.

Associated sites

R086AY007TX	**Southern Clay Loam** The Clay Loam site is often downslope from the Chalky Ridge site. It differs from the site by having deeper soils, higher soil fertility, low to moderate runoff, and lower erosion rates.
R086AY011TX	**Southern Blackland** The Blackland site is often downslope from the Chalky Ridge site. It differs from the site by having deeper soils, higher soil fertility, and higher soil clay content.

Similar sites

R086AY001TX	**Northern Chalky Ridge** The Northern Chalky Ridge site is similar to the Southern Chalky Ridge site by having similar physiographic features and representative soil features. It differs from the site by receiving more effective precipitation.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

These are nearly level to moderately steep soils on uplands and terraces. The slope gradients range from 0 to 20 percent but are usually less than 8 percent. Some sites flood, but only rarely. Runoff is low to medium.

Table 2. Representative physiographic features

Landforms	(1) Ridge (2) Paleoterrace
Flooding frequency	None to rare
Ponding frequency	None
Elevation	400–1,000 ft
Slope	0–20%
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 86A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. Tropical maritime air controls the climate during spring, summer and fall. In winter and early spring, frequent surges of Polar Canadian air cause sudden drops in temperatures and add considerable variety to the daily weather. When these cold air masses stagnate and are overrun by moist air from the south, several days of cold, cloudy, and rainy weather follow. Generally, these occasional cold spells are of short duration with rapid clearing following cold frontal passages. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of sunny skies, mild days, and cool nights. The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time during the summer and 50 percent in winter. The prevailing wind direction is from the south and highest wind speeds occur during the spring months. Rainfall during the spring and summer months generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. High-intensity rains of short duration are likely to produce rapid runoff almost anytime during the year. The predominantly anticyclonic atmospheric circulation over Texas in summer and the exclusion of cold fronts from North Central Texas result in a decrease in rainfall during midsummer. The amount of rain that falls varies considerably from month-to-month and from year-to-year.

Table 3. Representative climatic features

Frost-free period (average)	244 days
Freeze-free period (average)	276 days
Precipitation total (average)	36 in

Climate stations used

- (1) TAYLOR 1NW [USC00418862], Taylor, TX
- (2) WACO DAM [USC00419417], Waco, TX
- (3) CAMERON [USC00411348], Cameron, TX
- (4) LULING [USC00415429], Luling, TX
- (5) TEMPLE [USC00418910], Temple, TX
- (6) NEW BRAUNFELS [USC00416276], New Braunfels, TX
- (7) SAN ANTONIO 8NNE [USC00417947], San Antonio, TX
- (8) SAN MARCOS [USC00417983], San Marcos, TX
- (9) AUSTIN-CAMP MABRY [USW00013958], Austin, TX
- (10) GRANGER DAM [USC00413686], Granger, TX
- (11) SAN ANTONIO INTL AP [USW00012921], San Antonio, TX
- (12) AUSTIN BERGSTROM AP [USW00013904], Austin, TX
- (13) CEDAR CREEK 5 S [USC00411541], Cedar Creek, TX
- (14) RED ROCK [USC00417497], Red Rock, TX

Influencing water features

A stream or wetland does not influence the plant communities of this site.

Soil features

The site consists of very shallow to moderately deep, well drained soils that are very slowly to moderately slowly permeability. The upland soils were formed in calcareous chalk and the terrace soils were formed in gravelly, clayey, and sandy alluvial sediments. In a representative profile the surface layer is light brownish gray, gravelly clay loam about 10 inches thick. Below 10 inches and to depths of more than 60 inches, the parent material is calcareous chalk. Available water capacity to a depth of 60 inches is very low.

The associated soil series for the Chalky Ridge are: Castephen, Doss, Eddy, Howe, Patrick, Queeny, Quihi, Stephen, and Whitewright.

Table 4. Representative soil features

Surface texture	(1) Gravelly clay loam (2) Silty clay loam (3) Silty clay
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Very slow to moderately slow
Soil depth	3–38 in
Surface fragment cover <=3"	0–25%
Surface fragment cover >3"	0–10%
Available water capacity (0-40in)	0.3–5.2 in
Calcium carbonate equivalent (0-40in)	10–80%
Electrical conductivity (0-40in)	0–2 mmhos/cm

Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	7.9–8.4
Subsurface fragment volume <=3" (Depth not specified)	0–35%
Subsurface fragment volume >3" (Depth not specified)	0–70%

Ecological dynamics

Introduction – The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background – Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Florida paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsuta*), and dropseeds (Sporobolus spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak (*Quercus virginiana*) and hackberry (Celtis spp.) trees are also native to the region. In some areas, cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), and honey locust (*Gleditsia triacanthos*) are abundant. In the Northern Blackland Prairie oaks (Quercus spp.) are common increasers, but in the Southern Blackland Prairie oaks are less prevalent. Junipers are common invaders, particularly in the northern part of the region.

During the first half of the nineteenth century, row crop agriculture lead to over 80 percent of the original vegetation lost. During the second half, urban development has caused even an even greater decline in the remaining prairie. Today, less than one percent of the original tallgrass prairie remains. The known remaining blocks of intact prairie range from 10 to 2,400 acres. Some areas are public, but many are privately owned and have conservation easements.

Current State – Much of the area is classified as prime farmland and has been converted to cropland. Most areas where native prairie remains have histories of long-term management as native hay pastures. Tallgrasses remain dominant when haying of warm-season grasses is done during the dormant season or before growing points are elevated, meadows are not cut more than once, and the cut area is deferred from grazing until frost.

Due to the current-widespread farming, the Northern Blackland Prairie is still relatively free from the invasion of brush that has occurred in other parts of Texas. In contrast, many of the more sloping have experienced heavy brush encroachment, and the continued increase of brush encroachment is a concern. The shrink-swell and soil cracking characteristics of the soils favor brush species with tolerance for soil movement.

Current Management – Rangeland and pastureland are grazed primarily by beef cattle. Horse numbers are increasing rapidly in the region, and in recent years goat numbers have increased significantly. There are some areas where dairy cattle, poultry, goats, and sheep are locally important. Whitetail deer, wild turkey, bobwhite quail, and dove are the major wildlife species, and hunting leases are a major source of income for many landowners in this area.

Introduced pasture has been established on many acres of old cropland and in areas with deeper soils. Coastal bermudagrass (*Cynodon dactylon*) and kleingrass (*Panicum coloratum*) are by far the most frequently used introduced grasses for forage and hay. Hay has also been harvested from a majority of the prairie remnants, where long-term mowing at the same time of year has possibly changed the relationships of the native species. Cropland is found in the valleys, bottomlands, and deeper upland soils. Wheat (Triticum spp.), oats (Avena spp.), forage and grain sorghum (Sorghum spp.), cotton (Gossypium spp.), and corn (*Zea mays*) are the major crops in the region.

Fire Regimes – The prairies were a disturbance-maintained system. Prior to European settlement (pre-1825), fire and infrequent, but intense, short-duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes - Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases. Wet periods allow tallgrasses to increase in dominance. These natural disturbances cause shifts in the states and communities of the ecological sites.

State and transition model

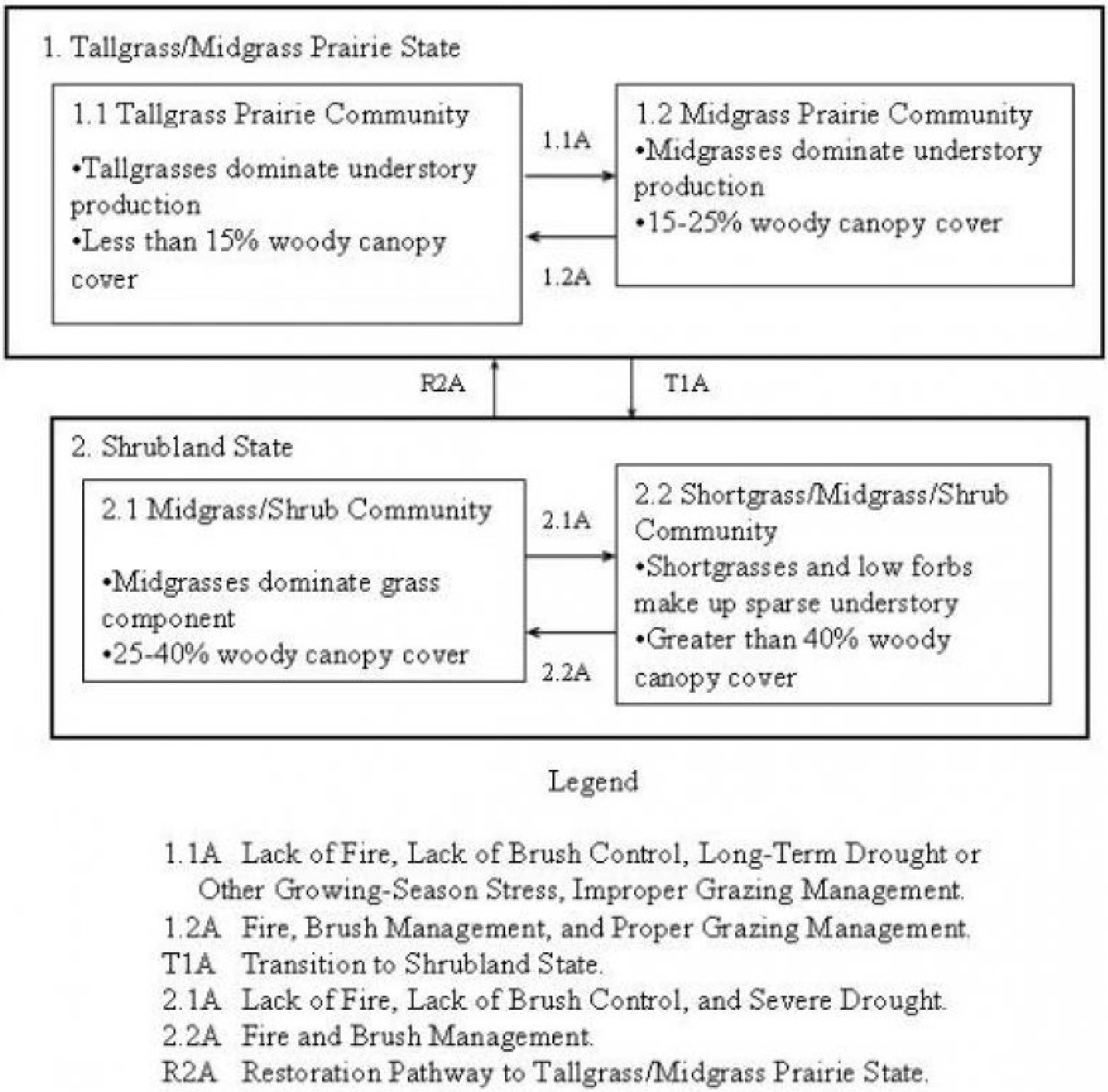

Figure 6. STM

State 1
Tallgrass/Midgrass Prairie

Two communities exist in the Tallgrass/Midgrass State: the 1.1 Tallgrass Prairie Community and the 1.2 Midgrass Plant Community. Community 1.1 is characterized by tallgrasses dominating the understory annual production and woody species cover less than 15 percent of the area. Community 1.2 is characterized by midgrass dominance, but the woody species cover is 15 to 25 percent, with some species attaining heights of three feet.

Community 1.1
Tallgrass Prairie

The Tallgrass Prairie Community (1.1) is the reference community and is characterized as a tallgrass prairie with scattered trees and low-growing shrubs as well as a diverse population of perennial forbs. Little bluestem dominates the herbaceous component of the site. Other important grasses are Indiangrass, big bluestem, sideoats grama, Texas wintergrass, silver bluestem (*Bothriochloa laguroides*), dropseeds, hairy grama (*Bouteloua hirsuta*), slim tridens (*Tridens muticus* var. muticus), rough tridens (*Tridens muticus* var. elongatus), buffalograss (*Bouteloua dactyloides*), and curlymesquite (*Hilaria belangeri*). A wide variety of forbs is commonly found on the site, including Maximilian sunflower (*Helianthus maximiliani*), awnless bushsunflower (*Simsia calva*), Engelmann's daisy (*Engelmannia peristenia*), dotted gayfeather (*Liatris punctata*), halfshrub sundrop (*Calylophus berlandieri*), bundleflowers (Desmanthus spp.), and many others. Scattered shrub and tree species found in the reference community (1.1) include live oak, hackberry, elm (Ulmus spp.), bumelia (*Sideroxylon lanuginosum*) skunkbush sumac (*Rhus aromatica*), and agarito (*Mahonia trifoliolata*). The reference Tallgrass Prairie Community (1.1) will transition to the Midgrass Prairie Community (1.2) with lack of fire, lack of brush control, long-term drought, repeated, long-term growing-season defoliation, and/or other repeated critical growing-season stress. The first species to decrease in dominance will be the grasses and forbs with the least tolerance for disturbance and highest moisture requirements (i.e. Indiangrass, big bluestem, and Engelmann's daisy). This will initially result in an increase in composition of little bluestem. As shrub canopy cover increases, little bluestem will decrease and shade and drought tolerant midgrasses and forbs will increase in composition.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1600	2400	3200
Forb	200	300	400
Shrub/Vine	200	300	400
Total	**2000**	**3000**	**4000**

Community 1.2
Midgrass Prairie

The Midgrass Prairie Community (1.2) typically results from long-term improper grazing management and/or lack of fire over a long period of time (transition 1.1A). During this period, indigenous or invading woody species increase on the site. The site will return to the Tallgrass Prairie Community (1.1) when brush management combined with proper grazing management allows competition from a vigorous grass component to dominate open areas while shrubs dominate mottes and constitute 15 percent or less woody canopy cover (transition 1.2A). When the Midgrass Prairie Community (1.2) is continually overgrazed and fire is excluded, the community crosses a threshold (T1A) to a state that is dominated by woody plants, the Midgrass/Shrub Community (2.1). Important grasses are little bluestem, sideoats grama, silver bluestem, tall dropseed (*Sporobolus compositus*), and Texas cupgrass (*Eriochloa sericea*). More grazing-resistant shortgrasses and less palatable forbs begin replacing the midgrasses. Some of the reference perennial forbs persist, but less palatable forbs will increase. Woody canopy is more than 15 percent. Numerous shrub and tree species will continue to increase because shrub canopy intercepts rainfall and creates drier growing conditions for understory species, reducing their vigor and competitiveness. Typically, trees such as oak, elm, hackberry, and ash (Fraxinus spp.) will increase in size, while other tree and shrub species such as bumelia, sumac, elbowbush (*Forestiera pubescens*), agarito, honey mesquite (*Prosopis glandulosa*), juniper, and pricklypear (Opuntia spp.) will increase in density. To control woody species populations, prescribed grazing (browsing) and fire can be used to control smaller shrubs and trees. Mechanical removal of larger shrubs and trees may be necessary in older stands. The time frame for woody species to dominate a healthy community is not precisely known, but indications are that re-growth of woody species reached 75 percent canopy cover in about 25 years. Fire and brush management are difficult to use on this site. Examples exist of restoration using strategic burning with small fires. Chemical control may require hand spraying or aerial application to create openings in a closed shrub canopy. It may take several years to achieve change, depending upon growing conditions and the aggressiveness of treatment. Large scale prescribed fires require careful fuel management and generally involve burning this site at the same time as surrounding more productive sites with plentiful fine fuels. The transition 1.1A will result in an increase in bare ground, shrub density, and length of water flow patterns, in addition to decreased infiltration. Heavy continuous grazing will reduce plant cover, litter, and mulch. Litter and mulch will move off site as plant cover declines. Ashe juniper (*Juniperus ashei*) is a particularly aggressive shrub on this site. Once the midgrasses decrease below 25 percent of composition, woody species exceeds 25 percent canopy cover, and the woody plants within the grassland portion of the site reach fire-resistant size (about three feet in height), the site crosses a threshold into the Shrubland State (2) and the Midgrass/Shrub Plant Community (2.1). Until the Midgrass Prairie Community (1.2) crosses the threshold (T1A) into the Midgrass/Shrub Community (2.1), this community can be managed back toward the reference community (1.1) through the use of cultural practices including strategic burning and strategic brush management. Once invasive woody species become established, returning fully to the reference is difficult, but it is possible to return to a similarly functioning plant community. The risk of soil erosion under shrub canopy is much less than deeper sites due to shallow soil depths. The large fragments that cover 35 to 65 percent of the soil surface provide numerous interruptions to waterflow that reduces the opportunity for soil to flow off site. Unlike sites with deeper soils, changing management practices (brush control combined with proper grazing management) can create sufficient change in growing conditions for the site to follow restoration pathway R2A to the Tallgrass/Midgrass/Prairie State within a reasonable time frame.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	480	800	1080
Grass/Grasslike	480	800	1080
Forb	240	400	540
Total	**1200**	**2000**	**2700**

Pathway 1.1A
Community 1.1 to 1.2

Tallgrass Prairie

Midgrass Prairie

The Tallgrass Prairie Community (1.1) will shift to the Midgrass Prairie Community (1.2) when there is continued growing season stress on reference grass species. These stresses include lack of fire, lack of brush management, long-term drought and/or other repeated critical growing season stress. Increaser species (lower successional midgrasses, shortgrasses, and woody species) are generally endemic species released from competition as vigor of tallgrasses declines. Woody species canopy exceeding 15 percent and/or dominance of tallgrasses falling below 50 percent of species composition indicate a shift to the Midgrass Prairie Community. Pre-settlement, the reference community was dependent on fire to maintain the prairie’s balance of grass and shrubs. Currently, fire and/or brush management are required to maintain the reference community. Due to the infrequent and irregular nature of fire pre-settlement, one can theorize the site shifted between the two communities within the Tallgrass/Midgrass Prairie State. The site may have may have crossed the threshold to the Shrubland State, even under natural influences in some cases. This site would be less stable than the surrounding sites. The driver for community shift 1.1A can either be improper grazing or not enough grazing, leading to increased competition from invader midgrasses, forbs, and shrubs. Increasing canopy cover of woody species due to lack of fire and/or brush control will drive woody cover towards the Midgrass Prairie Community (1.2).

Pathway 1.2A
Community 1.2 to 1.1

Midgrass Prairie

Tallgrass Prairie

The Midgrass Prairie Community (1.2) will return to the Tallgrass Prairie Community (1.1) under grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. The understory component may return to dominance by tallgrasses in the absence of fire. However, reduction of the woody component to reference conditions of 15 percent or less canopy cover will require inputs of fire and/or brush control. Due to the shallow soils of the site, brush management may be limited to hand work or chemical control using aerial or all-terrain vehicle (ATV) application because site conditions may not favor use of heavy machinery. The driver for community shift 1.2A for the herbaceous component is improper grazing management. The driver for the woody component is lack of fire and/or brush control. Brush management can also benefit tallgrasses and drive community shift 1.2A for the herbaceous community.

State 2
Shrubland

Two communities exist in the Shrubland State: the 2.1 Midgrass/Shrub Community and the 2.2

Shortgrass/Midgrass/Shrub Community. Community 2.1 is characterized by midgrasses dominating the understory annual production and woody species between 25 and 40 percent. Community 2.2 is characterized by shortgrass dominance, but the woody species cover is greater than 40 percent.

Community 2.1
Midgrass/Shrub

The Midgrass/Shrub Community (2.1) has less than 40 percent woody plant canopy, with honey mesquite and juniper invading the former grassland areas. The community loses its prairie appearance with invasive shrubs beginning to fill the open grassland portion of the site. This community type is the result of lack of fire and accompanying increase in shrub canopy cover. Dense juniper stands are commonly referred to locally as “old growth cedar” or “cedar breaks”. These juniper stands can occur in either the Midgrass/Shrub community (2.1) or Midgrass/Shortgrass/Shrub community (2.2) depending on the composition of the understory. Canopy cover of these juniper stands can reach 80 percent if left unchecked. Sideoats grama and other reference (1.1) midgrasses decrease to the point that grasses no longer form the dominant component. Shortgrasses such as low panicums (Panicum spp.) and threeawns (Aristida spp.) increase. Remnants of the historic grasses and forbs along with lower successional grasses and forbs are often protected under the canopies or between rocks. Cool-season species such as Texas wintergrass and sedges (Carex spp.) can be found under and around woody plants. Plant vigor and productivity of the grassland component is reduced due to competition for nutrients and water from woody plants. Common herbaceous species include tall grama, and Mexican sagewort (*Artemisia ludoviciana* ssp. mexicana). Buffalograss, western ragweed (*Ambrosia psilostachya*), and curlymesquite are persistent increasers until shrub density reaches maximum canopy. Once juniper stands have become dense and extensive, it is difficult to establish other woody species. Although difficult, managers can restore the grassland openings within the shrubs through properly executed brush management. The degree of treatment depends upon practicality. The success of reestablishment of desirable native grasses and forbs is dependant upon soil being left when juniper is removed. Brush removal that leaves the thin layer of soil can increase the likelihood of success of reseeding efforts. Reclamation success is often dependant on the skill of those removing brush. The slope of this site makes restoration a difficult practice and often limits the size of restoration operations. As the grassland vegetation declines, more soil is exposed, leading to crusting and erosion. Higher rainfall interception losses by the increasing woody canopy combined with increased evaporation and runoff can reduce the effectiveness of rainfall. Soil organic matter and soil structure decline within the interspaces, but soil conditions improve under the woody plant cover. Soil loss can occur during rainfall events. Unless brush management and proper grazing management are applied at this stage, understory composition will continue to shift towards shortgrasses and unpalatable forbs, causing the community to convert to the Shortgrass/Midgrass/Shrub Community (2.2). Aggressive shrubs (such as juniper) can facilitate this shift even under proper grazing management. Excessive grazing by deer or goats will create a community dominated by large trees. Few remnant midgrasses and opportunistic shortgrasses, annuals, and perennial forbs occupy the woody plant interspaces. Characteristic grasses are threeawns and cedar sedge (*Carex planostachys*). Grasses and forbs make up as little as five percent of annual biomass production. Excessive cattle grazing tends to create a different response and structure to the community than does excessive deer or goat grazing. Unrestricted cattle grazing tends to accelerate invasion of shrubs because all shrubs invade the site and gain competitive advantage over herbaceous species. Excess deer or goat browsing tends to create a dominance of large trees by removing both young shrubs and the young growth that grows below the browse line on larger shrubs and trees. While large trees will continue to increase in size, they will have very little production below the browse line, creating a park-like look. The site becomes dominated by large trees with little forage available for livestock or wildlife. Large trees with little understory provide much less soil protection than do dense stands of grass. As soils erode, understory species have reduced potential to revegetate the site. The bare area under the browse line creates a situation that provides poor forage conditions and poor visual cover for wildlife.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	350	500	1000
Grass/Grasslike	245	350	700
Forb	105	150	300
Total	**700**	**1000**	**2000**

Community 2.2
Shortgrass/Midgrass/Shrub

The Shortgrass/Midgrass/Shrub Community (2.2) is the result of many years of improper grazing management, lack of periodic fires, and/or lack of proper brush management. Oaks, honey mesquite, and/or juniper dominate the Shortgrass/Midgrass/Shrub Community (2.2), which has greater than 40 percent woody canopy cover and little or low understory production. It is now essentially a shrubland with remnant grasses, sedges, and forbs under the canopy and within interspaces. As brush canopy increases, annual production for the understory declines to very low levels, due to shading, competition for nutrients, and interception of rainfall by the shrub canopy. Most of the remaining understory is shade tolerant, grazing tolerant, and/or unpalatable. Common understory shrubs are pricklypear, yucca, agarito, and sumacs. Grazing pressure generally becomes less of a factor once the community has reached this stage, particularly if junipers have replaced shrubs with browsing value. Canopy cover will increase until the site is covered with a dense stand of brush. Reference sites demonstrate that the Chalky Ridge site is highly resilient when brush control is accompanied by favorable growing conditions. Because soils on this site are shallow to very shallow even in historic conditions, erosion is not severe under shrub canopy. If remnant plants are present, tallgrasses such as big bluestem, little bluestem, and Indiangrass reestablish and increase following brush control or fire accompanied by grazing deferment. Remnant grasses are protected between the rocks so that once the overstory is removed, they can express themselves. Cleared sites frequently re-grow to dense juniper stands that can reach 75 percent cover in less than 25 years unless juniper control measures are taken. These dense stands of juniper can reach 80 percent canopy cover with an understory that is primarily cedar sedge with trace amounts of tallgrasses and higher successional midgrasses. The shrub canopy acts to intercept rainfall and increase evapotranspiration losses and interception losses, creating a more xeric microclimate. Soil fauna and organic mulch are reduced, exposing more of the soil surface to erosion in interspaces. The percent of exposed chalk increases with erosion. However, within the woody canopy, hydrologic processes stabilize and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. The Shortgrass/Midgrass/Shrub Community (2.2) provides good cover for wildlife, but only limited forage or browse is available for livestock or wildlife. At this stage, highly intensive restoration practices are needed to return the shrubland to grassland. Alternatives for restoration include brush control and range planting, proper stocking, prescribed grazing, and prescribed burning following restoration to maintain the desired community.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	280	490	700
Grass/Grasslike	60	105	150
Forb	60	105	150
Total	**400**	**700**	**1000**

Pathway 2.1A
Community 2.1 to 2.2

Midgrass/Shrub

Shortgrass/Midgrass/Shrub

Without fire (natural or human-caused) and/or brush management, woody density and canopy cover will increase in the Midgrass/Shrub Community (2.1) until it converts into the Shortgrass/Midgrass/Shrub Community (2.2). Improper grazing management and/or long-term drought (or other growing-season stress) will accelerate this shift. Due to the shallow nature of the soils, woody species (particularly live oak and juniper) may die or be seriously stressed under severe drought conditions. This may facilitate a transition back to the Tallgrass/Midgrass Prairie State by providing canopy openings for grass cover to increase when favorable growing conditions return. While woody species canopy may continue to increase, the indicator for this transition is the change of the understory from domination by midgrasses to a sparse understory of shortgrasses and unpalatable forbs. There may be areas under dense shrub cover with almost no understory. Improper grazing management or other long-term growing-season stress can decrease the composition of midgrasses and palatable forbs in the herbaceous component. Even without grazing, in the absence of fire, the woody component will increase to the point that the herbaceous component will shift in composition toward shortgrasses and forbs more suited to growing in shaded conditions with little available soil moisture. The driver for community shift 2.1A is lack of fire and/or brush management.

Pathway 2.2A
Community 2.2 to 2.1

Shortgrass/Midgrass/Shrub

Midgrass/Shrub

Brush management and/or fire can create great openings in the canopy so that remnant midgrasses and shade intolerant forbs can increase in vigor and composition. Large populations of forbs may remain with stands of herbaceous growth in the openings of shrub canopy. Continued fire and/or brush management will be required to maintain openings in the canopy. Fire is limited on steeper slopes due to sparse grass fuel. This site is usually burned along with adjacent ecological sites. If the herbaceous component has transitioned to shortgrasses and low forbs, proper grazing management (combined with favorable moisture conditions) will be necessary to facilitate the shift of the understory component to the midgrass-dominated Midgrass/Shrub Community (2.1). Range planting may accelerate the transition of the herbaceous community, particularly when combined with favorable growing conditions. However, the shallow soils of the Chalky Ridge site make seeding somewhat risky. It is difficult to consistently establish a successful stand of seeded grasses unless done in conjunction with mechanical removal. Range planting is more commonly associated with restoration efforts associated with Restoration Pathway R2A. The driver for community shift 2.2A is fire and/or brush control.

Transition T1A

State 1 to 2

While the Tallgrass/Midgrass Prairie State has some resistance to shrub dominance, long-term lack of fire or brush management may allow brush to dominate the site even under proper grazing management. Shrubs make up a portion of the plant community in this state, therefore propagules are present. The mean fire return interval to maintain the Tallgrass/Midgrass Prairie State is 5 to 10 years. Even with proper grazing management and favorable climate conditions, lack of fire for 15 to 25 years will allow woody species to increase in canopy to reach the 25 percent threshold level. An infusion of invasive woody species (i.e. juniper or mesquite) will speed up the process. Improper grazing management, prolonged drought, and a warming climate will provide a competitive advantage to shrubs which will accelerate this process. Tallgrasses will decrease to less than 10 percent species composition. The driver for Transition T1A is lack of fire and/or brush control. The Tallgrass/Midgrass Prairie State is always at risk for the transition to the Shrubland State because woody species are present in the prairie plant community. Introduction of aggressive woody invader species (i.e. juniper) increase the risk that this state transition will occur and accelerate the rate at which it is likely to occur.

Restoration pathway R2A
State 2 to 1

Restoration of the Shrubland State to the Tallgrass/Midgrass Prairie State requires substantial energy input. Mechanical or herbicidal brush control treatments can be used to remove woody species. A long-term prescribed fire program may sufficiently reduce brush density to a level below the threshold of the Tallgrass/Midgrass Prairie State, particularly if the woody component is dominated by species that are not re-sprouters. Brush management in combination with prescribed fire, proper grazing, and favorable growing conditions may be the most economical means of creating and maintaining the desired plant community. If remnant populations of tallgrasses, midgrasses, and desirable forbs are not present at sufficient levels, range seeding will be necessary. Remnant grasses may be protected between rocks. Once the overstory is removed, they express themselves. Range planting on this site is somewhat risky, and it is a challenge to establish a successful stand of seeded grass on a consistent basis. The driver for Restoration Pathway R2A is fire and/or brush management combined with restoration of the herbaceous community and proper grazing management. Restoration may require aggressive treatment of invader species.

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			1000–2000	
	little bluestem	SCSCS	*Schizachyrium scoparium var. scoparium*	1000–2000	–
2	**Tallgrasses**			300–600	
	big bluestem	ANGE	*Andropogon gerardii*	150–600	–
	Indiangrass	SONU2	*Sorghastrum nutans*	300–600	–
3	**Midgrasses**			200–400	
	sideoats grama	BOCU	*Bouteloua curtipendula*	200–400	–
	tall grama	BOHIP	*Bouteloua hirsuta var. pectinata*	200–400	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	200–400	–
	Arizona cottontop	DICA8	*Digitaria californica*	200–400	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	200–400	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	200–400	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	200–400	–
	Drummond's dropseed	SPCOD3	*Sporobolus compositus var. drummondii*	200–400	–
4	**Mid/Shortgrasses**			100–200	

	purple threeawn	ARPU9	*Aristida purpurea*	100–200	–
	Wright's threeawn	ARPUW	*Aristida purpurea var. wrightii*	100–200	–
	buffalograss	BODA2	*Bouteloua dactyloides*	100–200	–
	hairy grama	BOHI2	*Bouteloua hirsuta*	100–200	–
	sedge	CAREX	*Carex*	100–200	–
	fall witchgrass	DICO6	*Digitaria cognata*	100–200	–
	curly-mesquite	HIBE	*Hilaria belangeri*	100–200	–
	panicgrass	PANIC	*Panicum*	100–200	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	100–200	–
	slim tridens	TRMUM	*Tridens muticus var. muticus*	100–200	–
Forb					
5	**Forbs**			300–600	
	western yarrow	ACMIO	*Achillea millefolium var. occidentalis*	0–200	–
	prairie false foxglove	AGHE4	*Agalinis heterophylla*	0–200	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	0–200	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	0–200	–
	Berlandier's sundrops	CABE6	*Calylophus berlandieri*	0–200	–
	purple poppymallow	CAIN2	*Callirhoe involucrata*	0–200	–
	Indian paintbrush	CASTI2	*Castilleja*	0–200	–
	croton	CROTO	*Croton*	0–200	–
	prairie clover	DALEA	*Dalea*	0–200	–
	bundleflower	DESMA	*Desmanthus*	0–200	–
	ticktrefoil	DESMO	*Desmodium*	0–200	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	0–200	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	0–200	–
	snow on the prairie	EUBI2	*Euphorbia bicolor*	0–200	–
	beeblossom	GAURA	*Gaura*	0–200	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	0–200	–
	Chalk Hill hymenopappus	HYTE2	*Hymenopappus tenuifolius*	0–200	–
	coastal indigo	INMI	*Indigofera miniata*	0–200	–
	dotted blazing star	LIPU	*Liatris punctata*	0–200	–
	Texas lupine	LUTE	*Lupinus texensis*	0–200	–
	plains blackfoot	MELE2	*Melampodium leucanthum*	0–200	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	0–200	–
	yellow puff	NELU2	*Neptunia lutea*	0–200	–
	rosy palafox	PARO	*Palafoxia rosea*	0–200	–
	beardtongue	PENST	*Penstemon*	0–200	–
	scurfpea	PSORA2	*Psoralidium*	0–200	–
	snoutbean	RHYNC2	*Rhynchosia*	0–200	–
	skullcap	SCUTE	*Scutellaria*	0–200	–
	fuzzybean	STROP	*Strophostyles*	0–200	–
	vervain	VERBE	*Verbena*	0–200	–

	vetch	VICIA	*Vicia*	0–200	–
Shrub/Vine					
6	**Shrubs/Vines/Trees**			200–600	
	live oak	QUVI	*Quercus virginiana*	100–400	–
	fragrant sumac	RHAR4	*Rhus aromatica*	0–200	–
	prairie sumac	RHLA3	*Rhus lanceolata*	0–200	–
	gum bully	SILA20	*Sideroxylon lanuginosum*	0–200	–
	coralberry	SYOR	*Symphoricarpos orbiculatus*	0–200	–
	elm	ULMUS	*Ulmus*	0–200	–
	yucca	YUCCA	*Yucca*	0–200	–
	hawthorn	CRATA	*Crataegus*	0–200	–
	black prairie clover	DAFR2	*Dalea frutescens*	0–200	–
	common persimmon	DIVI5	*Diospyros virginiana*	0–200	–
	algerita	MATR3	*Mahonia trifoliolata*	0–200	–
	pricklypear	OPUNT	*Opuntia*	0–200	–
	Texas almond	PRMI2	*Prunus minutiflora*	0–200	–

Animal community

The animal community differs depending on what state the site is currently in. Northern Bobwhite prefer the reference state. They require dense bunchgrasses for nesting and cover. As the site transitions into State 2, white-tailed deer will become more prevalent. Deer are woodland and edge species, with their primary diet consisting of browse. Mourning dove need open areas with semi-clear ground and forbs with desirable seed sources. Go-back land and communities with shortgrasses and forbs provide the best habitat for dove.

Hydrological functions

Site specific information showed that in its historic state this site has no rills or gullies. This site can be very erosive in degraded states. Drainageways should be stable and covered with vegetation. Some water flow patterns are normal for this site due to landscape position and slope but should be vegetated and stable. A few slightly elevated pedestals or terracettes may occur due to slope, landscape position, and natural lack of cover on this site. Expect no more than 10 percent bare ground randomly distributed throughout. Small to medium-size litter movement for short distances should be expected during intense rainfall events. The soil surface under reference conditions is resistant to erosion and the soil stability class range is expected to be 4 to 6. This prairie site is dominated by tallgrasses and forbs having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Ashe juniper, Honey mesquite, and oak are used for posts, firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as agarito. Seeds are harvested from many reference community plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants.

Inventory data references

Information presented was derived from NRCS clipping data, literature, field observations and personal contacts with range-trained personnel.

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Approval

David Kraft, 5/06/2020

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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)	Lem Creswell, RMS, NRCS, Weatherford, Texas
Contact for lead author	817-596-2865
Date	09/17/2007
Approved by	David Kraft
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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2. **Presence of water flow patterns:** Some water flow patterns are normal for this site due to landscape position and slope but should be vegetated and stable.

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3. **Number and height of erosional pedestals or terracettes:** A few slightly elevated pedestals or terracettes may occur due to slope, landscape position, and natural lack of cover on this site.

---

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 20 percent bare ground randomly distributed throughout.

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5. **Number of gullies and erosion associated with gullies:** No gullies should be present. Drainageways should be stable and covered with vegetation.

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

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7. **Amount of litter movement (describe size and distance expected to travel):** Small to medium-size litter movement for short distances should be expected on this site during intense rainfall events.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface under reference conditions is resistant to erosion. Stability class range is expected to be 4 to 6.

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface is 6 to 10 inches thick with colors of very dark brown with moderately fine to very fine subangular blocky structure. SOM is 1 to 3 percent.

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** This prairie site is dominated by tallgrasses and forbs having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events.

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

---

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 tallgrasses >>

    Sub-dominant: Warm-season midgrasses > Forbs >

    Other: Cool-season grasses > Trees > Shrubs/Vines

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups in the reference community.

---

14. **Average percent litter cover (%) and depth (in):** Litter is dominantly herbaceous.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 2,000 pounds per acre for below average moisture years and 4,000 pounds per acre for above average moisture years.

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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:** Potential invasive species for this site includes yellow bluestems, bermudagrass, mesquite, elm, huisache, Eastern red cedar, osage orange and prickly pear.

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17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing except during periods of prolonged drought conditions, heavy natural herbivory or intense wildfires.

Natural Resources
Conservation Service

Ecological site R086AY007TX
Southern Clay Loam

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

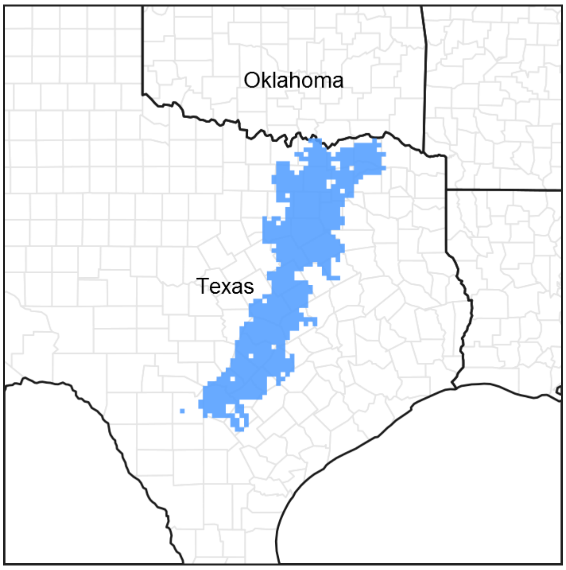

Figure 1. Mapped extent

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): 086A–Texas Blackland Prairie, Northern Part

MLRA 86A, The Northern Part of Texas Blackland Prairie is entirely in Texas. It makes up about 15,110 square miles (39,150 square kilometers). The cities of Austin, Dallas, San Antonio, San Marcos, Temple, and Waco are located within the boundaries. Interstate 35, a MLRA from San Antonio to Dallas. The area supports tall and mid-grass prairies, but improved pasture, croplands, and urban development account for the majority of the acreage.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 86A

Ecological site concept

The Clay Loam ecological site is a true tallgrass prairie, dominated by little bluestem. The soils are shallow to deep and characterized by their clay loam texture.

Associated sites

R086AY002TX	**Southern Chalky Ridge** The Chalky Ridge site is often upslope from the Clay Loam site. It differs from the Clay Loam site by having shallow soils and low soil fertility.

R086AY004TX	**Southern Claypan Prairie** The Claypan Prairie site is often adjacent to the Clay Loam site. It differs from the Clay Loam site by only occurring along major rivers and their tributaries and having a fine sandy loam soil surface layer.
R086AY012TX	**Loamy Bottomland** The Loamy Bottomland site is often downslope from the Clay Loam site. It differs from the Clay Loam site by occurring on floodplains and having thin strata of varying textured soils in the soil profile from flooding events.

Similar sites

R086AY006TX	**Northern Clay Loam** The Northern Clay Loam site is similar to the Southern Clay Loam site by having similar physiographic features and representative soil features. It differs by receiving more effective precipitation.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

The site consists of nearly level to moderately sloping soils with very low to medium runoff, with slopes ranging from 0 to 9 percent. The Clay Loam can be found on fluvial terraces and piedmont alluvial plains below limestone hills. The soils formed in alluvium high in calcium carbonate.

Table 2. Representative physiographic features

Landforms	(1) Plain (2) Terrace
Flooding duration	Very brief (4 to 48 hours)
Flooding frequency	None to rare
Ponding frequency	None
Elevation	430–1,899 ft
Slope	0–9%
Water table depth	57–80 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 86A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. Tropical maritime air controls the climate during spring, summer and fall. In winter and early spring, frequent surges of Polar Canadian air cause sudden drops in temperatures and add considerable variety to the daily weather. When these cold air masses stagnate and are overrun by moist air from the south, several days of cold, cloudy, and rainy weather follow. Generally, these occasional cold spells are of short duration with rapid clearing following cold frontal passages. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of sunny skies, mild days, and cool nights. The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time during the summer and 50 percent in winter. The prevailing wind direction is from the south and highest wind speeds occur during the spring months. Rainfall during the spring and summer months generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. High-intensity rains of short duration are likely to produce rapid runoff almost anytime during the year. The predominantly anticyclonic atmospheric circulation over Texas in summer and the exclusion of cold fronts from North Central Texas result in a decrease in rainfall during midsummer. The amount of rain that falls varies considerably from month-to-month and from year-to-year.

Table 3. Representative climatic features

Frost-free period (average)	244 days
Freeze-free period (average)	276 days
Precipitation total (average)	36 in

Climate stations used

- (1) CAMERON [USC00411348], Cameron, TX
- (2) LULING [USC00415429], Luling, TX
- (3) TAYLOR 1NW [USC00418862], Taylor, TX
- (4) TEMPLE [USC00418910], Temple, TX
- (5) SAN MARCOS [USC00417983], San Marcos, TX
- (6) AUSTIN-CAMP MABRY [USW00013958], Austin, TX
- (7) GRANGER DAM [USC00413686], Granger, TX
- (8) NEW BRAUNFELS [USC00416276], New Braunfels, TX
- (9) SAN ANTONIO 8NNE [USC00417947], San Antonio, TX
- (10) WACO DAM [USC00419417], Waco, TX
- (11) CEDAR CREEK 5 S [USC00411541], Cedar Creek, TX
- (12) RED ROCK [USC00417497], Red Rock, TX
- (13) SAN ANTONIO INTL AP [USW00012921], San Antonio, TX
- (14) AUSTIN BERGSTROM AP [USW00013904], Austin, TX

Influencing water features

This site is not influenced by water from wetland or streams.

Soil features

The soils are shallow to very deep, well drained soils that have moderate to slow permeability. The the parent material is calcareous alluvium weathered from limestone hills. In a representative profile, the surface layer is dark grayish-brown, calcareous clay loam about 10 to 18 inches thick over a brown calcareous clay loam subsoil. Depth to bedrock ranges from 22 to more than 60 inches below the surface. The available water capacity is low to moderate.

The following dominant soil series are: Altoga, Austin, Blum, Bonham, Culp, Cuthand, Howe, Krum, Lamar, Lewisville, Lott, McLennan, Seawillow, Sunev, Venus, and Whiteright.

Table 4. Representative soil features

Surface texture	(1) Clay loam (2) Silty clay loam
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderate to slow
Soil depth	20–80 in
Surface fragment cover <=3"	0%
Surface fragment cover >3"	0%

Available water capacity (0-40in)	1.2–3 in
Calcium carbonate equivalent (0-40in)	0–68%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	2–20%
Subsurface fragment volume >3" (Depth not specified)	0–11%

Ecological dynamics

Introduction – The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background – Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Florida paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsuta*), and dropseeds (Sporobolus spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak (*Quercus virginiana*) and hackberry (Celtis spp.) trees are also native to the region. In some areas, cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), and honey locust (*Gleditsia triacanthos*) are abundant. In the Northern Blackland Prairie oaks (Quercus spp.) are common increasers, but in the Southern Blackland Prairie oaks are less prevalent. Junipers are common invaders, particularly in the northern part of the region.

During the first half of the nineteenth century, row crop agriculture lead to over 80 percent of the original vegetation lost. During the second half, urban development has caused even an even greater decline in the remaining prairie. Today, less than one percent of the original tallgrass prairie remains. The known remaining blocks of intact prairie range from 10 to 2,400 acres. Some areas are public, but many are privately owned and have conservation easements.

Current State – Much of the area is classified as prime farmland and has been converted to cropland. Most areas where native prairie remains have histories of long-term management as native hay pastures. Tallgrasses remain dominant when haying of warm-season grasses is done during the dormant season or before growing points are elevated, meadows are not cut more than once, and the cut area is deferred from grazing until frost.

Due to the current-widespread farming, the Northern Blackland Prairie is still relatively free from the invasion of brush that has occurred in other parts of Texas. In contrast, many of the more sloping have experienced heavy brush encroachment, and the continued increase of brush encroachment is a concern. The shrink-swell and soil cracking characteristics of the soils favor brush species with tolerance for soil movement.

Current Management – Rangeland and pastureland are grazed primarily by beef cattle. Horse numbers are increasing rapidly in the region, and in recent years goat numbers have increased significantly. There are some areas where dairy cattle, poultry, goats, and sheep are locally important. Whitetail deer, wild turkey, bobwhite quail, and dove are the major wildlife species, and hunting leases are a major source of income for many landowners in this area.

Introduced pasture has been established on many acres of old cropland and in areas with deeper soils. Coastal bermudagrass (*Cynodon dactylon*) and kleingrass (*Panicum coloratum*) are by far the most frequently used introduced grasses for forage and hay. Hay has also been harvested from a majority of the prairie remnants, where long-term mowing at the same time of year has possibly changed the relationships of the native species. Cropland is found in the valleys, bottomlands, and deeper upland soils. Wheat (Triticum spp.), oats (Avena spp.), forage and grain sorghum (Sorghum spp.), cotton (Gossypium spp.), and corn (*Zea mays*) are the major crops in the region.

Fire Regimes – The prairies were a disturbance-maintained system. Prior to European settlement (pre-1825), fire and infrequent, but intense, short-duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes - Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases. Wet periods allow tallgrasses to increase in dominance. These natural disturbances cause shifts in the states and communities of the ecological sites.

State and transition model

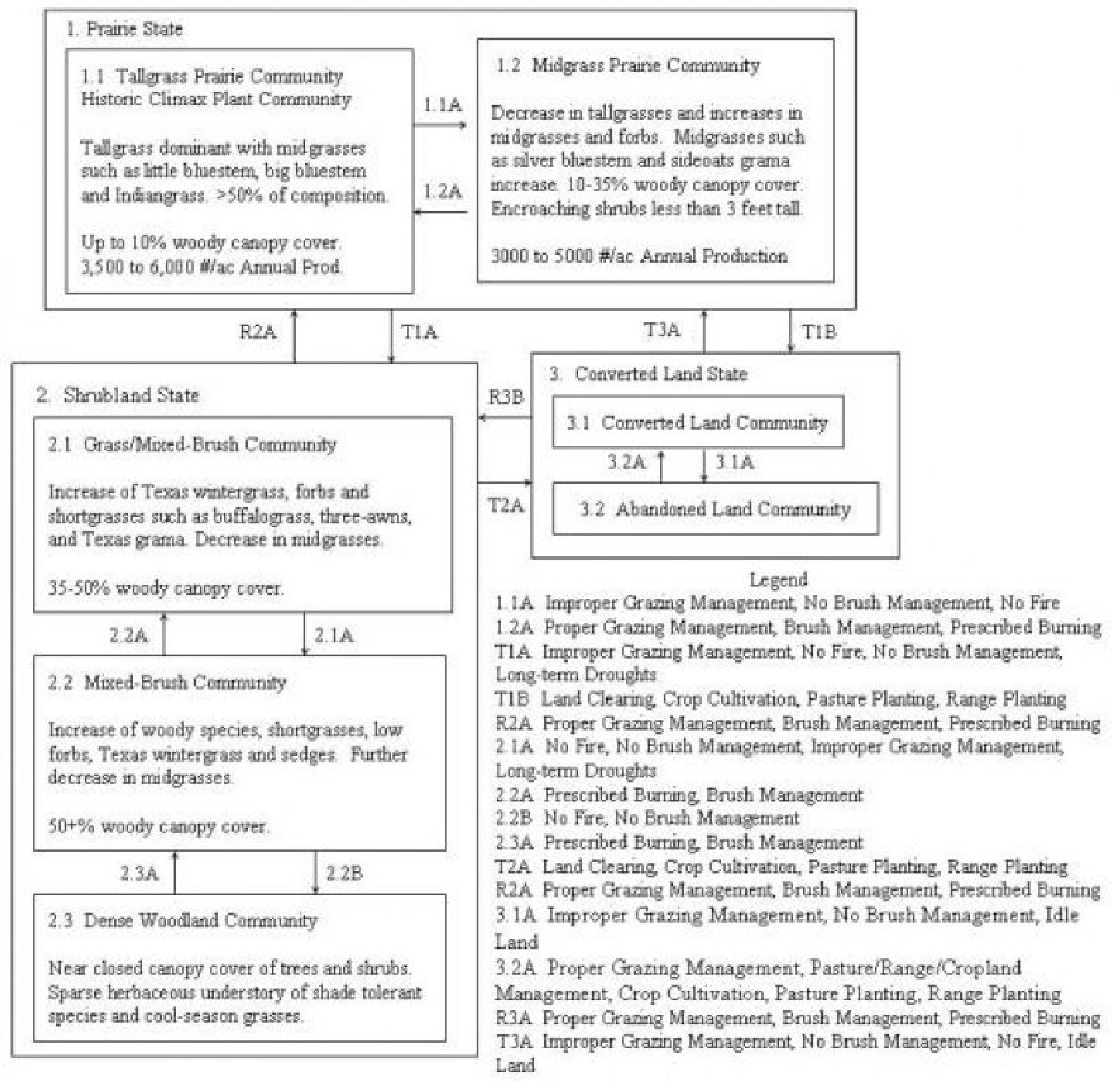

Figure 6. STM

State 1
Prairie

Two communities exist in the Prairie State: the 1.1 Tallgrass Prairie Community and the 1.2 Midgrass Prairie Community. Community 1.1 is characterized by tallgrasses comprising more than 50 percent of the composition. The site is colonized by less than 10 percent woody plants and ranges from 3,500 to 6,000 pounds per acre of biomass. Community 1.2 is characterized by a decrease in tallgrass abundance and an increase in midgrasses. The woody canopy cover has increased from 10 to 35 percent, with some attaining heights of three feet.

Community 1.1
Tallgrass Prairie

The Tallgrass Prairie Community (1.1) is a true prairie with a few large live oak, elm (Ulmus spp.), and hackberry trees along the draws and in occasional mottes. It is characterized by deeper soils dominated by warm-season, perennial tallgrasses, with warm-season, perennial midgrasses filling most of the remaining species composition. The warm-season, perennial forb component varies between 5 and 15 percent depending on climatic patterns and local precipitation. Woody species make up a minor component of the community, 5 percent by weight, even in the short-term absence of fire (two to five years). Little bluestem, Indiangrass, and big bluestem dominate the site. Other important grasses include Canada wildrye (*Elymus canadensis*), eastern gamagrass (*Tripsacum dactyloides*), switchgrass, sideoats grama, silver bluestem (*Bothriochloa laguroides*), Texas wintergrass, and Florida paspalum. Forbs commonly found on the site include Engelmann's daisy (*Engelmannia peristenia*), Maximilian sunflower (*Helianthus maximiliani*), blacksamson (*Echinacea angustifolia*), halfshrub sundrop (*Calylophus serrulatus*), sensitive-briar (Mimosa spp.), and yellow neptunia (*Neptunia lutea*). Typical, but infrequent, shrub and tree species found in the reference community (1.1) include species of oak, hackberry, pecan (*Carya illinoinensis*), and elm, along with bumelia (Sideroxylon spp.) and coralberry (*Symphoricarpos orbiculatus*). The reference prairie community will transition to a midgrass-dominated community under the stresses of improper grazing management. The first species to decrease in dominance will be the most palatable and/or least grazing tolerant grasses and forbs (i.e. eastern gamagrass, switchgrass, Indiangrass, big bluestem, and Engelmann's daisy). This will initially result in an increase in composition of little bluestem and sideoats grama. If improper grazing management continues, little bluestem and Florida paspalum will decrease and midgrasses such as silver bluestem and Texas wintergrass will increase in composition. Less palatable forbs will increase at this stage. Because the woody species that dominate in the Shrubland State are native species that occur as part of the Prairie State, the transition to the Shrubland State is a linear process with shrubs starting to increase soon after fire or brush control. Unless some form of brush control takes place, woody species will increase to the 35 percent canopy cover level that indicates a state change. This is a continual process that is always in effect. Managers need to detect the increase in woody species when canopy is less than 35 percent and take management action before the state change occurs. There is not a 10-year window before shrubs begin to increase followed by a rapid transition to the Shrubland State. The drivers of the transition (lack of fire and lack of brush control) constantly pressure the system towards the Shrubland State. Canopy cover drives the transitions between community and states because of the influence of shade and interception of rainfall. This plant community has very little bare ground. Plant basal cover and litter make up almost 100 percent ground cover. Soils are fertile with good permeability and produce abundant high quality palatable forage.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	3325	4500	5700
Forb	125	160	180
Shrub/Vine	50	90	120
Total	**3500**	**4750**	**6000**

Community 1.2
Midgrass Prairie

The Midgrass Community (1.2) is the result of long-term improper cattle grazing management. Tallgrasses in the reference prairie community decrease in vigor and production, allowing midgrasses and forbs to increase to the point that they make up more than 50 percent of species composition. Indigenous or invading woody species may increase on the site depending on fire and brush control methods. In the Tallgrass Prairie Community (1.1), repeated fires and competition from a vigorous grass component keep woody canopy cover low. When the Midgrass Community (1.2) is continually overgrazed and fire is excluded, the community crosses a threshold to a state that is dominated by woody plants, the Grass/Mixed-Brush Community (2.1). Important grasses include little bluestem, sideoats grama, silver bluestem, Texas wintergrass, and low panicums. Some of the reference community perennial forbs persist, but less palatable forbs will increase. Woody canopy may be as high as 35 percent, depending on the type of grazing animal, fire interval, brush control, and/or availability of increaser shrub species. Numerous shrub and tree species will encroach because overgrazing by livestock has reduced grass cover, exposed more soil, and reduced grass fuel for fire. Typically, trees such as oak, elm, and hackberry will increase in size, while other woody species such as bumelia, coralberry, honey locust, elbowbush (*Forestiera pubescens*), and sumac (Rhus spp.) species will increase in density. Aggressive, introduced pasture species may begin to invade the Midgrass Plant Community, particularly if they have been seeded in nearby pastures. These include introduced paspalums, such as bahiagrass (*Paspalum notatum*), Old World bluestems (Bothriochloa spp.), and Bermudagrass. Increasing woody dominants are oak, hackberry, elm, and juniper. Once shrubs reach a height of about three feet, they become more resistant to being killed by fires. When woody species exceed 35 percent canopy cover, the site crosses a threshold (T1A) into the Shrubland State (2) and the Grass/Mixed-Brush Plant Community (2.1). Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to crusting and erosion. Some mulch and litter movement may occur during rainstorms, but little soil movement occurs due to gentle slopes in this vegetation type. Litter and mulch will move off site as plant cover declines. Until the Midgrass Prairie Community (1.2) crosses the threshold into the Grass/Mixed-Brush Community (2.1), this community can be managed back toward the reference community (1.1) through the use of prescribed grazing, prescribed burning, and strategic brush control. It may take several years to achieve this state, depending upon climate and the aggressiveness of management. Once woody species begin to establish, returning fully to the reference is difficult, but it is possible to return to a similar plant community. If improper grazing management continues but shrubs are held in check through fire, brush control, browsing, or mowing, the Midgrass Plant Community will continue to degrade. Tallgrasses will continue to decrease in species composition, and midgrasses will begin to decrease. Grazing-resistant shortgrasses, annuals, and forbs will represent more of species composition. These species may increase in relative composition due to the loss of tall and midgrasses. The site will have reduced production and poor ecological processes. Brush control in this community will be more cost effective than after the transition has been made to the Shrubland State.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1800	2400	3000
Forb	600	800	1000
Shrub/Vine	600	800	1000
Total	**3000**	**4000**	**5000**

Pathway 1.1A
Community 1.1 to 1.2

Tallgrass Prairie

Midgrass Prairie

The Tallgrass Prairie Community will shift to the Midgrass Prairie Community when there is continued growing season stress on reference grass species. These stresses include improper grazing management that creates insufficient critical growing season deferment, excess intensity of defoliation, repeated, long-term growing season defoliation, long-term drought, and/or other repeated critical growing season stress. Increaser species (midgrasses and woody species) are generally endemic species released by disturbance. Woody species canopy exceeding 10 percent and/or dominance of tallgrasses falling below 50 percent of species composition indicate a transition to the Midgrass Prairie Community. The reference community can be maintained through implementation of brush management combined with properly managed grazing that provides adequate growing season deferment to allow establishment of tallgrass propagules and/or the recovery of vigor of stressed plants. The driver for community shift 1.1A for the herbaceous component is improper grazing management, while the driver for the woody component is lack of fire and/or brush control.

Pathway 1.2A
Community 1.2 to 1.1

Midgrass Prairie

Tallgrass Prairie

The Midgrass Prairie Community will return to the Tallgrass Prairie Community under grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition. The understory component may return to dominance by tallgrasses in the absence of fire or brush control. However, reduction of the woody component to 10 percent or less canopy cover will require inputs of fire or brush control. The understory and overstory components can act independently when canopy cover is less than 35 percent, meaning, an increase in shrub canopy cover can occur while proper grazing management creates an increase in desirable herbaceous species. The driver for community shift 1.2A for the herbaceous component is proper grazing management, while the driver for the woody component is fire and/or brush control.

State 2
Shrubland

The Shrubland State has three communities: 2.1 Grass/Mixed-Brush Community, 2.2 Mixed-Brush Community, and 2.3 Woodland Community. The 2.1 community has a woody species overstory canopy of 35 to 50 percent, the 2.2 community over 50 percent, and the 2.3 community has a closed canopy. As tree and brush canopy increases, the herbaceous understory production decreases due to lack of light availability.

Community 2.1
Grass/Mixed Brush

The Grass/Mixed-Brush Community (2.1) presents a 35 to 50 percent woody plant canopy, with oak, hackberry, elm, or juniper as dominant woody species. This community can occur as a result of continuous improper grazing management combined with lack of fire or brush control. It can also occur where there has been proper grazing management without brush control or fire. Improper grazing management speeds the process. Although it is rarely found, it is possible for the herbaceous component to include substantial production from tallgrasses. Palatable woody species tend to decrease and unpalatable woody species tend to increase, particularly where there is heavy browsing from deer or goats. Honey mesquite is an early increaser throughout the MLRA. Ashe juniper (*Juniperus ashei*) invaded from the south, and eastern red cedar is found more frequently in the northern portion of the MLRA. Many of the tallgrass community shrubs are still present. Sideoats grama and other reference (1.1) midgrasses decrease, but still remain the dominant component of composition, while shortgrasses such as buffalograss (*Bouteloua dactyloides*) increase. Remnants of reference grasses and forbs along with unpalatable invaders occupy the interspaces between shrubs. Cool-season species such as Texas wintergrass and sedges (Carex spp.), plus other grazing-resistant reference species, can be found under and around woody plants. Plant vigor and productivity of the grassland component is reduced due to grazing pressure and competition for sunlight, nutrients, and water from woody plants. Common herbaceous species include threeawns (Aristida spp.), dropseeds, and dotted gayfeather (*Liatris punctata*). Tumblegrass (*Schedonnardus paniculatus*), Texas grama (*Bouteloua rigidiseta*), western ragweed (*Ambrosia psilostachya*), broomweed (*Amphiachyris dracunculoides*), nightshades (Solanum spp.), curlycup gumweed (*Grindelia squarrosa*), and annual species are persistent increasers until shrub density reaches maximum canopy. This community can be dominated by a mix of forbs and short stature shrubs when there is continued growing season stress on reference and midgrass species. This transition usually results from heavy, long-term continuous grazing and is often associated with farm lots and horse pastures. Invasive species often dominate the site, including invasive forbs, shrubs, and grasses. As the grassland vegetation declines, more soil is exposed, leading to crusting and erosion. In this vegetation type, erosion can be severe. Higher rainfall interception losses by the increasing woody canopy combined with evaporation and runoff can reduce the effectiveness of rainfall. Soil organic matter and soil structure decline within the interspaces, but soil conditions improve under the woody plant cover. Some soil loss can occur during rainfall events. Annual primary production is approximately 2,000 to 4,500 pounds per acre. In this plant community, annual production is balanced between herbaceous plants and woody species, with herbaceous production still the dominant component of annual production. Browsing animals such as goats and deer can find fair food value if browse plants have not been grazed excessively. Forage quantity and quality for cattle is low. Unless brush management and good grazing management are applied at this stage, woody species canopy will exceed 50 percent, causing the community to convert to the Mixed-Brush Community (2.2). The trend cannot be reversed with proper grazing management alone. Extensive brush management and range planting may be needed to manage the site towards the Prairie State. Soil erosion may prevent the site from recovering. Brush control and range planting can help restore fuel loads to provide the option of reintroducing prescribed fire into the ecosystem. Without fire, the manager will need to be diligent in the use of individual plant treatment of woody species.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	800	1300	1800
Grass/Grasslike	800	1300	1800
Forb	400	650	900
Total	**2000**	**3250**	**4500**

Community 2.2
Mixed-Brush

The Mixed-Brush Community (2.2) has 50 to 80 percent woody canopy cover and is the result of many years of improper grazing, lack of periodic fires, and/or a lack of proper brush management. Reference woody species or increasers, such as juniper, dominate the Mixed-Brush Community (2.2). The site can now have the appearance of a dense shrubland or savannah of interspersed shrubland and grassland areas. Common understory shrubs are pricklypear (Opuntia spp.) and sumac. Woody shrubs seem to increase more rapidly in the southern portion of the MLRA. With continued lack of brush control, the trees and shrubs can exceed 80 percent canopy cover, which indicates the transition to the Woodland Community (2.3). Remnant midgrasses and opportunistic shortgrasses, annuals, and perennial forbs occupy the woody plant interspaces. Characteristic grasses are curly-mesquite (*Hilaria belangeri*), buffalograss, and tumblegrass. Texas wintergrass and annuals are found in and around tree/shrub cover. Grasses and forbs make up 50 percent or less of the annual herbage production. Common forbs include dotted gayfeather, halfshrub sundrop, croton (Croton spp.), western ragweed, verbena (Verbena spp.), snow-on-the-prairie (*Euphorbia bicolor*), Mexican sagewort (*Artemisia ludoviciana* ssp. mexicana), and sensitive-briar. The shrub canopy acts to intercept rainfall and increase evapotranspiration losses, creating a more xeric microclimate. Soil fauna and organic mulch are reduced, exposing more of the soil surface to erosion in interspaces. The exposed soil crusts readily. However, within the woody canopy, hydrologic processes stabilize and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. The Mixed-Brush Community (2.2) can provide good cover habitat for wildlife, but only limited forage or browse is available for livestock or wildlife. At this stage, highly intensive restoration practices are needed to return the shrubland to prairie. Alternatives for restoration include brush control and range planting with proper stocking, prescribed grazing, and prescribed burning following restoration to maintain the desired community.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	1050	1400	1750
Grass/Grasslike	225	300	375
Forb	225	300	375
Total	**1500**	**2000**	**2500**

Community 2.3
Dense Woodland

The Dense Woodland Community (2.3) has more than 80 percent woody canopy cover as the result of lack of periodic fires, and/or a lack of proper brush management. Reference condition woody species or increasers such as honey mesquite and/or juniper dominate the Dense Woodland Community (2.3) with little herbaceous understory. The site has the appearance of a dense shrubland or woodland. Herbaceous understory plants are limited to shade-tolerant grasses, sedges, and forbs. Under the woody canopy, hydrologic processes stabilize, and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become nonexistent under dense juniper canopies. The Dense Woodland Community (2.3) can provide good habitat for wildlife that favor woodland habitat. Highly intensive restoration practices are needed to return the woodland to prairie. Alternatives for restoration include brush control and range planting with proper stocking, prescribed grazing, and prescribed burning following restoration to maintain the desired community. Prescribed burning may be difficult due to lack of fine fuels.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	1800	2700	3600
Forb	150	225	300
Grass/Grasslike	50	75	100
Total	**2000**	**3000**	**4000**

Pathway 2.1A
Community 2.1 to 2.2

Without some form of brush control, woody density and canopy cover will increase in the Grass/Mixed-Brush Community until it converts into the Mixed-Brush Community. Improper grazing management and/or long-term drought (or other growing season stress) will accelerate this transition. Woody species canopy exceeding 50 percent indicates this transition. Herbaceous understory may be similar to any of the Prairie State Communities. Improper grazing or other long-term growing season stress can increase the composition of less productive grasses and low-growing (or unpalatable) forbs in the herbaceous component. Even with proper grazing, in the absence of fire the woody component will increase to the point that the herbaceous component will decline in production and shift in composition toward sedges, grasses, and forbs suited to growing in shaded conditions with reduced available soil moisture. The driver for community shift 2.1A is lack of fire and/or brush control.

Pathway 2.2A

Community 2.2 to 2.1

Brush management and/or fire can reduce the woody component of the Mixed-Brush Community to below the transition level of 50 percent brush canopy. Continued fire and/or brush management will be required to maintain woody density and canopy below 50 percent. If the herbaceous component has transitioned to shortgrasses and low forbs, proper grazing management (combined with favorable moisture conditions and adequate seed source) will be necessary to facilitate the shift of the understory component in the Mixed-Brush Community to a midgrass-dominated Grass/Mixed-Brush Community. Range planting may accelerate the transition of the herbaceous community, particularly when combined with favorable growing conditions. The driver for community shift 2.2A is fire and/or brush control.

Pathway 2.2B
Community 2.2 to 2.3

Without fire (natural or human-caused) and/or brush control, woody density and canopy cover will increase in the Mixed-Brush Community until it converts into the Dense Woodland Community. Woody species canopy exceeding approaching closed canopy (greater than 80 percent) and a decline of herbaceous understory species composition of less than 20 percent indicate this transition. Herbaceous understory will be sparse and comprised of sedges, grasses, and forbs suited to growing in shaded conditions with reduced available soil moisture. The driver for community shift 2.2A is lack of fire and/or brush control.

Pathway 2.3A
Community 2.3 to 2.2

Brush management and/or fire can reduce the woody component of the Dense Woodland Community below the transition level of 80 percent woodland canopy. Continued fire and/or brush management will be required to maintain woody density and canopy below 80 percent. Due to limited understory of fine fuels, prescribed fires will be difficult to use. The site may carry crown fires or fires carried by the shrubby understory. Range planting may accelerate the transition of the herbaceous community, particularly when combined with favorable growing conditions. Transition Pathway 2.3A is more likely to accompany small fires or tree disease than be a part of a management plan. The driver for community shift 2.3A is removal of canopy cover to allow limited recovery of understory species.

State 3
Converted

Two communities exist in the Converted State: 3.1 Converted Land Community and the 3.2 Abandoned Land Community. The 3.1 Community is characterized by agricultural production. The site may be planted to improved pasture for hay or grazing. The site may otherwise be planted to row crops. The 3.2 community represents an agricultural state that has not been managed. The land is colonized by first successional species.

Community 3.1
Converted Land

The Converted Land Community (3.1) occurs when the site, either the Prairie State (1) or Shrubland State (2), is cleared and plowed for planting to cropland, hayland, native grasses, tame pasture, or use as non-agricultural land. The Converted State includes cropland, tame pasture, hayland, rangeland, and go-back land. Agronomic practices are used with non-native forages in the Converted State and to make changes between the communities in the Converted State. The native component of the prairie is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed. The Clay Loam site is frequently converted to cropland or tame pasture sites because of its deep fertile soils, favorable soil/water/plant relationship, and level terrain. Hundreds of thousands of acres have been plowed up and converted to cropland, pastureland, or hayland. Small grains are the principal crop, and Bermudagrass is the primary introduced pasture species on loamy soils in this area. The Clay Loam site can be an extremely productive forage producing site with the application of optimum amounts of fertilizer. Cropland, pastureland, and hayland are intensively managed with annual cultivation and/or frequent use of herbicides, pesticides, and commercial fertilizers to increase production. Both crop and pasturelands require weed and shrub control because seeds remain present on the site, either by remaining in the soil or being transported to the site. Converted sites require continual fertilization for crops or tame pasture (particularly Bermudagrass) to perform well. Common introduced species include coastal Bermudagrass, kleingrass, and Old World bluestems which are used in hayland and tame pastures. Wheat, oats, forage sorghum, grain sorghum, cotton, and corn are the major crop species. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. Without agronomic inputs, the site will eventually return to either the Prairie or Shrubland state. The site is considered go-back land during the period between active management for pasture or cropland and the return to a native state.

Community 3.2
Abandoned Land

The Abandoned Land Community (3.2) occurs when the Converted Land Community (3.1) abandoned or mismanaged. Mismanagement can include poor crop or haying management. Pastureland can transition to the Abandoned Land Community when subjected to improper grazing management (typically long-term overgrazing). Heavily disturbed soils left alone will eventually “go-back” to the Shrubland State. These sites may become an eastern red cedar brake over time. Long-term cropping can create changes in soil chemistry and structure that make restoration to the reference state very difficult and/or expensive. Return to native prairie communities in the Clay Loam State is more likely to be successful if soil chemistry, microorganisms, and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions. Restoration to native prairie will require seedbed preparation and seeding of native species. Protocols and plant materials for restoring prairie communities is a developing portion of restoration science. Sites can be restored to the Prairie State in the short-term by seeding mixtures of commercially-available native grasses. With proper management (prescribed grazing, weed control, brush control) these sites can come close to the diversity and complexity of Tallgrass Prairie Community (1.1). It is unlikely that abandoned farmland will return to the Prairie State without active brush management because the rate of shrub increase will exceed the rate of recovery by desirable grass species. Without active restoration the site is not likely to return to reference conditions due to the introduction of introduced forbs and grasses. The native component of the prairie is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed.

Pathway 3.1A
Community 3.1 to 3.2

The Converted Land Community (3.1) will transition to the Abandoned Land Community (3.2) if improperly managed as cropland, hayland, or pastureland. Each of these types of converted land is unstable and requires constant management input for maintenance or improvement. This community requires inputs of tillage, weed management, brush control, fertilizer, and reseeding of annual crops. The driver of this transition is the lack of management inputs necessary to maintain cropland, hayland, or pastureland.

Pathway 3.2A
Community 3.2 to 3.1

The Abandoned Land Community (3.2) will transition to the Converted Land Community (3.1) with proper management inputs. The drivers for this transition are weed control, brush control, tillage, proper grazing management, and range or pasture planting.

Transition T1A
State 1 to 2

Shrubs make up a portion of the plant community in the Prairie State, hence woody propagules are present. Therefore, the Prairie State is always at risk for shrub dominance and the transition to the Shrubland State in the absence of fire. The driver for Transition T1A is lack of fire and/or brush control. Maintenance of the Prairie State will require prescribed fire every three to five years. Even with proper grazing and favorable climate conditions, lack of fire or brush control for 10 to 15 years will allow woody species to increase in canopy to reach the 35 percent threshold level. Improper grazing management, prolonged drought, and a warming climate will provide disturbance conditions which will accelerate this process. Introduction of aggressive woody invader species (i.e. juniper) also increase the risk and accelerate the rate at which this transition state is likely to occur. This transition can occur from any of the Prairie State Communities.

Transition T1B
State 1 to 3

The transition to the Converted State from the Grassland State occurs when the prairie is plowed for planting to cropland or hayland. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered go-back land during the period between cessation of active cropping, fertilization, and weed control and the return to States 1 or 2. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R2A
State 2 to 1

Restoration of the Shrubland State to the Prairie State requires substantial energy input. Mechanical or herbicidal brush control treatments can be used to remove woody species. A long-term prescribed fire program may sufficiently reduce brush density to a level below the threshold of the Prairie State, particularly if the woody component is dominated by species that are not re-sprouters following top removal. However, fire may not be sufficient to remove mature trees. A mixed program consisting of mechanical, chemical, and fire measures may be used. Brush control in combination with prescribed fire, proper grazing management, and favorable growing conditions may be the most economical means of creating and maintaining the desired plant community. Proper grazing management will be required to promote recovery of the understory towards a tallgrass community. If remnant populations of tallgrasses, midgrasses, and desirable forbs are not present at sufficient levels, range planting will be necessary to restore the prairie plant community. Depending on the understory community and inputs of seed, the restoration pathway can result in return to any of the Prairie State Communities.

Transition T2A
State 2 to 3

The transition to the Converted State from either the Grassland State (T1B) or Shrubland State (T2A) occurs when the prairie is plowed for planting to cropland or hayland. The size and density of brush in the Shrubland State will require heavy equipment and energy-intensive practices (e.g. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration from the Converted State can occur in the short-term through active restoration or over the long-term due to cessation of agronomic practices. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. If the soil chemistry and structure have not been overly disturbed (which is most likely to occur with tame pasture) the site can be restored to the Prairie State. Heavily disturbed soils are more likely to return to the Shrubland State. Without continued disturbance from agriculture the site can eventually return to either the Prairie or Shrubland State. The level of disturbance while in the converted state determines whether the site restoration pathway is likely to be R3A (a return to the Prairie State) or T3A (a return to the Shrubland State). Return to native prairie communities in the Prairie State is more likely to be successful if soil chemistry and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions. Converted sites can be returned to the Prairie State through active restoration, including seedbed preparation and seeding of native grass and forb species. Protocols and plant materials for restoring prairie communities are a developing part of restoration science. The driver for both of these restoration pathways is the cessation of agricultural disturbances.

Transition T3A
State 3 to 2

Transition to the Shrubland State (2) occurs with the cessation of agronomic practices. The site will move from the Abandoned Land Community when woody species begin to invade. After shrubs and trees have established over 35 percent, and reached a height greater than three feet, the threshold has been crossed. The driver for the change is lack of agronomic inputs, improper grazing, no brush management, and no fire.

Additional community tables

Table 10. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			2800–4800	
	little bluestem	SCSCS	*Schizachyrium scoparium var. scoparium*	1750–3000	–
	Indiangrass	SONU2	*Sorghastrum nutans*	1050–1800	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	200–1800	–
	big bluestem	ANGE	*Andropogon gerardii*	1050–1800	–
	switchgrass	PAVI2	*Panicum virgatum*	200–1500	–
2	**Midgrasses**			350–600	
	sideoats grama	BOCU	*Bouteloua curtipendula*	350–600	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	350–600	–
	Canada wildrye	ELCA4	*Elymus canadensis*	350–600	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	350–600	–
	Drummond's dropseed	SPCOD3	*Sporobolus compositus var. drummondii*	350–600	–
3	**Mid/Shortgrasses**			175–300	
	sedge	CAREX	*Carex*	175–300	–
	fall witchgrass	DICO6	*Digitaria cognata*	175–300	–
	mourning lovegrass	ERLU	*Eragrostis lugens*	175–300	–
	panicgrass	PANIC	*Panicum*	175–300	–
	purpletop tridens	TRFL2	*Tridens flavus*	175–300	–
	longspike tridens	TRST2	*Tridens strictus*	175–300	–
Forb					
4	**Forbs**			105–180	

4	**Forbs**			105–180	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	105–180	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	105–180	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	105–180	–
	prairie clover	DALEA	*Dalea*	105–180	–
	bundleflower	DESMA	*Desmanthus*	105–180	–
	ticktrefoil	DESMO	*Desmodium*	105–180	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	105–180	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	105–180	–
	snow on the prairie	EUBI2	*Euphorbia bicolor*	105–180	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	105–180	–
	coastal indigo	INMI	*Indigofera miniata*	105–180	–
	dotted blazing star	LIPU	*Liatris punctata*	105–180	–
	sensitive plant	MIMOS	*Mimosa*	105–180	–
	yellow puff	NELU2	*Neptunia lutea*	105–180	–
	beardtongue	PENST	*Penstemon*	105–180	–
	woolly plantain	PLPA2	*Plantago patagonica*	105–180	–
	prairie parsley	POLYT	*Polytaenia*	105–180	–
	scurfpea	PSORA2	*Psoralidium*	105–180	–
	snoutbean	RHYNC2	*Rhynchosia*	105–180	–
	fuzzybean	STROP	*Strophostyles*	105–180	–
	vetch	VICIA	*Vicia*	105–180	–
Shrub/Vine					
5	**Shrubs/Vines/Trees**			70–120	
	pecan	CAIL2	*Carya illinoinensis*	70–120	–
	hackberry	CELTI	*Celtis*	70–120	–
	stretchberry	FOPU2	*Forestiera pubescens*	70–120	–
	oak	QUERC	*Quercus*	70–120	–
	sumac	RHUS	*Rhus*	70–120	–
	bully	SIDER2	*Sideroxylon*	70–120	–
	western snowberry	SYOC	*Symphoricarpos occidentalis*	70–120	–
	elm	ULMUS	*Ulmus*	70–120	–

Animal community

The animal community differs depending on what state the site is currently in. Northern Bobwhite prefer the reference state. They require dense bunchgrasses for nesting and cover. As the site transitions into State 2, white-tailed deer will become more prevalent. Deer are woodland and edge species, with their primary diet consisting of browse. Mourning dove need open areas with semi-clear ground and forbs with desirable seed sources. Go-back land and communities with shortgrasses and forbs provide the best habitat for dove.

Hydrological functions

The tallgrass community water cycle functions well with good infiltration and deep percolation of rainfall. The water cycle functions best in the Tallgrass Prairie Community (1.1) and degrades as the vegetation community declines. Rapid rainfall infiltration, high soil organic matter, good soil structure and good porosity accompany high bunchgrass cover. Surface runoff quality will be high and erosion and sedimentation rates will be low. High rates of infiltration will allow water to move below the rooting zone during periods of heavy rainfall.

A shift to the Midgrass Community (1.2) means reduced plant and litter cover, which impairs the water cycle. Infiltration will decrease and runoff will increase due to reduced ground cover, rainfall splash, soil capping, reduced organic matter, and poor structure. With a combination of a sparse ground cover and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor and sedimentation increases.

Domination of the site by woody species, especially oaks and juniper, further degrades the water cycle. Interception of rainfall by tree canopies increases, which reduces the amount of rainfall reaching the surface and being available to understory plants. Increased flow, due to the funneling effect of the canopy, will increase soil moisture at the base of trees, especially on mesquite. Evergreen species, such as live oak and juniper, create increased transpiration, which provides less water for deep percolation. Increases in woody canopy create declines in grass cover, which creates similar causes impacts as those described for improper grazing above. Return of the Shrubland State to the Tallgrass Plant Community through brush management and good grazing management can help improve hydrologic function of the site.

Under the dense canopy of a mature woodland, leaf litter builds up. This increases soil organic matter, builds structure, improves infiltration, and reduces surface erosion. These conditions improve the function of the water cycle compared to lower levels of canopy cover. Site specific information showed that the reference has no rills or gullies. Water flow patterns are common and follow old stream meanders. Deposition and erosion is uncommon for normal rainfall but may occur during intense rainfall events. Pedestals and terracettes are not common in the reference community. There is generally less than 20 percent bare ground which is randomly distributed throughout. Soil surface is resistant to erosion and the soil stability class range is expected to be 5 to 6. Under reference conditions, this Clay Loam site is dominated by tallgrasses and forbs, having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Honey mesquite, eastern red cedar, and some oak are used for posts, firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as agarito (Mahonia trifoliolata). Seeds are harvested from many reference plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants.

Inventory data references

Information presented was derived from the NRCS clipping data, literature, field observations, and personal contacts with range-trained personnel.

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Approval

David Kraft, 5/06/2020

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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)	Lem Creswell, RMS, NRCS, Weatherford, Texas
Contact for lead author	817-596-2865
Date	01/17/2008
Approved by	David Kraft

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

Indicators

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

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2. **Presence of water flow patterns:** Water flow patterns are common and follow old stream meanders. Deposition or erosion is uncommon for normal rainfall but may occur during intense rainfall events.

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

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Essentially none. Site has litter filling interspaces between plant bases.

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5. **Number of gullies and erosion associated with gullies:** No gullies should be present on side drains into perennial and intermittent streams. Drainageways should be vegetated and stable.

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

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7. **Amount of litter movement (describe size and distance expected to travel):** This site is a flood plain with occasional out of bank flow. Under normal rainfall, little litter movement should be expected; however, litter of all sizes may move long distances under flood conditions.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is resistant to erosion. Soil stability class range is expected to be 5 to 6.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 0 to 53 inches thick with colors from dark reddish brown clay to very dark gray clay with generally weak very fine subangular blocky structure. SOM is approximately 1 to 6 percent. See soil survey for specific soils.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** This site is dominated by tallgrasses and forbs and trees having adequate litter and little bare ground can provide for maximum infiltration and little runoff under normal rainfall events.

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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.

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 tallgrasses >>

    Sub-dominant: Warm-season midgrasses > Cool-season grasses > Trees >

    Other: Forbs > Shrubs/Vines

    Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Grasses and forbs due to their growth habit will exhibit some mortality and decadence, though very slight. Open spaces from disturbance are quickly filled by new plants through seedlings and vegetative reproduction (tillering).

14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 3,500 pounds per acre for below average moisture years to 6,000 pounds per acre for above average moisture years.

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:** Potential invasive species include yellow bluestems, mesquite, Bermudagrass, elm, huisache, eastern red cedar, osage orange and Chinese tallow.

17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing, except during periods of prolonged drought conditions, heavy natural herbivory and intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R086AY009TX Southern Eroded Blackland

Last updated: 5/06/2020
Accessed: 10/26/2022

General information

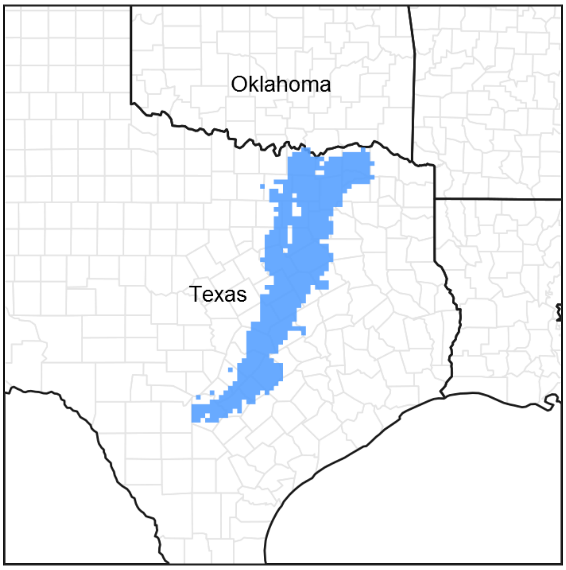

Figure 1. Mapped extent

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): 086A–Texas Blackland Prairie, Northern Part

MLRA 86A, The Northern Part of Texas Blackland Prairie is entirely in Texas. It makes up about 15,110 square miles (39,150 square kilometers). The cities of Austin, Dallas, San Antonio, San Marcos, Temple, and Waco are located within the boundaries. Interstate 35, a MLRA from San Antonio to Dallas. The area supports tall and mid-grass prairies, but improved pasture, croplands, and urban development account for the majority of the acreage.

Classification relationships

USDA-Natural Resources Conservation Service, 2006.
-Major Land Resource Area (MLRA) 86A

Ecological site concept

The Eroded Blackland ecological site is a tallgrass prairie. Reference sites show intact communites of grasses with pockets of woody species interspersed. Biomass productivity is not as high as the Blackland site due to the erosion that has partially, or completely, removed the A horizon.

Associated sites

R086AY013TX	**Clayey Bottomland** The Clayey Bottomland site is frequently adjacent to the site. It differs from the site by its occurrence on floodplains, intact A horizon, and high shrink-swell properties.

Similar sites

R086AY008TX	**Northern Eroded Blackland** The Northern Eroded Blackland site is similar to the Southern Eroded Blackland site by having similar physiographic features and representative soil features. It differs from the Northern Eroded Blackland site by receiving less effective precipitation.
R086AY011TX	**Southern Blackland** The Blackland site is similar in that both sites have similar soils and topography. It differs from the site by having an intact A horizon, no rills or gullies, and stable, vegetated drainage ways.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

The site consists of nearly level to gently sloping eroded soils on uplands. The slope gradients range from 1 to 20 percent but are usually less than 12 percent. The runoff class is high to very high. Runoff increases as slope gradient increases.

Table 2. Representative physiographic features

Landforms	(1) Plain (2) Ridge
Flooding frequency	None
Ponding frequency	None
Elevation	249–1,000 ft
Slope	1–20%
Water table depth	72–80 in
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 86A is humid subtropical and is characterized by hot summers, especially in July and August, and relatively mild winters. Tropical maritime air controls the climate during spring, summer and fall. In winter and early spring, frequent surges of Polar Canadian air cause sudden drops in temperatures and add considerable variety to the daily weather. When these cold air masses stagnate and are overrun by moist air from the south, several days of cold, cloudy, and rainy weather follow. Generally, these occasional cold spells are of short duration with rapid clearing following cold frontal passages. The summer months have little variation in day-to-day weather except for occasional thunderstorms that dissipate the afternoon heat. The moderate temperatures in spring and fall are characterized by long periods of sunny skies, mild days, and cool nights. The average relative humidity in mid-afternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time during the summer and 50 percent in winter. The prevailing wind direction is from the south and highest wind speeds occur during the spring months. Rainfall during the spring and summer months generally falls during thunderstorms, and fairly large amounts of rain may fall in a short time. High-intensity rains of short duration are likely to produce rapid runoff almost anytime during the year. The predominantly anticyclonic atmospheric circulation over Texas in summer and the exclusion of cold fronts from North Central Texas result in a decrease in rainfall during midsummer. The amount of rain that falls varies considerably from month-to-month and from year-to-year.

Table 3. Representative climatic features

Frost-free period (average)	244 days
Freeze-free period (average)	276 days
Precipitation total (average)	36 in

Climate stations used

- (1) RED ROCK [USC00417497], Red Rock, TX
- (2) SAN MARCOS [USC00417983], San Marcos, TX
- (3) TAYLOR 1NW [USC00418862], Taylor, TX
- (4) TEMPLE [USC00418910], Temple, TX
- (5) NEW BRAUNFELS [USC00416276], New Braunfels, TX
- (6) SAN ANTONIO 8NNE [USC00417947], San Antonio, TX
- (7) WACO DAM [USC00419417], Waco, TX
- (8) AUSTIN-CAMP MABRY [USW00013958], Austin, TX
- (9) CAMERON [USC00411348], Cameron, TX
- (10) CEDAR CREEK 5 S [USC00411541], Cedar Creek, TX
- (11) GRANGER DAM [USC00413686], Granger, TX
- (12) LULING [USC00415429], Luling, TX
- (13) SAN ANTONIO INTL AP [USW00012921], San Antonio, TX
- (14) AUSTIN BERGSTROM AP [USW00013904], Austin, TX

Influencing water features

This site is not influenced by water from wetlands or streams.

Soil features

The site consists of moderately deep to very deep, well drained soils that are slow to very permeable. These soils formed in weakly consolidated calcareous marine sediments, high in smectitic clays. As such, these soils are comprised of thin clayey surface layers and subsoils depending on the severity of their erosion. Erosion on the site occurs as gently sloping to rolling upland ridges. Uncultivated areas often have narrow microridges and microvalleys that extend up and down the slope.

In a representative profile the surface layer is dark grayish brown or very dark gray clay about 32 inches thick. The subsoil is grayish brown or light yellowish brown clay. These soils formed in calcareous clayey shale. The available water capacity is low to moderate. Infiltration is rapid when the soil is dry and cracked, but very slow when the soil is wet.

The dominant associated soil series for the Eroded Blackland include: Engle, Ellis, Ferris, Heiden, Houston Black, Sumter, and Vertel.

Table 4. Representative soil features

Surface texture	(1) Clay (2) Stony clay (3) Clay loam
Family particle size	(1) Clayey
Drainage class	Well drained
Permeability class	Slow to very slow
Soil depth	24–80 in
Surface fragment cover <=3"	0%

Surface fragment cover >3"	0%
Available water capacity (0-40in)	3–12.4 in
Calcium carbonate equivalent (0-40in)	0–55%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0–12
Soil reaction (1:1 water) (0-40in)	6.1–8.4
Subsurface fragment volume <=3" (Depth not specified)	4–15%
Subsurface fragment volume >3" (Depth not specified)	0–12%

Ecological dynamics

Introduction – The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background – Natural vegetation on the uplands is predominantly tall warm-season perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), eastern gamagrass (*Tripsacum dactyloides*), and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Florida paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsuta*), and dropseeds (Sporobolus spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak (*Quercus virginiana*) and hackberry (Celtis spp.) trees are also native to the region. In some areas, cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), and honey locust (*Gleditsia triacanthos*) are abundant. In the Northern Blackland Prairie oaks (Quercus spp.) are common increasers, but in the Southern Blackland Prairie oaks are less prevalent. Junipers are common invaders, particularly in the northern part of the region.

During the first half of the nineteenth century, row crop agriculture lead to over 80 percent of the original vegetation lost. During the second half, urban development has caused even an even greater decline in the remaining prairie. Today, less than one percent of the original tallgrass prairie remains. The known remaining blocks of intact prairie range from 10 to 2,400 acres. Some areas are public, but many are privately owned and have conservation easements.

Current State – Much of the area is classified as prime farmland and has been converted to cropland. Most areas where native prairie remains have histories of long-term management as native hay pastures. Tallgrasses remain dominant when haying of warm-season grasses is done during the dormant season or before growing points are elevated, meadows are not cut more than once, and the cut area is deferred from grazing until frost.

Due to the current-widespread farming, the Northern Blackland Prairie is still relatively free from the invasion of brush that has occurred in other parts of Texas. In contrast, many of the more sloping have experienced heavy brush encroachment, and the continued increase of brush encroachment is a concern. The shrink-swell and soil cracking characteristics of the soils favor brush species with tolerance for soil movement.

Current Management – Rangeland and pastureland are grazed primarily by beef cattle. Horse numbers are increasing rapidly in the region, and in recent years goat numbers have increased significantly. There are some areas where dairy cattle, poultry, goats, and sheep are locally important. Whitetail deer, wild turkey, bobwhite quail, and dove are the major wildlife species, and hunting leases are a major source of income for many landowners in this area.

Introduced pasture has been established on many acres of old cropland and in areas with deeper soils. Coastal bermudagrass (*Cynodon dactylon*) and kleingrass (*Panicum coloratum*) are by far the most frequently used introduced grasses for forage and hay. Hay has also been harvested from a majority of the prairie remnants, where long-term mowing at the same time of year has possibly changed the relationships of the native species. Cropland is found in the valleys, bottomlands, and deeper upland soils. Wheat (Triticum spp.), oats (Avena spp.), forage and grain sorghum (Sorghum spp.), cotton (Gossypium spp.), and corn (*Zea mays*) are the major crops in the region.

Fire Regimes – The prairies were a disturbance-maintained system. Prior to European settlement (pre-1825), fire and infrequent, but intense, short-duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes - Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases. Wet periods allow tallgrasses to increase in dominance. These natural disturbances cause shifts in the states and communities of the ecological sites.

State and transition model

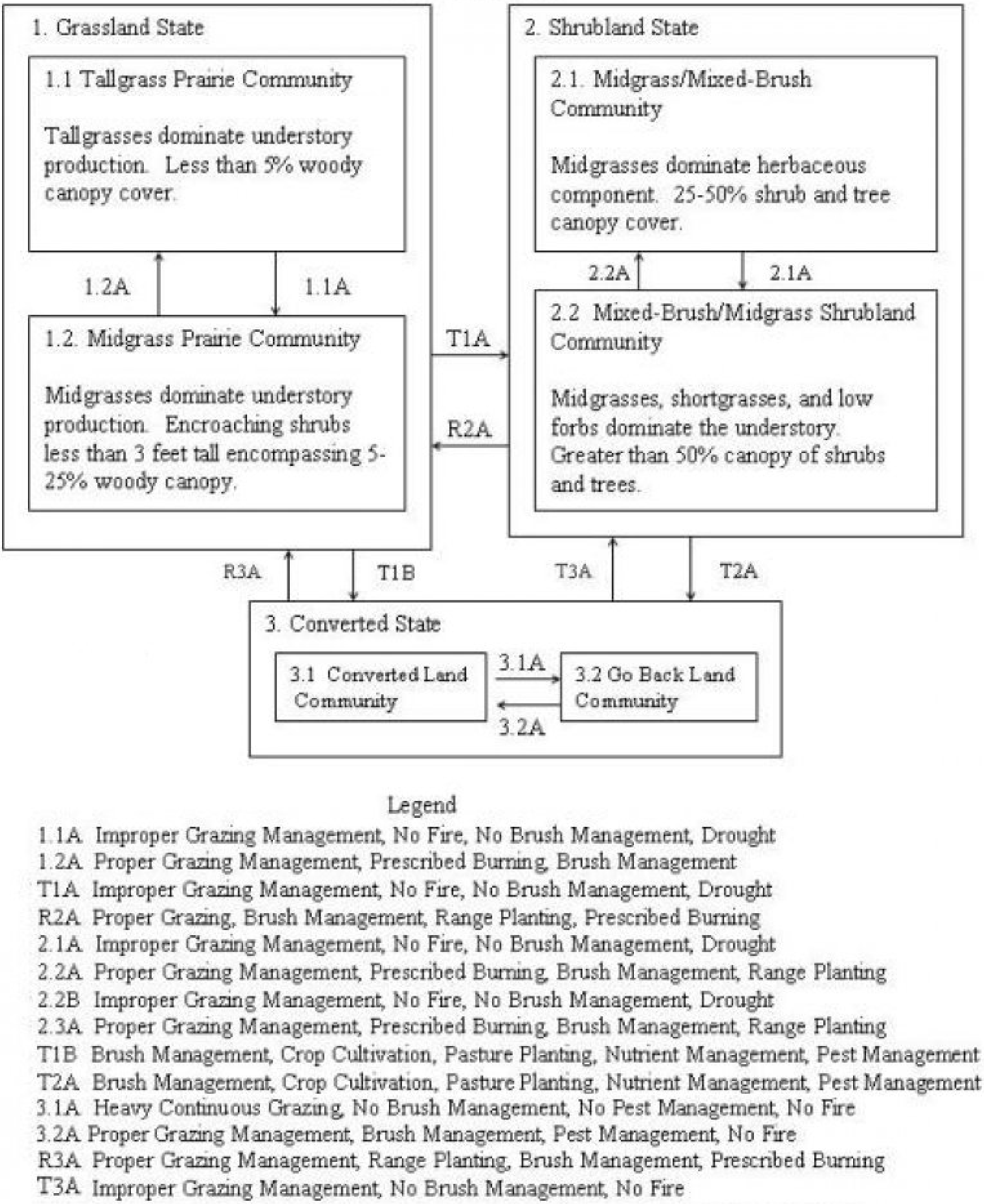

Figure 6. STM

State 1
Grassland

Two communities exist in the Grassland State: the 1.1 Tallgrass Prairie Community and the 1.2 Midgrass Prairie Community. Community 1.1 is characterized by tallgrasses dominating the understory and woody species cover less than five percent of the area. Community 1.2 is characterized by my midgrass dominance, but the woody species cover is 5 to 25 percent, with some species attaining heights of three feet.

Community 1.1
Tallgrass Prairie

The Tallgrass Prairie Plant Community (1.1) mosaic includes deeper soils dominated by warm-season, perennial tallgrasses. Warm-season, perennial midgrasses constitute most of the remaining species composition. The warm-season perennial forb component varies from 5 to 15 percent of the community composition depending on climatic patterns and local precipitation. Woody species make up a minor component of the community even in the absence of fire (at least 25 to 50 years). Midgrasses dominate the shallower “eroded” areas. The eroded area, from which the site derives its name, resulted from prehistoric loss of the A horizon. These areas form a mosaic with deeper soils and may range in size from less than 200 to over 1,000 square feet. These areas often appear to be associated with prehistoric water courses. They appear to be associated more with water erosion than with wind erosion, but are probably a result of a combination of both. Little bluestem dominates the site, while other important grasses are Indiangrass, big bluestem, switchgrass, vine mesquite (*Panicum obtusum*), silver bluestem (*Bothriochloa laguroides*), tall dropseed (*Sporobolus compositus*), and Texas wintergrass. Forbs commonly found on the site include Engelmann’s daisy (*Engelmannia peristenia*), Maximilian sunflower (*Helianthus maximiliani*), and halfshrub sundrop (*Calylophus serrulatus*). Typical, but infrequent shrub and tree species found in the reference community (1.1) include species of bumelia (Sideroxylon spp.), elbowbush (*Forestiera pubescens*), hackberry, elm, and live oak. The reference grassland community will transition to a midgrass-dominated community under the stresses of improper grazing. The first species to decrease in dominance will be the most palatable and/or least grazing tolerant grasses and forbs (Indiangrass, big bluestem, Engelmann’s daisy). This will initially result in an increase in composition of little bluestem, which will increase its dominance. If improper grazing management continues, little bluestem will decrease and midgrasses such as silver bluestem and sideoats grama will increase in composition. Less palatable forbs will increase at this stage. This plant community has very little bare ground. Plant basal cover and litter make up almost 100 percent of the ground cover.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1275	2335	3400
Forb	150	275	400
Shrub/Vine	75	140	200
Total	**1500**	**2750**	**4000**

Community 1.2
Midgrass Prairie

The Midgrass Prairie Plant Community (1.2) typically results from improper cattle grazing management over a long period of time. Indigenous or invading woody species increase on the site (with or without fire). In the Tallgrass Prairie Plant Community (1.1), repeated fires and competition from a vigorous grass component keep woody canopy cover low. When the Midgrass Prairie Plant Community (1.2) is continually overgrazed and fire is excluded, the community crosses a threshold to a state that is dominated by woody plants, the Midgrass/Mixed-Brush Plant Community (2.1). Important grasses are little bluestem, Indiangrass, big bluestem, vine mesquite, silver bluestem, tall dropseed, Texas wintergrass, and switchgrass. More grazing-resistant shortgrasses, such as Texas wintergrass, and less palatable forbs begin replacing the midgrasses. Some of the reference perennial forbs persist, but less palatable forbs will increase. Woody canopy varies between 5 and 15 percent, depending on the severity of grazing, fire interval, and availability of increaser species. Numerous shrub and tree species will encroach because overgrazing by livestock has reduced grass cover, exposed more soil, and reduced grass fuel for fire. Typically, trees such as oaks, elms, hackberry, and hawthorn (Crataegus spp.) will increase in size, while woody species such as bumelia, coralberry (*Symphoricarpos orbiculatus*), elbowbush, and wild plum (Prunus spp.) will increase in density. Brown and Archer (1999) concluded that even with a healthy and dense stand of grasses, woody species will populate the site and eventually dominate the community. To control woody species populations, prescribed grazing and/or browsing and fire can be used to control smaller shrubs and trees. Mechanical removal of larger shrubs and trees may be necessary in older stands. The time frame for woody species to dominate a healthy community with proper grazing management is unknown, but reference sites indicate this will take over 50 years (and possibly hundreds of years). Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to erosion. Some mulch and litter movement may occur during rainstorms, but little soil movement occurs due to gentle slopes in this vegetation type. Litter and mulch will move off-site as plant cover declines. Increasing woody dominants are oaks, juniper, and honey mesquite (prosopis glandulosa). Once the tallgrasses have been eliminated from the site, woody species cover exceeds 5 to 25 percent canopy cover, and the plants reach fire-resistant size (about three feet in height). At this point the site crosses a threshold into the Shrubland State (2) and the Midgrass/Mixed-Brush Plant Community (2.1). Until the Midgrass Prairie Plant Community (1.2) crosses the threshold into the Midgrass/Mixed-Brush Plant Community (2.1), this community can be managed back toward the reference community (1.1) through the use of cultural practices, including prescribed grazing, prescribed burning, and strategic brush control. It may take several years to achieve this state, depending upon climate and the aggressiveness of the manager. Once woody species begin to establish, returning fully to the reference community is difficult, but it is possible to return to a similar plant community. Potential exists for soils to erode to the point that irreversible damage may occur. If soil-holding herbaceous cover decreases to the point that soils are no longer stable, the shrub overstory will not prevent erosion of the A and B soil horizons. This is a critical shift in the ecology of the site. Once the A horizon has eroded, the hydrology, soil chemistry, soil microorganisms, and soil physics are altered to the point where intensive restoration is required to restore the site to another state or community. Simply changing management (improving grazing management or controlling brush) cannot create sufficient change to restore the site within a reasonable time frame.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	975	1875	2775
Tree	195	375	555
Forb	130	250	370
Total	**1300**	**2500**	**3700**

Pathway 1.1A
Community 1.1 to 1.2

Tallgrass Prairie

Midgrass Prairie

The Tallgrass Prairie Plant Community will shift to the Midgrass Prairie Plant Community when there is continued growing season stress on reference grass species. These stresses include insufficient critical growing season deferment, excess defoliation intensity, repeated long-term growing season defoliation, and/or long-term drought. Increaser species (midgrasses and woody species) are generally endemic species released from competition. Woody species canopy exceeding 5 percent and/or dominance of tallgrasses falling below 50 percent of species composition indicate a transition to the Midgrass Plant Community. Implementation of managed grazing that provides adequate growing season deferment to allow establishment of tallgrass propagules and/or the recovery of vigor of stressed individual plants. Proper grazing management may be combined with fire and/or brush management to create a shift towards or maintain the reference community.

Pathway 1.2A
Community 1.2 to 1.1

Midgrass Prairie

Tallgrass Prairie

The Midgrass Prairie Plant Community will return to the Tallgrass Prairie Plant Community under grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity as long as the seedbank or seed source is still present. Favorable moisture conditions will facilitate or accelerate this transition. The understory component may return to dominance by tallgrasses in the absence of fire. However, reduction of the woody component to reference conditions of five percent or less canopy cover will require inputs of fire or brush control.

State 2
Shrubland

The Shrubland State has two communities; 2.1 Midgrass/Mixed-Brush Community and 2.2 Mixed-Brush/Midgrass Shrubland Community. The 2.1 community has a woody species overstory canopy of 25 to 50 percent and the 2.2 community has a woody canopy cover over 50 percent. As tree and brush canopy increases, the herbaceous understory production decreases due to lack of light availability.

Community 2.1
Midgrass/Mixed-Brush

The Midgrass/Mixed-Brush Plant Community (2.1) presents a 25 to 50 percent woody plant canopy, with cedar elm, juniper, and rarely live oak as the dominant species. This community type is the result of continuous improper grazing management and a lack of fire. In areas where high deer densities occur, heavy browsing can decrease preferred woody plants. There is a continued decline in diversity of the grassland component and an increase in woody species and unpalatable forbs. Once the brush canopy exceeds 30 to 35 percent, annual production for the understory is very limited and is generally made up of unpalatable shrubs, grasses, and forbs within tree and shrub interspaces. Annual herbage production has decreased due to a decline in soil structure and organic matter and has shifted toward the woody component. All unpalatable woody species have increased in size and density. Honey mesquite is an early increaser throughout the MLRA. Redberry juniper (*Juniperus pinchotii*) occurs only in the southern counties of the MLRA and eastern redcedar (*Juniperus virginiana*) occurs only in the north. Ashe juniper (*Juniperus ashei*) occurs mostly in the south, but can be found throughout the MLRA. Typically, agarito (*Mahonia trifoliolata*), pricklypear (Opuntia spp.), and sumac (Rhus spp.) form thickets on this site. Many of the reference (1.1) shrubs are still present. Sideoats grama and other reference (1.1) midgrasses decrease, but still remain the dominant component, while shortgrasses such as buffalograss (*Bouteloua dactyloides*) and Texas wintergrass increase. Remnants of the reference (1.1) grasses and forbs along with unpalatable invaders occupy the interspaces between shrubs. Cool-season species such as Texas wintergrass, plus other grazing-resistant reference (1.1) species, can be found under and around woody plants. Plant vigor and productivity of the grassland component is reduced due to grazing pressure and competition for nutrients and water from woody plants. Common herbaceous species include threeawns (Aristida spp.), hairy grama (*Bouteloua hirsuta*), and upright prairie coneflower (*Ratibida columnifera*). Buffalograss, western ragweed (*Ambrosia psilostachya*), and curly-mesquite (*Hilaria belangeri*) are persistent increasers until shrub density reaches maximum canopy. As the grassland vegetation declines, more soil is exposed, leading to crusting and erosion. In this vegetation type, erosion can be severe. Higher rainfall interception losses by the increasing woody canopy combined with evaporation and runoff can reduce the effectiveness of rainfall. Soil organic matter and soil structure decline within the interspaces, but soil conditions improve under the woody plant cover. Some soil loss can occur during rainfall events. Annual primary production is approximately 1,000 to 3,000 pounds per acre. In this plant community, annual production is balanced between herbaceous plants and woody species, with herbaceous production still the dominant component of annual production. Browsing animals such as goats and deer can find fair food value if browse plants have not been grazed excessively. Forage quantity and quality for cattle is low. Unless brush management and good grazing management are applied at this stage, woody species canopy will increase until it exceeds 50 percent, indicating a conversion to the Mixed-Brush/Midgrass Plant Community (2.2). The trend for increased shrub cover cannot be reversed with proper grazing management alone.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	550	1100	1650
Tree	300	600	900
Forb	150	300	450
Total	**1000**	**2000**	**3000**

Community 2.2
Mixed-Brush/Midgrass

The Mixed-Brush/Midgrass Plant Community (2.2) is the result of many years of improper grazing, lack of periodic fires, and/or a lack of proper brush management. Cedar elm, honey mesquite, and/or juniper dominate the Mixed-Brush/Midgrass Plant Community (2.2), which has greater than 50 percent woody canopy cover. It is now essentially a dense shrubland. Common understory shrubs are tasajillo (*Cylindropuntia leptocaulis*), agarito, sumacs, and elbowbush. With continued heavy cattle grazing and/or browsing and no brush control, the trees and shrubs can exceed 70 percent canopy cover, and potentially reach almost 100 percent cover. Excessive browsing by deer or goats will create a community dominated by large trees. Few remnant midgrasses and opportunistic shortgrasses, annuals, and perennial forbs occupy the woody plant interspaces. Characteristic grasses are curly-mesquite, buffalograss, and fall witchgrass (*Digitaria cognata*). Texas wintergrass and annuals are found in and around tree/shrub cover. Grasses and forbs make up 35 percent or less of the annual herbage production. Common forbs include dotted gayfeather (*Liatris punctata*), orange zexmenia (Wedelia texana), croton (Croton spp.), western ragweed, upright prairie coneflower, Mexican sagewort (*Artemisia ludoviciana*), and sensitive-briar (Mimosa spp.). At its most extreme, this community takes on a woodland appearance: large woody species with understory dominated by low production grasses, sedges, and forbs that have low palatability and high shade tolerance. Excessive cattle grazing tends to create a different response and structure to the community than does excessive deer or goat grazing. Excessive grazing accelerates invasion of shrubs because it creates conditions where young shrubs increase in vigor and size while palatable grasses decrease in vigor and abundance. Excess deer or goat grazing tends to create a dominance of large trees by removing both young shrubs and the young twigs and branches that grow below the browse line on larger shrubs and trees. While large trees will continue to increase in size, they will have very little production below the browse line. The site becomes dominated by large trees with little forage available for livestock or wildlife. Large trees with little understory provide much less soil protection than do dense stands of grass. As soils erode, understory species have reduced potential to revegetate the site. The bare area under the browse line creates a situation that provides poor forage conditions and poor visual cover for wildlife. Even if irreversible soil damage has occurred, it may be possible to remove brush and seed the site to a grassland community. The resulting grassland will not look or function like the reference community (1.1). Instead, it is likely to be dominated by few introduced midgrasses and produce less biomass than the reference community (1.1). However, it is very difficult and expensive to restore the site to reference conditions due to the loss of organic matter, soil horizons, soil microbes, and soil structure. Rangeland health functions will depart substantially from reference conditions. The shrub canopy acts to intercept rainfall and increase evapotranspiration losses, creating a more xeric microclimate. Soil fauna and organic mulch are reduced, exposing more of the soil surface to erosion in interspaces. The exposed soil readily forms crusts. However, within the woody canopy, hydrologic processes stabilize, and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. The Mixed-Brush/Shortgrass Plant Community (2.2) provides good habitat cover for wildlife, but only limited forage or browse is available for livestock or wildlife. At this stage, highly intensive restoration practices are needed to return the shrubland to a grassland. Alternatives for restoration include brush control and range planting, with proper stocking, prescribed grazing, and prescribed burning following restoration to maintain the desired community.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	240	600	900
Grass/Grasslike	100	250	375
Forb	60	150	225
Total	**400**	**1000**	**1500**

Pathway 2.1A
Community 2.1 to 2.2

Without fire (natural or human-caused) and/or brush control, woody density and canopy cover will increase in the Midgrass/Mixed-Brush Plant Community until it converts into the Mixed-Brush/Midgrass Plant Community. Improper grazing and/or long-term drought (or other growing season stress) will accelerate this transition. Woody species canopy exceeding 50 percent indicates this transition. Improper grazing or other long-term growing season stress can increase the composition of shortgrasses and low-growing (or unpalatable) forbs in the herbaceous component. Even with proper grazing, in the absence of fire the woody component will increase to the point that the herbaceous component will shift in composition toward shortgrasses and forbs suited to growing in shaded conditions with little available soil moisture.

Pathway 2.2A
Community 2.2 to 2.1

Brush management and/or fire can reduce the woody component below the transition level of 25 percent brush canopy. Continued fire and/or brush management will be required to maintain woody density and canopy below 25 percent. If the herbaceous component has transitioned to shortgrasses and low forbs, proper grazing (combined with favorable moisture conditions) will be necessary to facilitate the shift of the understory component to the midgrass-dominated Midgrass/Mixed-Brush Plant Community. Range planting may accelerate the transition of the herbaceous community, particularly when combined with favorable growing conditions.

State 3
Converted Land

Two communities exist in the Converted State: 3.1 Converted Land Community and the 3.2 Go-Back Land Community. The 3.1 Community is characterized by agricultural production. The site may be planted to improved pasture for hay or grazing. The site may otherwise be planted to row crops. The 3.2 community represents an agricultural state that has not been managed. The land is colonized by first successional species.

Community 3.1
Converted Land

The Converted Land State (3) occurs when the prairie, either the Grassland State (1) or Shrubland State (2), is plowed for planting to cropland, hayland, or tame pasture, or use as non-agricultural land. The Converted State includes cropland, tame pasture, and go-back land. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities in the Converted State. Many or all native species are replaced by seeding crops or introduced species into the plowed soil. The native component of the prairie is usually lost in this state, and even with reseeding, the ecological processes defining the past states of the site can be permanently changed. Common introduced species include coastal Bermudagrass and Kleingrass, which are used in hayland and tame pastures. Wheat, oats, forage sorghum, grain sorghum, cotton, and corn are the major crop species. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. Without agronomic inputs the site will eventually return to either the grassland or shrubland state. The site is considered go-back land during period between active management for pasture or cropland and return to a “native” state. Both crop and pasturelands require weed and shrub control because seeds are present on the site, either by remaining in the soil or being transported to the site. Without agronomic inputs the site will eventually return to either the grassland or shrubland state over the long term due to competitive grass, forb, and shrub species sprouting from seeds. These species are often aggressive weed species. Sites can be restored to the Grassland State in the short term or allowed to return to the Grassland State over the long term. Without active restoration the site is not likely to return to reference conditions due to the introduction of introduced forbs and grasses. Return to native prairie communities in the Grassland state is more likely to be successful if soil chemistry and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference (or near reference) conditions. Restoration to native prairie will require seedbed preparation and seeding of native species. Protocols and plant materials for restoring prairie communities is a developing portion of restoration science. Long-term cropping can create changes in soil chemistry, biology, and structure that make restoration to the reference state very difficult and/or expensive. Heavily disturbed soils return to the Shrubland State. These sites will generally become a mesquite thicket with an understory of “weedy” forbs.

Community 3.2
Go-Back Land

Without agronomic inputs, the site will eventually return to either the Grassland or Shrubland State. The site is considered go-back land when active management for pasture ceases. Heavily disturbed soils usually return to the Shrubland State but could return to a Grassland State if shrub seeds are not present. Long-term cropping creates changes in soil chemistry, microflora and structure that make restoration to the reference state very difficult and/or expensive. Moreover, the residual seedbank is usually depleted depending upon the length of time the site has been in the converted state. Restoration to near native prairie is possible. It will nearly always require seedbed preparation, suppression of shrubs and seeding of native species. Otherwise, it would take a very long time to reestablish from natural processes. Protocols and plant materials for restoring prairie communities are a developing portion of restoration science.

Pathway 3.1A
Community 3.1 to 3.2

The driver for this transition is lack of agricultural management. Without practices to suppress forbs and woody species, the land will eventually grow first successional species. Annual forbs and grasses are common colonizers and first provide ground cover and soil stability. Eventually, woody species will encroach and begin rapid expansion.

Pathway 3.2A
Community 3.2 to 3.1

The driver for this transition is a reestablishment of agricultural management. What the Go-Back Land looks like depends on the prescription. Proper grazing, brush management, herbicides, and/or fire are all potential practices the landowner can use to create more agricultural production on the site.

Transition T1A
State 1 to 2

The Grassland State is resistant to shrub dominance. However, shrubs make up a portion of the plant community in the Grassland State, therefore propagules are present. Even with proper grazing and favorable climate conditions, lack of fire for 25 to 50 years will allow woody species to increase in canopy to reach the 25 percent threshold level. Improper grazing, prolonged drought, and warming climate will provide a competitive advantage to shrubs, which will accelerate this process. Tallgrasses will decrease to less than 5 percent species composition.

Transition T1B
State 1 to 3

The transition to the Converted State from the Grassland State occurs when the prairie is plowed for planting to cropland or hayland. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community.

Restoration pathway R2A
State 2 to 1

Restoration of the Shrubland State to the Grassland State requires substantial energy input. Mechanical or herbicidal brush control treatments can be used to remove woody species. A long-term prescribed fire program may sufficiently reduce brush density to a level below the threshold of the Grassland State, particularly if the woody component is dominated by species that are not fire sprouters (e.g., Ashe juniper). However, fire may not be sufficient to remove mature trees. Brush control in combination with prescribed fire, proper grazing management, and favorable growing conditions may be the most economical means of creating and maintaining the desired plant community. If remnant populations of tallgrasses, midgrasses, and desirable forbs are not present at sufficient levels, range planting will be necessary to restore the reference plant community.

Transition T2A
State 2 to 3

The transition to the Converted State from the Shrubland State occurs when the prairie is plowed for planting to cropland or hayland. The size and density of brush in the Shrubland State will require heavy equipment and energy-intensive practices (e.g. rootplowing, raking, rollerchopping, or heavy disking) to prepare a seedbed. The threshold for this transition is the plowing of the prairie soil and removal of the prairie plant community. The Converted State includes cropland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states. Agronomic practices are used to convert rangeland to the Converted State and to make changes between the communities. The driver for these transitions is management’s decision to farm the site.

Restoration pathway R3A
State 3 to 1

Restoration from the Converted State can occur in the short-term through active restoration or over the long-term due to cessation of agronomic practices. Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State. If the soil chemistry and structure have not been overly disturbed (which is most likely to occur with tame pasture) the site can be restored to the Grassland State. Heavily disturbed soils are more likely to return to the Shrubland State. Without continued disturbance from agriculture the site can eventually return to either the Grassland or Shrubland State. The level of disturbance while in the converted state determines whether the site restoration pathway is likely to be R3A (a return to the Grassland State) or T3A (a return to the Shrubland State). Return to native prairie communities in the Grassland State is more likely to be successful if soil chemistry and structure are not heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions. Converted sites can be returned to the Grassland State through active restoration, including seedbed preparation and seeding of native grass and forb species. Protocols and plant materials for restoring prairie communities are a developing part of restoration science. The driver for both of these restoration pathways is the cessation of agricultural disturbances.

Transition T3A
State 3 to 2

Transition to the Shrubland State (2) occurs with the cessation of agronomic practices. The site will move from the Abandoned Land Community when woody species begin to invade. After shrubs and trees have established over 25 percent, and reached a height greater than three feet, the threshold has been crossed. The driver for the change is lack of agronomic inputs, improper grazing, no brush management, and no fire.

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrasses**			600–1600	
	little bluestem	SCSCS	*Schizachyrium scoparium var. scoparium*	600–1600	–
2	**Tallgrasses**			375–1000	
	big bluestem	ANGE	*Andropogon gerardii*	375–1000	–
	Indiangrass	SONU2	*Sorghastrum nutans*	375–1000	–
	switchgrass	PAVI2	*Panicum virgatum*	200–500	–
3	**Midgrasses**			225–600	
	sideoats grama	BOCU	*Bouteloua curtipendula*	200–500	–

	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	150–400	–
	vine mesquite	PAOB	*Panicum obtusum*	150–400	–
	Drummond's dropseed	SPCOD3	*Sporobolus compositus var. drummondii*	100–300	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	100–300	–
	panicgrass	PANIC	*Panicum*	100–300	–
4	**Other Grasses**			75–200	
	purple threeawn	ARPU9	*Aristida purpurea*	50–150	–
	sedge	CAREX	*Carex*	50–150	–
	Canada wildrye	ELCA4	*Elymus canadensis*	50–150	–
	Virginia wildrye	ELVI3	*Elymus virginicus*	50–150	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	50–150	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	50–150	–
	Florida paspalum	PAFL4	*Paspalum floridanum*	50–150	–
	crowngrass	PASPA2	*Paspalum*	50–150	–
	marsh bristlegrass	SEPA10	*Setaria parviflora*	50–150	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	50–150	–
	slim tridens	TRMUM	*Tridens muticus var. muticus*	50–150	–
Forb					
5	**Forbs**			150–400	
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	150–400	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	150–400	–
	ticktrefoil	DESMO	*Desmodium*	100–350	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	100–350	–
	button eryngo	ERYU	*Eryngium yuccifolium*	100–350	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	100–350	–
	partridge pea	CHFA2	*Chamaecrista fasciculata*	100–350	–
	prairie clover	DALEA	*Dalea*	100–350	–
	fuzzybean	STROP	*Strophostyles*	100–350	–
	sensitive plant	MIMOS	*Mimosa*	100–350	–
	yellow puff	NELU2	*Neptunia lutea*	100–350	–
	beardtongue	PENST	*Penstemon*	100–350	–
	coastal indigo	INMI	*Indigofera miniata*	100–350	–
	dotted blazing star	LIPU	*Liatris punctata*	100–350	–
	scurfpea	PSORA2	*Psoralidium*	100–350	–
	snoutbean	RHYNC2	*Rhynchosia*	100–350	–
	vetch	VICIA	*Vicia*	100–350	–
	skullcap	SCUTE	*Scutellaria*	75–200	–
	Texas lupine	LUTE	*Lupinus texensis*	75–200	–
	woolly plantain	PLPA2	*Plantago patagonica*	75–200	–
	prairie parsley	POLYT	*Polytaenia*	75–200	–
	vervain	VERBE	*Verbena*	75–200	–
	larkspur	DELPH	*Delphinium*	75–200	–

	croton	CROTO	*Croton*	75–200	–
	Indian paintbrush	CASTI2	*Castilleja*	75–200	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	75–200	–
	milkweed	ASCLE	*Asclepias*	75–200	–
	purple poppymallow	CAIN2	*Callirhoe involucrata*	75–200	–
	snow on the prairie	EUBI2	*Euphorbia bicolor*	75–200	–
	beeblossom	GAURA	*Gaura*	75–200	–
	Chalk Hill hymenopappus	HYTE2	*Hymenopappus tenuifolius*	75–200	–
Tree					
6	**Trees, Shrubs, Vines**			75–200	
	oak	QUERC	*Quercus*	75–200	–
	live oak	QUVI	*Quercus virginiana*	75–200	–
	elm	ULMUS	*Ulmus*	50–150	–
	hackberry	CELTI	*Celtis*	50–150	–
	hawthorn	CRATA	*Crataegus*	35–100	–
	stretchberry	FOPU2	*Forestiera pubescens*	35–100	–
	plum	PRUNU	*Prunus*	35–100	–
	bully	SIDER2	*Sideroxylon*	35–100	–
	coralberry	SYOR	*Symphoricarpos orbiculatus*	35–100	–

Animal community

The animal community differs depending on what state the site is currently in. Northern Bobwhite prefer the reference state. They require dense bunchgrasses for nesting and cover. As the site transitions into State 2, white-tailed deer will become more prevalent. Deer are woodland and edge species, with their primary diet consisting of browse. Mourning dove need open areas with semi-clear ground and forbs with desirable seed sources. Go-back land and communities with shortgrasses and forbs provide the best habitat for dove.

Hydrological functions

Site-specific information indicated that rills are not common in the reference community. The extent of rills is influenced by length of slope. This site has potential for gullies to heal, but most often the site has 10 to 20 percent of gullies and rills active, even when in functioning condition. Drainage ways should be vegetated and stable. Some water flow patterns are normal due to landscape position and slope but should be vegetated and stable. Occasional low pedestals or terracettes are expected in association with rills and water flow areas. Expect no more than 5 percent bare ground randomly distributed throughout. This site has slowly permeable soils. Due to density of vegetation, even on sloping sites, small to medium-sized litter will move very little during intense storms. Soil surface under reference conditions is highly resistant to erosion. This prairie site is dominated by tallgrasses and forbs having adequate litter and little bare ground which can provide for maximum infiltration and little runoff under normal rainfall events.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Honey mesquite, juniper (cedar), and some oak are used for posts, firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as agarito, pricklypear, and wild plum. Seeds are harvested from many reference plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants.

Inventory data references

Information presented was derived from the revised Eroded Blackland Range Site, NRCS clipping data, literature, field observations, and personal contacts with range-trained personnel.

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Approval

David Kraft, 5/06/2020

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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)	Lem Creswell, RMS, NRCS, Weatherford, Texas
Contact for lead author	817-596-2865
Date	09/21/2007
Approved by	David Kraft
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

1. **Number and extent of rills:** Rills are not common on this site. Extent is influenced by length of slope.

2. **Presence of water flow patterns:** Some water flow patterns are normal for this site due to landscape position and slope but should be vegetated and stable.

3. **Number and height of erosional pedestals or terracettes:** Occasional low pedestals or terracettes are expected in association with rills and water flow areas.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 30 percent bare ground randomly distributed throughout.

5. **Number of gullies and erosion associated with gullies:** No gullies should be present on side drains into perennial and intermittent streams. Drainageways should be vegetated and stable.

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

7. **Amount of litter movement (describe size and distance expected to travel):** This site has slowly permeable soils.

On sloping sites, small to medium-sized litter will move short distances during intense storms.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface under reference conditions is resistant to erosion. Soil stability class range is expected to be 3 to 5.

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 40 to 60 inches thick. Colors range from olive gray to dark grayish brown having very fine and moderately fine subangular blocky structure. SOM is 1 to 3 percent.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** This site is dominated by tallgrasses and forbs and trees having adequate litter and little bare ground can provide for maximum infiltration and little runoff under normal rainfall events.

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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 tallgrasses >

    Sub-dominant: Warm-season midgrasses > Warm-season shortgrasses >

    Other: Cool-season grasses > Trees > Forbs > Shrubs/Vines

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Grasses due to their growth habit will exhibit some mortality and decadence, though very slight.

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14. **Average percent litter cover (%) and depth (in):** Litter is primarily herbaceous.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1,500 to 4,000 pounds per acre.

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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:** Invasives include yellow bluestems, common Bermudagrass, mesquite, elm, huisache, eastern

red cedar, Macartney rose.

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17. **Perennial plant reproductive capability:** Under reference conditions, all perennial plants should be capable of reproducing, except during periods of prolonged drought conditions, heavy herbivory, and intense wildfires.

USDA Natural Resources Conservation Service

Ecological site R081CY362TX
Steep Adobe 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/26/2022

General information

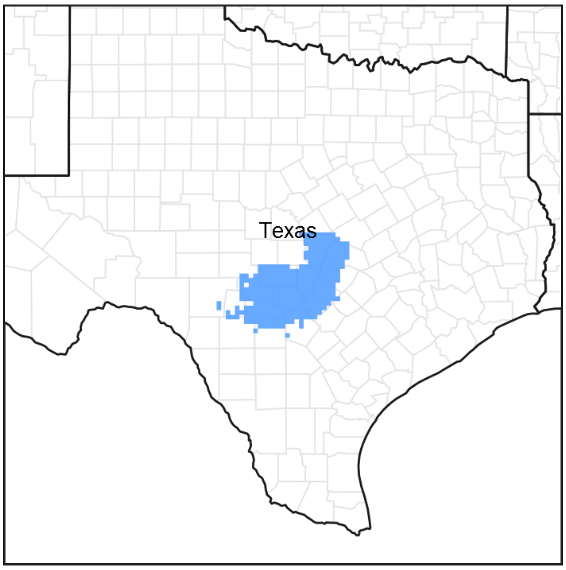

Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. Elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

These sites occur on gravelly clay loam soils on steep slopes. The reference vegetation includes a savannah of live oak and Texas red oak with midgrasses, tallgrasses, forbs and few shrubs. Without periodic fire or other brush management, juniper and other woody species will likely increase across the site.

Associated sites

R081CY355TX	**Adobe 29-35 PZ** The Adobe site has less slope, higher production but less woody plant diversity.
R081CY363TX	**Steep Rocky 29-35 PZ** The Steep Rocky site has larger boulders and has a lower pH.

Similar sites

R081CY363TX	**Steep Rocky 29-35 PZ** The plant communities of Steep Rocky do not have the woody plant diversity as the Steep Adobe site.

Table 1. Dominant plant species

Tree	(1) *Quercus buckleyi* (2) *Quercus fusiformis*
Shrub	Not specified
Herbaceous	(1) *Schizachyrium scoparium* (2) *Muhlenbergia reverchonii*

Physiographic features

This site is located in the 81C, Eastern Edwards Plateau Major Land Resource Area (MLRA). It is classified as an upland site. Slope gradient range from 8 to 60 percent. This site was formed in residuum from weathered limestone. Elevation of this site ranges from 1200 to 2000 feet above mean sea level. This site has a distinctive “bench-like” appearance with “stair-stepping” occurring with the limestone ledges. This is characteristic of the Glen Rose formation.

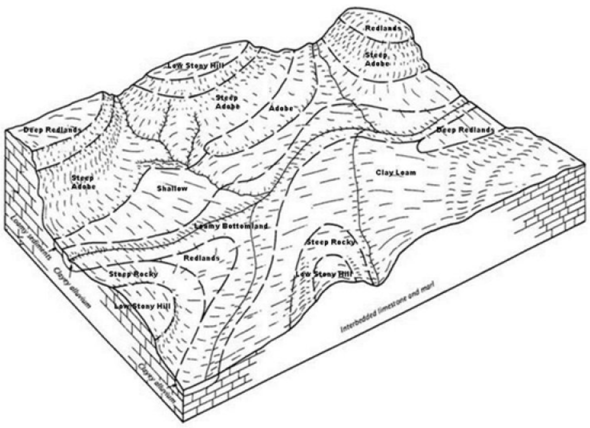

Figure 2. Diagram revealing the landscape position of the St

Table 2. Representative physiographic features

Landforms	(1) Ridge
Flooding frequency	None
Ponding frequency	None
Elevation	1,200–2,200 ft
Slope	8–60%
Ponding depth	0 in
Water table depth	60 in
Aspect	NE, SW

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below “normal” at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This being an upland site, it is not influenced by water from a wetland or a stream. These upland sites may shed some water via runoff during heavy rain events. The presence of good ground cover and deep rooted grasses can help facilitate infiltration and reduce sediment loss.

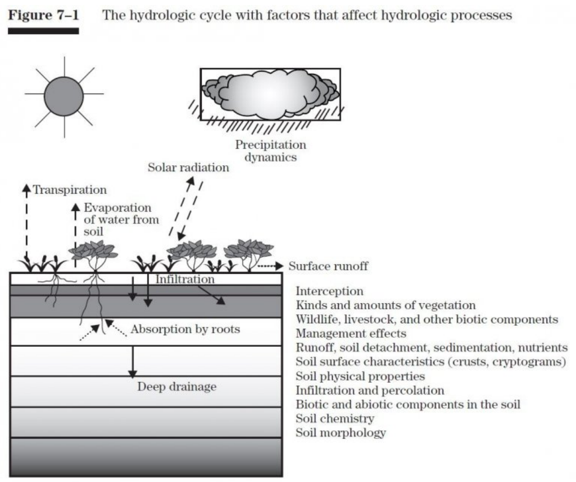

Figure 9.

Soil features

The representative soils of this site are very shallow, shallow, and moderately deep, usually gravelly, light-colored loam and clay loam over soft limestone. Because of slope, runoff is rapid even under good plant cover. In the absence of plant cover and residues, the soils crust readily. The soil formed in residuum over interbedded limestone and marl. These soils are strongly calcareous and have low water holding capacity. For these reasons, the site is droughty. Forage grown on this site is usually low in plant nutrients, especially phosphorus.

In a representative profile, the surface layer is a pale brown gravelly clay loam ranging from 0 to 15 inches in depth. The substratum in the Kerrville Series is 15 to 24 inches of marl with indurated limestone bedrock at 24 to 30 inches. In the Real and Brackett Series, the substratum ranges from 13 to 60 inches of interbedded marl. In these two series, after 20 inches, the potential for hitting indurated limestone bedrock increases with depth.

Most map units contain slopes that are convex and range from 8 percent to 30 percent slopes on Steep Adobe sites. Kerrville and Brackett soils may range from 20 percent to 60 percent. Horizontal outcrops of limestone give the slopes a stair-stepped or benched appearance. Angular limestone pebbles and cobbles are on the surface of some areas. Sites with less than 20 percent slopes are more accessible to vehicle and livestock traffic.

Due to the scale of mapping, there are inclusions of minor components of other soils within these mapping units. Before performing any inventories, conduct a field evaluation to ensure the soils are correct for the site.

The representative soils associated with the Steep Adobe ecological site are Brackett, Kerrville, and Real. These are the representative map units associated with the Steep Adobe ecological site:

Brackett-Real association, hilly
Kerrville-Real association, hilly

Table 4. Representative soil features

Parent material	(1) Residuum–limestone
Surface texture	(1) Clay loam (2) Gravelly clay loam
Drainage class	Well drained
Permeability class	Moderate
Soil depth	6–20 in
Surface fragment cover <=3"	5–25%
Surface fragment cover >3"	0–5%
Available water capacity (0-40in)	0.7–2.4 in

Calcium carbonate equivalent (0-40in)	40–90%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	7.4–8.4
Subsurface fragment volume <=3" (Depth not specified)	5–45%
Subsurface fragment volume >3" (Depth not specified)	0–9%

Ecological dynamics

The reference plant community on the Steep Adobe site is a Texas oak and live oak (*Quercus buckleyi*/*Quercus fusiformis*) Savannah Community. The Texas oak usually occurs in bands perpendicular to the slope. Plants such as little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and sideoats grama (*Bouteloua curtipendula*) dominate the inner spaces. Also prevalent but in smaller amounts are tall grama (Bouteloua pectinata), slim (*Tridens muticus*) and rough tridens (*Tridens muticus* var. elongates), seep muhly (*Muhlenbergia reverchonii*), canyon muhly (Muhlenbergia x involuta), and Lindheimer muhly (*Muhlenbergia lindheimeri*). The historic shrub and tree community comprised as much as a 20 percent canopy consisting of Texas oak, live oak, sumac (Rhus spp.), catclaw (Mimosa spp.), madrone (Arbutus texana), juniper (Juniperus spp.), and other associated species. Numerous forbs such as zexmenia (Wedelia hispida), dalea (Dalea spp.), sundrop (Calylophus spp.), bundleflower (Desmanthus spp.), and gayfeather (Liatris spp.) frequent the site.

Underlying geology, whether it is non-fractured limestone or fractured limestone determines the woody plant composition. (Fractured limestone favors larger and denser trees, whereas non-fractured limestone features shorter woody species and lower densities. The Woodland phase occurred primarily on north slopes).

A study of early photographs of this region reveals that today, these sites are much denser with woody cover and less covered with grasslike vegetation. Early accounts consistently describe this region as a vast expanse of hills covered with "cedar" from San Antonio to Austin. Accounts also describe an abundance of clean, flowing water, and abundant wildlife. These accounts seem to describe heavy wooded areas in mosaic patterns occurring along the highs and lows of the landscape. The shallow soils of the Steep Adobe site are located on the foot slopes of hills in the area. These adobe soils are laid over soft limestone and are predominated by open prairie grassland species in the historic plant community. This site historically became more wooded as slope increased.

The pre-settlement landscape is different than the landscape seen today. Observations and anecdotal records of early settlers and explorers were usually not site specific but do provide insight as to the general appearance of an area. One example is the Teran expedition in 1691 spoke of “great quantities of buffaloes” in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). In the Helotes, Texas area an early settler, Arnold Gugger who wrote in his journal about the mid to late 1800s, “in those days buffaloes were in droves by the hundreds…..and antelopes were three to four hundred in a bunch….and deer, turkeys at any amount (Massey).

The plant communities of this site are dynamic and vary in relation to grazing, fire, and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006).
Many research studies document the interaction of bison grazing and fire (Fuhlendorf, et al., 2008.). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape. Historic herbivory by bison may have been limited on this site because of the nutrient tie-up in the grasses and the slopes.

Fire was a major influence prior to European settlement. Fire occurred from lightning strikes whenever there were accumulations of fuel load and the grass was dry enough to burn. Fires would burn extensively and unrestrained except when rainfall would put it out or there were topographical changes that served as firebreaks. Native Americans also used fire at their discretion. It is estimated that a fire frequency of 3 to 10 years was possible (Frost, 1998). It is presumed that bison were attracted to the post burned areas, leaving unburned areas relatively ungrazed. Over time, the ungrazed areas would accumulate fuel until a random fire would occur. This usually occurs in a dry year following a period of favorable rainfall. A fire/grazing interaction would result in a mosaic of grass/woody species over the landscape depending upon time since the last burn.

Overgrazing with a corresponding reduction of periodic fire has changed these communities and altered the fire regime. Because of the basic topography of this site, contemporary grazing by cattle is less than on flatter more accessible sites. However, this site is accessible to grazing from animals such as deer, sheep, and goats.

Slope and geologic structure played a major role in the type, formation, and composition of the woody plant community. On flatter slopes (12 to 20 percent) soils are deeper, grass cover was better, and fire occurred more frequently than on steeper and rockier slopes which ranged from 20 to 60 percent. When fires did occur on the steeper slopes, they may have occurred more often on the southern slopes since predominant winds in this area are from the south. The presence of limestone escarpments (benches) running on contour to the slope often slowed or stopped less intensive fires and resulting in mosaic vegetative patterns. Periodic fires set either by Native Americans or by lighting kept oaks (Quercus spp.), Ashe juniper (*Juniperus ashei*), prairie sumac (*Rhus copallinum*), and other woody species suppressed and confined to protected areas. The structure of the trees was probably somewhat different historically than the contemporary structure as live oak takes on a more “thicketized” growth form than a tree form under a fire regime.

Ashe juniper will increase regardless of grazing. Juniper will establish with grazing and without unless goats are utilized. Goat and probably sheep will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997; Anderson et al., 2013). The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn. Ashe juniper is a non-resprouting species.

Small areas may exhibit water seepage or spring flow following long periods of rainfall because of small underground water-filled cavities slowly draining through the fractured rock and soil profile from the upper elevation. The muhly (Muhlenbergia spp.) grass species may dominate the seep areas. Some Eastern gamagrass will add to the mosaic pattern of the site.

Heavy continuous grazing by sheep, goats, and deer reduces the palatable forbs and browse plants. Low successional, unpalatable grasses, forbs, and shrubs have taken the place of the more desirable plant species over much of the sites’ range. The diversity of native forbs and grasses for this site are potentially greater than on the more accessible flatter slopes should proper management occur. Because of this plant diversity, no attempt in this document is made to list them all. The major key plants, however, are listed.

The screwworm fly (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker, 1965; Bushland, 1985).

Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition, and monitoring of habitat quality has been effective in managing the deer herd on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of non-indigenous (exotic) ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium- and small-sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity.

A State and Transition Model for the Steep Adobe Ecological Site (R081CY362TX) is depicted in this report. Descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases.

Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal. Other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are described as are other metrics. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover can drive the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

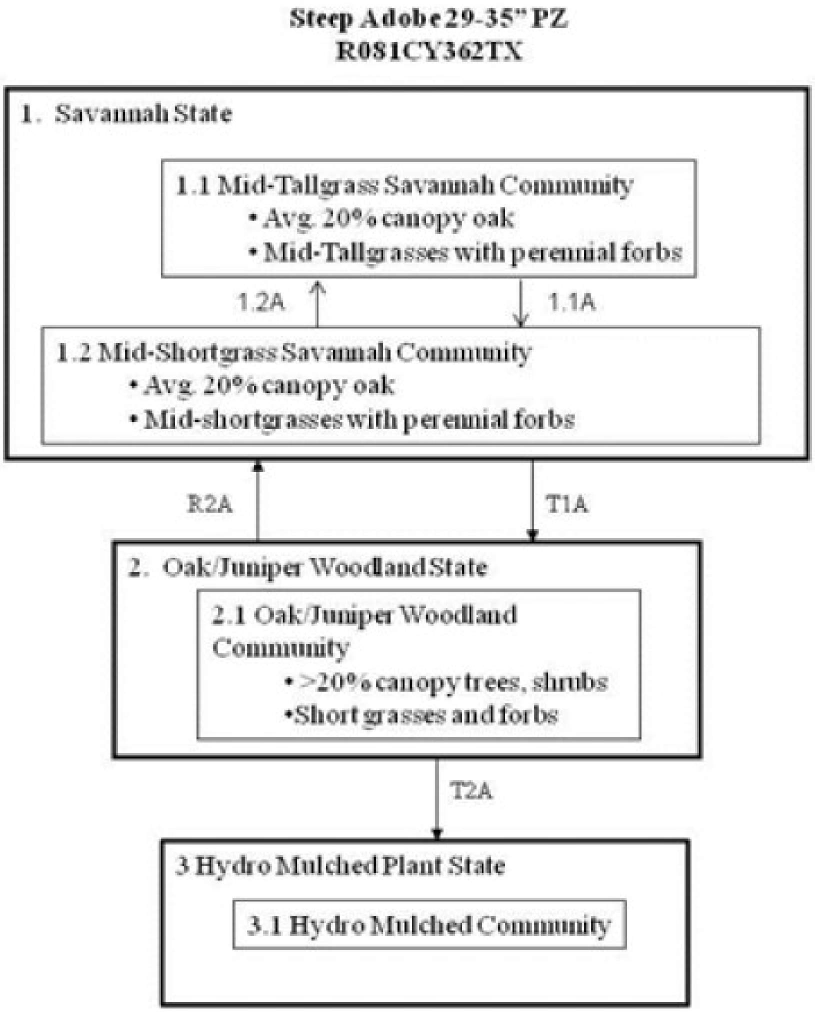

Figure 10. A State and Transition Model for the Steep Adobe E

State 1
Savannah State

The reference state is a Mid and Tallgrass Savannah plant community.

Community 1.1
Mid-Tallgrass Savannah Community

Figure 11. Steep Adobe ecological site. Kendall County, Texas

Figure 12. 1.1 Mid-Tallgrass Savannah Community

Figure 13. 1.1 Mid-Tallgrass Community (2)

The Mid-Tallgrass Savannah (1.1) will be the reference community as it is perceived to have been the most extensive community. The data for this community is derived from old range site descriptions, professional consensus, and professional interpretation of collected data. This community is composed of mid and tall grasses plus scattered live oaks, Texas oaks, shrubs, forbs, and juniper. Percent canopy for this site is variable depending on the geologic formations which influence vegetation types. The overstory canopy may average about 20 percent for the site, with isolated areas being very dense and others being very open. Common woody species will be live oak, Texas oak, Ashe juniper, Bigelow oak (*Quercus sinuata* var. breviloba), sumac walnut (Juglans spp.), madrone, and several associated species. Tall and mid grasses dominate the open areas throughout the site while far less herbaceous cover may exist in the shrub and tree community. Because of slope direction and exposure, woody species will vary. For example, Lacey (*Quercus laceyi*), Bigelow oak, and Ashe juniper are found more on the north facing slopes while the drier shrubland or thinner woody species occurs on the south facing slopes. Some seeps or spring flow would be present to add to the mosaic pattern of the site. Periodic fires and limited grazing by bison and other herbivores were natural processes that maintained this mosaic plant community. When species such as little bluestem, Indiangrass, sideoats grama, and Engelmann daisy (*Engelmannia peristenia*) are grazed out of the plant community, herbaceous species are replaced by Wright's threeawn (Aristida wrightii), canyon and seep muhly, and Ashe juniper. If heavy grazing continues for many years, retrogression of the plant community will occur and species such as Ashe juniper and other low succession species will increase. With no brush control and continued overgrazing, all palatable plants will disappear and juniper and oaks will dominate the site. It should be noted that Ashe juniper will also increase independently of grazing as its seeds are spread by birds and other animals. Ashe juniper (which originally occurred as a mosaic along more protected rocky, craggy outcrops on the steeper portions of the side where it was protected from historic fires) may increase to form a dense canopy and will suppress other vegetation. Soil, plant, and watershed health indicators are negatively impacted when the site is allowed to deteriorate. The integrity of the Reference Plant Community can be maintained with a few management practices. Brush control, proper stocking rates, and deferments can allow the site to respond positively relative to plant and soil health. Hand cutting of juniper and/or prescribed burning are examples of viable practices for the flatter slopes of this site. Individual Plant Treatment (IPT) alternatives are other options which may be effective. The Reference Plant community is a stable community with sunlight energy cycling through several functional groups such as warm season grasses, cool season grasses, trees, and shrubs. Erosion does occur naturally along steeper drains but for the most part, the site is stable.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	600	810	1680
Tree	200	360	560
Shrub/Vine	150	270	420
Forb	50	100	140
Total	**1000**	**1540**	**2800**

Table 6. Ground cover

Tree foliar cover	15-25%
Shrub/vine/liana foliar cover	3-8%
Grass/grasslike foliar cover	10-25%
Forb foliar cover	1-5%
Non-vascular plants	0%
Biological crusts	0%
Litter	55-65%
Surface fragments >0.25" and <=3"	5-25%
Surface fragments >3"	0%
Bedrock	1-5%
Water	0%
Bare ground	0-5%

Table 7. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-10%	0-1%
>0.5 <= 1	–	1-3%	1-15%	1-3%
>1 <= 2	–	5-8%	10-15%	3-5%
>2 <= 4.5	–	3-5%	50-60%	–
>4.5 <= 13	10-20%	–	–	–
>13 <= 40	15-25%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 15. Plant community growth curve (percent production by month). TX3622, Mid and Shortgrass Savannah, 10% canopy. Mid and shortgrasses dominate the site with less than 20 percent forbs, shrubs, and woody plants..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	3	5	13	23	15	4	5	15	7	5	3

Community 1.2
Mid-Shortgrass Savannah Community

Figure 16. 2009 Steep Adobe ecological site, along Scenic Loo

Figure 17. . 2013 Steep Adobe ecological site, along Scenic L

Figure 18. Steep Adobe ecological site, revealing a pocket of

Figure 19. . 2009 Steep Adobe ecological site, along Scenic

Figure 20. 2013 Steep Adobe ecological site, along Scenic Loo

The data for this plant community was derived from limited field data collection and professional consensus. The Mid-Shortgrass Savannah Community (1.2) still resembles the Mid-Tallgrass Savannah Community (1.1) plant structure to the casual observer. However, this community represents a decline of the previously dominate mid and tall grasses and perennial forbs and palatable shrubs. There are still some remnants of historic plants such as little bluestem, sideoats grama, dropseeds, perennial forbs, and shrubs. Less palatable annual and perennial forbs increase. Shrub canopy has slightly increased overall but has a higher proportion of less palatable species. Driving this shift is the suppression of fire. Because of the steepness of this site and the surface rock, cattle accessibility is limited. Sheep, goats, and browsing wildlife species are more suited to this site. Overgrazing/browsing can contribute to loss of fuel which results in long term fire suppression. Droughts, of course, will accelerate the shift. Again, the non-fractured geology produces somewhat shorter vegetation with lighter densities than fractured sites. More Ashe juniper plants (small plants, many times occurring under oak trees) are apparent as are some occasional scrubby mesquite seedlings. The Ashe juniper, which originally occurred in small amounts among the rocky, stepped, craggy outcrops are beginning to form a canopy which suppresses other vegetation. Grasslike vegetation is significantly reduced because of the competition for sunlight and moisture that Ashe juniper and other woody species rob. Improper grazing/browsing management also contributes to a loss of high successional species and allows invaders or lower successional species to proliferate. However, as woody canopy cover increase to maximum cover, cedar sedge will usually be one of the last existing plants before the soil becomes bare of grasslike vegetation and is covered with a thick mat of woody vegetation leaves and juniper duff. The photos show a community at risk of crossing a threshold. Notice the juniper growing underneath the live oak thickets and in the openings. At this stage, juniper and other brush species can still be managed with a relatively low input type of practice such as fire and individual plant treatment. In a short time, the juniper will have grown to the height and density that low input type of management is no longer an option. Photo 5 shows the beginning of juniper encroachment within a pocket of sotol. The hydrology of this site is changing as the canopy of woody plants is entrapping more rainfall and the lack of herbaceous cover is retaining less rainfall for infiltration. Seeps and/or spring flows are showing reduction accordingly. This plant community can be restored to something resembling the Mid-Tallgrass because some of the historic plants remain in a low vigor state. Prescribed grazing along with the use of prescribed burning and possible some Individual Plant Treatment type of brush management can restore the site. Prescribed burning will be effective until juniper exceeds about 4 feet in height. Continued maintenance will be needed on a 3- to 8-year basis to prevent the juniper from coming back.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	450	810	1260
Tree	250	450	700
Shrub/Vine	200	360	560
Forb	100	180	280
Total	**1000**	**1800**	**2800**

Table 9. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	0%
Grass/grasslike foliar cover	0%
Forb foliar cover	0%
Non-vascular plants	0%
Biological crusts	0%
Litter	40-60%
Surface fragments >0.25" and <=3"	5-25%
Surface fragments >3"	0%
Bedrock	0-10%
Water	0%
Bare ground	0-5%

Table 10. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	–	1-10%	0-1%
>0.5 <= 1	–	1-3%	1-15%	1-3%
>1 <= 2	–	5-8%	10-15%	3-5%
>2 <= 4.5	–	5-15%	20-50%	–
>4.5 <= 13	10-15%	–	–	–
>13 <= 40	10-25%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 22. Plant community growth curve (percent production by month). TX3622, Mid and Shortgrass Savannah, 10% canopy. Mid and shortgrasses dominate the site with less than 20 percent forbs, shrubs, and woody plants..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	3	5	13	23	15	4	5	15	7	5	3

Pathway 1.1A
Community 1.1 to 1.2

Mid-Tallgrass Savannah Community

Mid-Shortgrass Savannah Community

The shift from the Mid-Tallgrass community (1.1) to a Mid-Shortgrass Community (1.2) is driven primarily by a lack of periodic burning. Overgrazing can contribute to the shift by removing fuel load and removing a healthy, competitive grass cover.

Pathway 1.2A
Community 1.2 to 1.1

Mid-Shortgrass Savannah Community

Mid-Tallgrass Savannah Community

The shift back to a Mid-Tallgrass Community (1.1) can be achieved by prescribed grazing, periodic fires, and possibly some Individual Plant Treatment to manage small shrubs.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 2

Oak/Juniper Woodland State

The Oak/Juniper Woodland state has juniper and oak as co-dominates.

Community 2.1
Oak/Juniper Woodland Community

Figure 23. 2.1 Oak/Juniper Woodland Community

Figure 24. Steep Adobe ecological site, along Toutant Beaureg

Figure 25. Steep Adobe ecological site. Brackett Soil.

Figure 26. Steep Adobe ecological site. Brackett Soil

Figure 27. Steep Adobe ecological site. Brackett Soil

Figure 28. Steep Adobe ecological site

Figure 29. Steep Adobe ecological site. Brackett Soil.

The description of this plant community comes from old range site descriptions and some professional interpretation of field data. In the Oak/Juniper Woodland Community (2.1) a threshold has been crossed whereby it will take major inputs and mechanical energy to restore the site back to a Savannah State (1). Many open areas that were once tall or mid-grass communities are now covered with woody species such as Ashe juniper and live oak. There can still be remnants of Texas madrone, blackcherry (*Prunus serotina*), and walnut. Shrubs commonly growing in the area are Texas kidneywood (*Eysenhardtia texana*), sumac (Rhus spp.), algerita (Mahonia trifoliata), Texas persimmon (*Diospyros texana*), elbowbush (*Forestiera pubescens*), sotol, prickly ash, and hawthorn species (Crataegus spp.). The historically dominate grasses are being replaced by Wright's threeawn, hairy grama, red grama, cedar sedge (*Carex planostachys*), hairy tridens (*Erioneuron pilosum*), and other short grasses There is a complete shift in the hydrologic and mineral cycling. The juniper entraps more than 25 percent (Thurow, 1997) of the annual rainfall. The lack of herbaceous vegetation absorbs little of the rainfall and the runoff is beginning to carry some sediments, although some erosion is probably geologic. This is a harsh site and once the site reaches this stage, it is difficult to restore. Proper gazing management alone will not restore this community. Where slopes will permit, selective brush control measures such as hand cutting followed by necessary deferments and possibly seeding can shift the community towards a grassland/woodland mosaic community. The elimination of infrequent wildfires plus the lack of brush management has allowed Ashe juniper and other woody species to overtake this site. Any ground disturbance type brush management may trigger some amounts of willow baccharis (*Baccharis salicina*).

Table 11. Annual production by plant type

Plant Type	**Low (Lb/Acre)**	**Representative Value (Lb/Acre)**	**High (Lb/Acre)**
Tree	600	1080	1680
Shrub/Vine	300	540	740
Forb	50	90	140
Grass/Grasslike	50	90	140
Total	**1000**	**1800**	**2700**

Table 12. Soil surface cover

Tree basal cover	0-5%
Shrub/vine/liana basal cover	0-1%
Grass/grasslike basal cover	0-5%
Forb basal cover	0-3%
Non-vascular plants	0%
Biological crusts	0-5%
Litter	30-85%
Surface fragments >0.25" and <=3"	5-45%

Surface fragments >3"	5-15%
Bedrock	2-5%
Water	0%
Bare ground	0-5%

Table 13. Canopy structure (% cover)

Height Above Ground (Ft)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.5	–	0-5%	0-10%	0-5%
>0.5 <= 1	–	0-5%	0-10%	0-10%
>1 <= 2	–	0-5%	0-5%	0%
>2 <= 4.5	5-15%	5-15%	–	–
>4.5 <= 13	10-50%	–	–	–
>13 <= 40	50-25%	–	–	–
>40 <= 80	–	–	–	–
>80 <= 120	–	–	–	–
>120	–	–	–	–

Figure 31. Plant community growth curve (percent production by month). TX3778, Oak/Juniper Woodland Community. Oak/Juniper Hillside Community.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	7	13	20	15	7	5	10	7	5	5

State 3
Mulched State

The Mulched State results from heavy equipment reducing thick stands to varying degrees of surface mulch.

Community 3.1
Mulched Community

Figure 32. Steep Adobe ecological site. Brackett Soil.

Figure 33. . Steep Adobe ecological site. Brackett Soil

This plant community is a result of using mechanical mulching to reduce canopy and structure of dense woody species which is usually juniper. The objective of this treatment is to facilitate the movement of people in the landscape and to provide protective ground cover. The amounts of mulch on the ground and the orientation of the mulch are dependent upon the amount of woody cover treated and the time since treatment. The mulch tends to settle over time and is very resistant to deterioration. This community can structurally appear very similar to the reference plant community but without the herbaceous cover. The understanding of how this plant community reacts over time is unknown but studies are currently underway to monitor. One result is that the soil is protected for a long time. There will be a need for maintenance to treat juniper and other species as they re-establish.

Table 14. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1530	1870	2720
Shrub/Vine	90	110	160
Forb	90	110	160
Grass/Grasslike	54	66	96
Total	**1764**	**2156**	**3136**

Transition T1A
State 1 to 2

This Transition reflects the crossing of a threshold into a different vegetative state. This transition is driven by a lack of fire, no brush management and no prescribed grazing.

Restoration pathway R2A
State 2 to 1

The Recovery to the Savannah State is driven by significant inputs of energy from equipment such as skid loaders, bulldozers or other brush management equipment. Slope and rockiness will preclude some equipment. Only hand equipment can be used on the steeper slopes. Usually at this state, prescribed fire is a high risk option.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

Transition T2A
State 2 to 1

Mechanical conversion of primarily juniper canopy to a mulch cover restores the energy flow to the remaining species, usually oak. The hydrologic cycle retains nearly all the rainfall because of the heavy mulch. Little evaporation takes place.

Restoration pathway R2A
State 2 to 1

The recovery to the Savannah State is driven by significant inputs of energy from equipment such as skid loaders, bulldozers, or other brush management equipment. Slope and rockiness will preclude some equipment. Only hand equipment can be used on the steeper slopes. Usually at this state, prescribed fire is a high risk option.

Conservation practices

Brush Management

Transition T
State 2 to 3

Additional community tables

Table 15. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tallgrass**			600–800	
	little bluestem	SCSC	*Schizachyrium scoparium*	100–450	–
	Indiangrass	SONU2	*Sorghastrum nutans*	100–300	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	0–300	–
	big bluestem	ANGE	*Andropogon gerardii*	100–300	–
2	**Midgrasses**			100–150	
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	25–100	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	50–100	–
	tall grama	BOHIP	*Bouteloua hirsuta var. pectinata*	50–100	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	50–100	–
	slim tridens	TRMU	*Tridens muticus*	25–75	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	25–75	–
	threeawn	ARIST	*Aristida*	25–75	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	25–75	–
	Reverchon's bristlegrass	SERE3	*Setaria reverchonii*	25–50	–
3	**MId Grasses**			100–175	
	muhly	MUIN	*Muhlenbergia ×involuta*	50–150	–
	Lindheimer's muhly	MULI	*Muhlenbergia lindheimeri*	50–150	–
	seep muhly	MURE2	*Muhlenbergia reverchonii*	50–150	–
4	**Cool Season Grasses and Grasslikes**			30–50	
	cedar sedge	CAPL3	*Carex planostachys*	25–50	–
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	25–50	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	25–50	–
Forb					

Forb					
5	**Forbs**			50–100	
	awnless bushsunflower	SICA7	*Simsia calva*	50–100	–
	queen's-delight	STSY	*Stillingia sylvatica*	50–100	–
	Indian mallow	ABUTI	*Abutilon*	50–100	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	50–100	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	50–100	–
	Berlandier's sundrops	CABE6	*Calylophus berlandieri*	50–100	–
	prairie clover	DALEA	*Dalea*	50–100	–
	zarzabacoa comun	DEIN3	*Desmodium incanum*	50–100	–
	bundleflower	DESMA	*Desmanthus*	50–100	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	50–100	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	50–100	–
	eastern milkpea	GARE2	*Galactia regularis*	50–100	–
	Chalk Hill hymenopappus	HYTE2	*Hymenopappus tenuifolius*	50–100	–
	trailing krameria	KRLA	*Krameria lanceolata*	50–100	–
	dotted blazing star	LIPU	*Liatris punctata*	50–100	–
	hoary blackfoot	MECI	*Melampodium cinereum*	50–100	–
	showy menodora	MELO2	*Menodora longiflora*	25–100	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	50–100	–
	narrowleaf Indian breadroot	PELI10	*Pediomelum linearifolium*	50–100	–
	snoutbean	RHYNC2	*Rhynchosia*	50–100	–
	wild petunia	RUELL	*Ruellia*	20–75	–
	smartweed leaf-flower	PHPO3	*Phyllanthus polygonoides*	20–75	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	5–50	–
6	**Annual Forbs**			1	
	prairie broomweed	AMDR	*Amphiachyris dracunculoides*	0–1	–
Shrub/Vine					
7	**Shrubs and Vines**			75–270	
	eastern redbud	CECA4	*Cercis canadensis*	50–100	–
	fragrant sumac	RHAR4	*Rhus aromatica*	50–100	–
	winged sumac	RHCO	*Rhus copallinum*	50–100	–
	evergreen sumac	RHVI3	*Rhus virens*	50–100	–
	gum bully	SILAO	*Sideroxylon lanuginosum ssp. oblongifolium*	50–100	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	50–100	–
	mescal bean	SOSE3	*Sophora secundiflora*	50–100	–
	Eve's necklacepod	STAF4	*Styphnolobium affine*	50–100	–
	grape	VITIS	*Vitis*	15–50	–
	twistleaf yucca	YUPA	*Yucca pallida*	15–50	–
	stretchberry	FOPU2	*Forestiera pubescens*	15–50	–
	Texas barometer bush	LEFR3	*Leucophyllum frutescens*	0–50	–
	algerita	MATR3	*Mahonia trifoliolata*	15–50	–

	scarlet monkeyflower	MICA3	*Mimulus cardinalis*	15–50	–
	Texas sacahuista	NOTE	*Nolina texana*	15–50	–
	roundleaf greenbrier	SMRO	*Smilax rotundifolia*	15–50	–
	American smoketree	COOB2	*Cotinus obovatus*	0–50	–
	Texas sotol	DATE3	*Dasylirion texanum*	0–50	–
	Texas persimmon	DITE3	*Diospyros texana*	15–50	–
	jointfir	EPHED	*Ephedra*	15–50	–
Tree					
8	**Trees**			100–360	
	Texas live oak	QUFU	*Quercus fusiformis*	100–300	–
	bastard oak	QUSIB	*Quercus sinuata var. breviloba*	100–300	–
	Nuttall oak	QUTE	*Quercus texana*	100–300	–
	Texas madrone	ARXA80	*Arbutus xalapensis*	0–200	–
	hackberry	CELTI	*Celtis*	50–200	–
	Ashe's juniper	JUAS	*Juniperus ashei*	50–150	–
	Lacey oak	QULA	*Quercus laceyi*	0–100	–
	elm	ULMUS	*Ulmus*	25–50	–
	littleleaf leadtree	LERE5	*Leucaena retusa*	25–50	–

Animal community

The site is somewhat accessible to use by cattle but is more accessible to deer, sheep, Angora goats, and meat goats. Global Positioning Systems studies reveal slopes above 11 percent are generally less accessible to cattle while sheep and goats can utilize slopes up to 45 percent. Also revealed is that cattle will avoid a site once it contains about 30 percent surface rocks. (Hanselka, et al., 2009)

Wildlife species which utilize this site for at least a part of their habitat needs are white-tailed deer, raccoon, cottontail rabbit, jackrabbit, Rio Grande turkey, bob-white quail, mourning dove, mountain lion, bobcat, and exotic wildlife species. A large diversity of wildlife is native to this steep site. Sheep and goats were formerly raised in large numbers and are still present in reduced numbers.

An assessment of current vegetation is needed to determine stocking rates. Traditional regional average stocking rates should not be used and can be misleading. Wildlife species should be assessed when calculating carrying capacity.

With the eradication of the screwworm fly in the 1960s, the increase in woody vegetation and insufficient natural predation, white-tailed deer numbers have increased drastically and are often in excess of carrying capacity. Where deer, goats, sheep, and possibly cattle numbers are excessive, overbrowsing and overuse of preferred forbs causes further deterioration of the plant community. Management of deer populations is needed to keep populations in balance. Achieving a balance between woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep, and goats can cause damage to preferred vegetation and is an important consideration in livestock and wildlife management. Maintaining cover structure and food for wildlife on theses steeper slopes is extremely important to the wildlife ecology of this site and associated sites below or above.

A diversity of birds is found on this site including game birds, songbirds, and birds of prey. The different species of songbirds vary in their habitat preferences. In general, a habitat that provides a large variety of grasses, forbs, shrubs, vines, and trees and a complex of grassland, savannah, shrubland, and woodland 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. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow and red deer, aoudad sheep, and blackbuck antelope. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. Feral hogs are present and can cause damage when their numbers are not managed.

Hydrological functions

The soils on this site are well drained with very low water holding capacity. Surface runoff is very rapid causing water erosion because of the slope of the site. The water cycle on this site functions according to the existing plant community and the management of the plant community. The water cycle is most functional when the site is dominated by tall bunchgrass. Increased infiltration, soil organic matter, good soil structure and moderate porosity are present with a good cover of bunchgrass. Quality of surface runoff will be high and erosion and sedimentation rates will be low.

When there are periods of heavy rainfall where the amount of rainfall exceeds the plant covers capacity to retain it or utilize it, some water will move below the root zone of grasses into the limestone fractures. As water moves down below the root zone of the plants, it can contribute to the recharge of some aquifers. Any runoff from such a rainfall event will move downstream and collect in drainage ways. If these drains have geological features with fractures, karst, fissures, and sinkholes then recharge can occur.

Since this site is naturally more wooded than most, it functions well hydrologically as a woodland. Infiltration under mature woodland canopy is high, because of very good litter layer and stem flow, which directs a high percent of rainfall to the trunk where it soaks directly into fractures. Once the site becomes an Oak/Juniper Woodland State (2), a significant portion of received rainfall is caught in the leaves and branches of juniper where it evaporates before it can enter the soil. This interception loss has been measured as high as 36 percent of the rainfall. Heavy juniper litter has been measured to entrap as much as 43 percent of the rainfall (Thurow, et al., 1997).

When abusive grazing causes loss or reduction of bunchgrass and ground cover, the water cycle becomes impaired. Infiltration is decreased and runoff is increased because of poor ground cover, exposure to rainfall splash, soil capping, low organic matter, and poor structure. With a combination of a sparse ground cover, excessive slopes, and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed if management is inappropriate. Soil erosion is accelerated, quality of surface runoff is poor and sedimentation increased.

The full impact upon the site when hydro mulched is not fully understood and studies are underway to gain knowledge. However, most rainfall is held on the land with little or no erosion. Plants that do stick up through the mulch are of higher production that non-mulched areas because of the moisture conservation. It will take many years for the mulch to break down depending upon the thickness.

Recreational uses

This site has a high potential for recreational use because of the diversity of wildlife, which can inhabit the site. The tall and mid grasses and scattered oaks produce beautiful fall color variations. Many native plants valuable for landscaping may be found on sites nearer to the reference community. This site is used for hunting, hiking, birding and other nature tourism-related enterprises.

Wood products

Oaks and Ashe juniper may be used for firewood, fencing material, and/or in the specialty wood industry.

Other products

None.

Other information

This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition and diet overlap between kinds of herbivores. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. An animal’s preference or avoidance of certain plants is learned over time through grazing experience and maternal learning (http://extension.usu.edu/behave/Grazing). Preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food are rated. Refer to detailed habitat guides for a more complete description of a species habitat needs.

Legend
Rating Preference Description
P Preferred Percentage of plant in animal diet is greater than it occurs on the land
D Desirable Percentage of plant in animal diet similar to the percentage composition on the land
U Undesirable Percentage of plant in animal diet is less than it occurs on the land
N Not Consumed Plant would not be eaten under normal conditions. It is only consumed when other forages are not available
T Toxic Rare occurrence in diet and, if consumed in any tangible amounts results in death or severe illness in animal
X Used Degree of utilization unknown

Inventory data references

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

Other references

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Approval

David Kraft, 9/20/2019

Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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)	Joe Franklin, Zone RMS, NRCS, San Angelo, Texas
Contact for lead author	325-944-0147
Date	07/08/2009
Approved by	Colin Walden
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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2. **Presence of water flow patterns:** None, except following extremely high intensity storms where short flow patterns may appear.

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3. **Number and height of erosional pedestals or terracettes:** Rare, but could exist in the shallow soil areas.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** Expect no more than 10-15% bare ground randomly distributed throughout in small and non-connected areas.

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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):** Minimal and short, less than one foot.

---

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface for Refernce Community is resistant to erosion. Biological crusts and Nostoc, a blue green algae is common. Stability class range expected to be 5-6.

---

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface is light brownish gray gravelly clay loam with limestone moderately fine subangular blocky structure on the surface. Hard, firm, sticky. 15% limestone frags, SOM is approximately 0-3%. See Soil Survey for specific soils.

---

10. **Effect of community phase composition (relative proportion of different functional groups) and spatial**

distribution on infiltration and runoff: At Reference, the savannah of tallgrasses, midgrasses, forbs and trees having adequate litter and little bare ground can provide for maximum infiltration and little runoff under normal rainfall events.

---

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** No evidence of compaction.

---

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 tallgrasses >> Warm-season midgrasses >

    Sub-dominant: Trees > Forbs >

    Other: Shrubs

    Additional: Forbs make up <10 percent species composition, shrubs <10 percent species composition and trees have 10-20 percent annual production.

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups in Reference condition.

---

14. **Average percent litter cover (%) and depth (in):** Litter is dominantly herbaceous.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 1100# for below average moisture and 3000# for average average moisture.

---

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:** Ashe Juniper is dominant, Honey mesquite, baccharis, prickly pear, persimmon, agarito, and King Ranch bluestem.

---

17. **Perennial plant reproductive capability:** All perennial plants should be capable of reproducing except during periods of prolonged drought conditions, heavy natural herbivory or intensive wildfires.

Ecological site R081CY363TX
Steep Rocky 29-35 PZ

Last updated: 9/20/2019
Accessed: 10/26/2022

General information

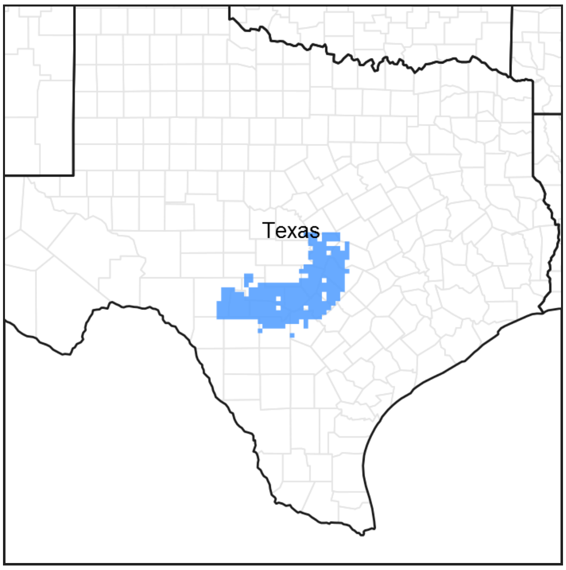

Figure 1. Mapped extent

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): 081C–Edwards Plateau, Eastern Part

This area represents the eastern part of the Edwards Plateau region. Limestone ridges and canyons and nearly level to gently sloping valley floors characterize the area. Elevation is 900 feet (275 meters) at the eastern end of the area and increases westward to 2,000 feet (610 meters) on ridges. This area is underlain primarily by limestones in the Glen Rose, Fort Terrett, and Edwards Formations of Cretaceous age. Quaternary alluvium is in river valleys.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)
National Vegetation Classification/Shrubland & Grassland/2C Temperate & Boreal Shrubland and Grassland/M051 Great Plains Mixedgrass Prairie & Shrubland/ G133 Central Great Plains Mixedgrass Prairie Group.

Ecological site concept

These sites occur on steep, shallow soils with numerous stones and/or boulders present. Reference vegetation includes an oak savannah with mid and tallgrasses, forbs and numerous shrubs. These sites have historically carried more woody species due to some areas being protected from recurring fires. However, if fire is removed completely, woody species are likely to increase across the site.

Associated sites

R081CY355TX	**Adobe 29-35 PZ** The adobe site has sparser woody cover, less slope, and more caliche type soils of a higher pH.
R081CY360TX	**Low Stony Hill 29-35 PZ** The low stony hill is generally higher in the landscape and is the plateau above the steep rocky.

Similar sites

R081CY355TX	**Adobe 29-35 PZ** The steep adobe is a more open site with few boulders and more soil. Hence the production is higher in the steep adobe. The soil is of a higher pH.

Table 1. Dominant plant species

Tree	(1) *Quercus fusiformis* (2) *Quercus texana*
Shrub	(1) *Eysenhardtia texana*
Herbaceous	(1) *Schizachyrium scoparium*

Physiographic features

This site is located in the 81C, Eastern Edwards Plateau Major Land Resource Area (MLRA). It is classified as an upland site. Slope gradient range from 12 to 65 percent. This site was formed in residuum from weathered limestone. Elevation of this site ranges from 500 to 1600 feet above mean sea level. Slopes on Steep Rocky sites range from 15 to 65 percent. Generally, because of steep slope and rockiness this site is not accessible to cattle, vehicular traffic, or machinery.

There is an effect observed in the vegetation brought about by landscape position. The southern exposure of the slopes are drier because of directly facing the sun and less rainfall retained on the steep slopes. The northern exposure of the slope is more mesic due to less direct sunlight causing a more moderate temperature range. This allowed for additional vegetation to grow and hold more rainfall on the steeper slopes.

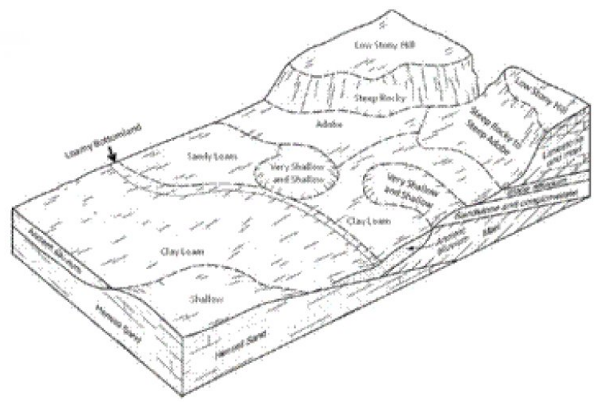

Figure 2. SR Illustration

Table 2. Representative physiographic features

Landforms	(1) Ridge
Flooding frequency	None
Ponding frequency	None
Elevation	500–1,600 ft

Slope	15–65%
Ponding depth	0 in
Water table depth	60 in
Aspect	Aspect is not a significant factor

Climatic features

The climate is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 15 and the last freeze of the season should occur around March 19.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is southeast.

Drought is calculated as 75% below average rainfall. It should be noted that timing of rainfall may be more significant than average rainfall.

Approximately two-thirds of annual rainfall occurs during the April to September period. Rainfall during this period generally falls during thunderstorms, and fairly large amount of rain may fall in a short time. Hurricanes provide another source of extremely high rains in a short time. A review of the rainfall records suggest that rainfall is below “normal” at least 60 percent of the time. Therefore, the erratic nature of the rainfall should be considered when developing any land management plans.

The impact of droughts in the Edwards Plateau cannot be under-estimated. Not only are droughts devastating to the land but also to those that manage the land. Droughts occur roughly every 20 years but not always. A severe drought in 2012 coupled with extreme heat resulted in a die off of juniper over millions of acres as well as other native plants.

Table 3. Representative climatic features

Frost-free period (characteristic range)	191-220 days
Freeze-free period (characteristic range)	227-269 days
Precipitation total (characteristic range)	32-37 in
Frost-free period (actual range)	187-223 days
Freeze-free period (actual range)	224-332 days
Precipitation total (actual range)	31-37 in
Frost-free period (average)	206 days
Freeze-free period (average)	257 days
Precipitation total (average)	34 in

Climate stations used

- (1) MEDINA 1NE [USC00415742], Medina, TX
- (2) SAN ANTONIO/SEAWORLD [USC00418169], San Antonio, TX
- (3) KERRVILLE 3 NNE [USC00414782], Kerrville, TX
- (4) BLANCO [USC00410832], Blanco, TX
- (5) CANYON DAM [USC00411429], Canyon Lake, TX
- (6) BURNET MUNI AP [USW00003999], Burnet, TX
- (7) AUSTIN GREAT HILLS [USC00410433], Austin, TX
- (8) GEORGETOWN LAKE [USC00413507], Georgetown, TX
- (9) PRADE RCH [USC00417232], Leakey, TX

Influencing water features

This being an upland site, it is not influenced by water from a wetland or stream. These upland sites may shed some water via runoff during heavy rain events. The presence of good ground cover and deep rooted grasses can help facilitate infiltration and reduce sediment loss.

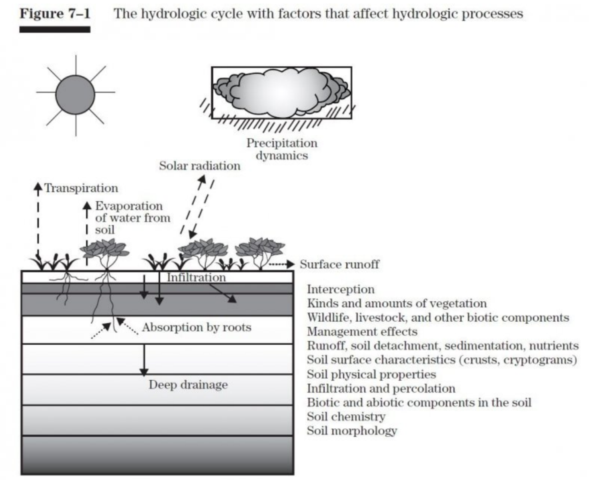

Figure 9.

Soil features

In a representative profile for the Steep Rocky ecological site, these soils are very shallow or shallow to indurated limestone. Depth of bedrock ranges from 4 to 20 inches. The soil is a black clayey soil and is neutral to alkaline. Stones and boulders cover 35 to 65 percent of the soil surface. Ledges of hard limestone outcrop on the contour, giving a banded appearance. The soils are fertile, usually have good structure, and take in water readily. Their fertility and moisture-holding capacity, however, is limited by soil depth and fragment volume. Fractures in the limestone bedrock, on the other hand, generally contain fine soil particles and store some moisture. Plant roots penetrate these cracks and crevices, and thus have access to more moisture and plant nutrients than is apparent in the soil. Forage produced on the site is of good quality. These sites occur on sideslopes of ridges on dissected plateaus.

Due to the scale of mapping, there are inclusions of minor components of other soils within these mapping units. Before performing any inventories, conduct a field evaluation to ensure the soils are correct for the site.

The representative soil associated with the Steep Rocky ecological site is Eckrant. These are the representative map units associated with the Steep Rocky ecological site:

Eckrant-Rock outcrop association, steep
Eckrant-Kerrville association, steep

Table 4. Representative soil features

Parent material	(1) Residuum–limestone
Surface texture	(1) Clay loam (2) Clay
Drainage class	Well drained
Permeability class	Moderately slow
Soil depth	4–20 in
Surface fragment cover <=3"	20–45%
Surface fragment cover >3"	10–35%
Available water capacity (0-40in)	0–2 in

Calcium carbonate equivalent (0-40in)	1–8%
Electrical conductivity (0-40in)	0–2 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.6–8.4
Subsurface fragment volume <=3" (Depth not specified)	20–30%
Subsurface fragment volume >3" (Depth not specified)	20–40%

Ecological dynamics

The reference plant community is a mixture of many woody species along with tall and midgrasses, and forbs, The structure of the woody component is somewhat determined by fire frequency, exposure, and the geologic formation. Many of the woody species, except the Ashe juniper (*Juniperus ashei*), are root sprouters. The large variety of plants that exist on this site precludes mentioning all of them.

The reference plant community for the Steep Rocky ecological site is diverse with Texas live oak (*Quercus fusiformis*), Texas red oak (*Quercus texana*), bigtooth maple (*Acer grandidentatum*), and Ashe juniper trees as well as some elm (Ulmus spp.) and hackberry (Celtis spp.). Grass species include little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), and sideoats grama (*Bouteloua curtipendula*). Other important species include green sprangletop (*Leptochloa dubia*), Texas wintergrass (*Nassella leucotricha*), and kidneywood (*Eysenhardtia texana*). Slope and geologic structure play a major role in the type, form, and composition of the plant community.

A study of early photographs of this region reveals that today these sites are much denser with woody cover and less covered with grasslike vegetation. Early accounts consistently describe this region as a vast expanse of hills covered with "cedar" from San Antonio to Austin. Accounts also describe an abundance of clean, flowing water and abundant wildlife. These accounts seem to describe heavy wooded areas in mosaic patterns occurring along the highs and lows of the landscape. The shallow soils of the Steep Rocky site are located on the slopes of hills in the area.

The plant communities of this site are dynamic and vary in relation to grazing, fire, and rainfall. Studies of the pre-European vegetation of the general area suggested 47 percent of the area was wooded (Wills, 2006). Historical records are not specific on the Steep Rocky site but do reflect area observations. From the Teran expedition in 1691, “great quantities of buffaloes” were noted in the area. By 1840 the Bonnell expedition reflected that “buffalo rarely range so far to the south” (Inglis, 1964). Another example is an early settler, Arnold Gugger, who wrote in his journal about the mid to late 1800s in the Helotes, Texas area, “in those days buffaloes were in droves by the hundreds…..and antelopes were three to four hundred in a bunch….and deer and turkeys at any amount” (Massey, 2009).

Many research studies document the interaction of bison grazing and fire (Fuhlendorf, 2008. et al.). Bison would come into an area, graze it down, leave and then not come back for many months or even years. Many times this grazing scheme by buffalo was high impact and followed fire patterns and available natural water. This usually long deferment period allowed the taller grasses and forbs to recover from the high impact bison grazing. This relationship created a diverse landscape both in structure and composition.

The historic plant community for the Steep Rocky ecological site was not greatly influenced by bison grazing but somewhat by fires. Fire, when it did occur, was an important factor in maintaining the mosaic structure of vegetation on these slopes. There were several “refuges” for fire-sensitive plants afforded in the geology. The northern exposure of this site had a denser population of Ashe juniper. Ashe juniper is native to this site but not as abundant as seen today. Wildfire frequency is anticipated to have been less frequent on this site than on adjacent flatter slopes because of the steeper topography and corresponding lower fine fuel loading. Historical fire frequencies for the region are suggested to be 13 to 25 years (Frost, 1998). When fires did occur, they were set either by Native Americans or by lighting. Woody plant control would vary in accordance with the intensity and severity of the fire encountered, which resulted in a mosaic of vegetation types within the same site.

Ashe juniper will increase regardless of grazing. Juniper will establish with grazing and without unless goats and possibly sheep are utilized. Goats and sometimes sheep will eat young juniper and when properly used, are an effective tool to maintain juniper (Taylor, 1997; Anderson, et al., 2013). Goats and sheep are very adapted to browse the Steep Rocky site with goats being the better of the two. The main role of excessive grazing relative to juniper is the removal of the fine fuel needed to carry an effective burn.

Ashe juniper, because of its dense low growing foliage, has the ability to retard grass and forb growth. Grass and forb growth can become nonexistent under dense juniper canopies. Many times there is a resurgence of the better grasses such as little bluestem when Ashe juniper is controlled and followed by proper grazing management. Seeds and dormant rootstocks of many plant species are contained in the leaf mulch and duff under the junipers.

Currently, goats, white-tailed deer, sheep, and exotic animals are the primary large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which allowed population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Because of their impacts on livestock production, large predators such as red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus), and eventually coyotes (Canis latrins) were reduced in numbers or eliminated (Schmidly, 2002).

The screwworm fly (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas, and Walker, 1965; Bushland, 1985).

Currently, due to the increased land ownership for recreational purposes and a corresponding reduction in livestock production, predator populations are on the increase. This includes feral hogs (Sus scrofa).

Progressive management of the deer herd, because of their economic importance through lease hunting, has the objective of improving individual deer quality and improving habitat. Managed harvest based on numbers, sex ratios, condition, and monitoring of habitat quality has been effective on individual properties. However, across the Edwards Plateau, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Edwards Plateau is home to a variety of exotic ungulates, mostly introduced for hunting (Schmidly, 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium- and small-sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity.

The plants and topography aided in increasing the infiltration of rainfall into the moderately slowly permeable soil. Any loss of soil organic matter and plant cover has a negative effect on infiltration. More rainfall is directed to overland flow, which causes increased soil erosion and flooding. Soils are also more prone to drought stress since organic matter acts like a sponge aiding in moisture retention for plant growth. Mulch buildup under the Ashe juniper canopy, following brush management and incorporation into the soil, can have a positive effect on increasing infiltration.

This site contains a large diversity of plants and this document does not attempt to cover them all. The intent of this document is to describe ecological processes on representative plants.

European settlement occurred in the mid to late 1800s (Raunick, 2007). This time period also coincided with a stoppage of fire. It was during this time that large-scale fencing was initiated to help the introduction of livestock. Predators were also reduced to protect livestock. In many cases sheep and goats heavily utilized the site. Low successional, unpalatable grasses, forbs, and shrubs have taken the place of the more desirable plant species.

Non-preferred browse, such as juniper, fared well at the expense of the palatable browse. Juniper is undoubtedly the dominant woody plant over most of the site today.

Plant Communities and Transitional Pathways (diagram)

A State and Transition Model for the Steep Rocky Ecological Site (R081CY363TX) is depicted in this report. Descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases.

Plant communities will differ across the MLRA because of the naturally occurring variability in weather, soils, and aspect. The Reference Plant Community is not necessarily the management goal; other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are described as are other metrics. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover can drive the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating the similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances. It does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

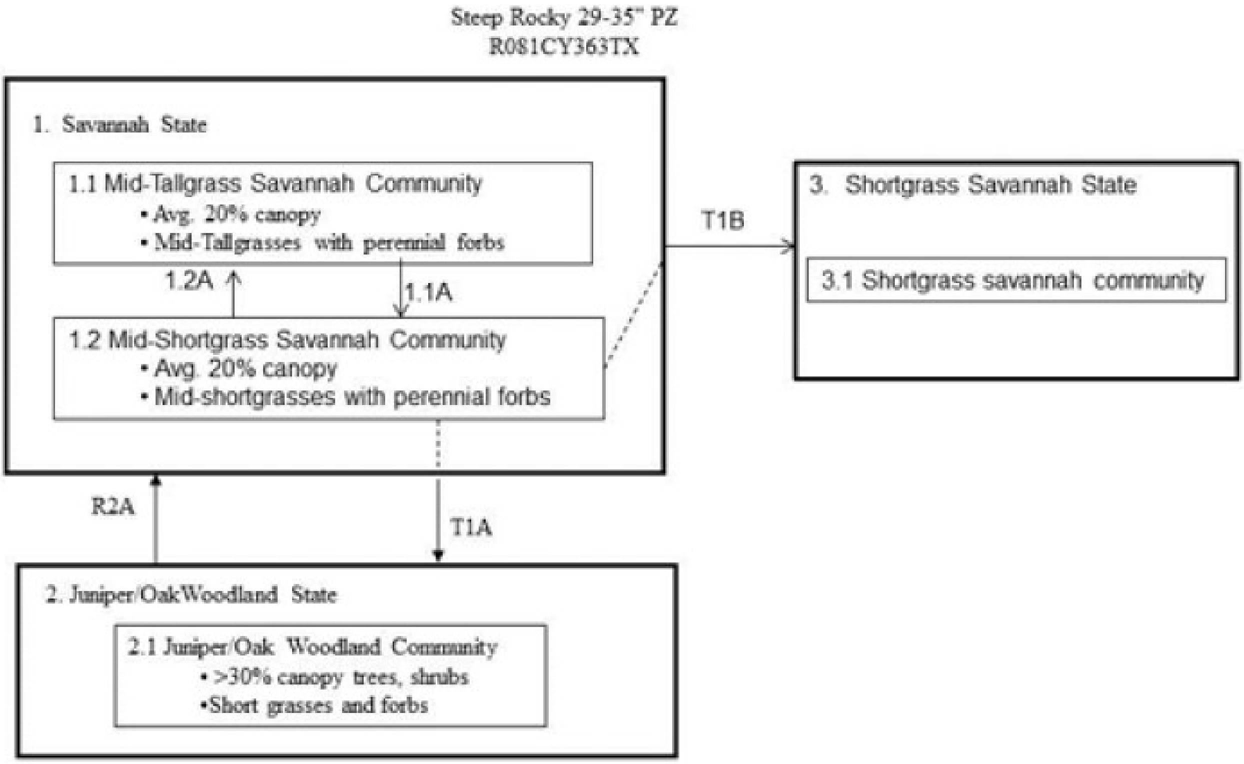

Figure 10. State and Transition Diagram Steep Rocky

State 1
Savannah State

Community 1.1
Mid- and Tallgrass Savannah Community

Figure 11. Photo 1: Mid and Tallgrass Savannah Community

Figure 12. Photo 2: Mid and Tallgrass Savannah Community

The Mid- and Tallgrass Savannah Community is the interpretive plant community for this and is a diverse mosaic. The information for this site is derived from vegetation inventories and professional opinion of range trained individuals. It is recognized the north slopes will have denser stands of juniper, however, the south slope is selected as the interpretive or diagnostic plant community as it is more dynamic. The density and frequency of woody vegetation is strongly dependent on the presence or absence of fractured limestone and exposure. Where non-fractured geology exists, canopies will be less dense. Large deep-rooted trees are rare. Northern facing exposures have higher canopy covers and larger trees than southern exposures. This site was referred to as a "cedar brake" by early explorers (Roemer, 1846) because of the juniper dominance in several locations. The absence or presence of juniper was directly related to the fire frequency and intensity but many times was limited by rock outcrops, lack of fuel or escarpments. The overstory canopy may be as much as 35 percent. Moreover, the canopy varied considerably over the full range of the site. The woody canopy consists primarily of Texas live oak, Texas red oak, Ashe juniper, white shin oak (*Quercus sinuata* var. breviloba), Lacey oak (*Quercus laceyi*), and several associated species. Unique indicator plants such as Lindheimer's silk tassel (*Garrya ovata* var. lindheimeri), Texas madrone (*Arbutus xalapensis*), bigtooth maple, escarpment black cherry (*Prunus serotina*), and walnut species (Juglans spp.) occurred in fractured limestone. Numerous forbs such as zexmenia (Wedelia spp.), Dalea (Dalea spp.), sundrop (Calyophus spp.), bundleflower (Desmanthus spp.), and gayfeather (Liatris spp.) frequent the site. Mid and tallgrasses are dominants of the site although a large portion of these sites often supported a shrub and tree community. The structure of many of the woody plants on this site, such as live oak, can exist either as a tree or as a shrub or thicket because of their resprouting ability following fire or top damage. Juniper is the exception, being a non-sprouter. Not only did periodic fires maintain the reference plant community in a mosaic nature but droughts are known to kill woody plants such as live oak and juniper (Wills, 2006). Retrogression of the site comes mainly from juniper. Juniper functions as an increaser on this site as it is native. Heavy browsing by livestock and wildlife weakens palatable browse and offers juniper an opportunity to increase. When retrogression is cattle induced (on the lower ranges of the slope), little bluestem, green sprangletop, sideoats grama, and the minor species Indiangrass, big bluestem, and palatable forbs are the primary decreasers. Feathery bluestems (Bothriochloa spp.), tall dropseed (*Sporobolus compositus* var. compositus), Texas wintergrass, tridens (Tridens spp.), threeawn (Aristida spp.), and woody species are increasers. Slim tridens (*Tridens muticus*), rough tridens (*Tridens muticus* var. elongatus), and threeawn (Aristida spp.) are the most persistent of the grasses under abusive use. Juniper can increase regardless of browsing. Seeds eaten by birds and deposited in the understory of other woody species will germinate and establish in the absence of fire. Over a period of time, the juniper will eventually dominate its surrogate woody plant. Other wildlife species will also eat the juniper berries then fecally deposit them over the site (Smeins, 1997). This process may take 20 or so years depending upon the rate of introduction and the fire frequency. Once juniper reaches approximately a 30 percent canopy, a threshold is being approached. At this point, the fine fuel necessary for an effective fire is diminished except for severe, catastrophic type fires. Because of the steep nature of this site, only a very few management practices can be used for maintenance. Hand cutting of juniper is an example to keep the canopy open enough to maintain some vegetative cover even though it is labor intensive. Mechanical clipping can be done on the lower slope classes. If selective removal is done, there is usually enough seed source for the site to recover once historic disturbances are returned. It is recognized that fire did not completely burn this site nor is it always feasible to burn because of difficult terrain.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1210	1650	1925
Tree	440	600	700
Shrub/Vine	330	450	525
Forb	220	300	350
Total	**2200**	**3000**	**3500**

Figure 14. Plant community growth curve (percent production by month). TX3770, Grassland/Oak Hillside Community. Tall and midgrasses with scattered live oak motts..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	7	13	20	15	7	5	10	7	5	5

Community 1.2
Mid-Shortgrass Savannah Community

This community closely resembles the reference plant community of an open grassland with interspersed mottes of oak and other species. The elimination of fire and brush management will allow the invasion and increase of woody plant species. The main woody species to increase on the site is Ashe juniper, usually introduced in wildlife droppings. The major grass species for the site are still little bluestem, Indiangrass, big bluestem, and sideoats grama but in reduced amounts. There is a shift from a little bluestem dominated plant community toward a sideoats grama-Texas wintergrass-Silver bluestem (*Bothriochloa laguroides*) dominated herbaceous plant community. This community with Ashe juniper of 5 feet or less in height presents challenges and a critical decision point for the land resource manager. Applying a prescribed burn or individual plant treatment of Ashe juniper at this time will allow the site to move back towards the mid and tallgrass savannah plant community at a more reasonable cost than waiting until the juniper is too big. The steepness of this site and the rock outcrops renders mechanical treatment to only the flatter more accessible portions. It gets too big for fire when it gets to about 10 feet high, then it takes a harsher fire requiring special precautions. Most of the time terrain vastly increases the complexity of the burn. Applying no control methods at this time will allow the juniper to increase in size and density and puts this community at risk for juniper dominating the site at the expense of a diversity of plants. The community will transition to the Juniper/Oak State (2) if remedial action is not taken soon. To move from this community back toward the Savannah State (1) will take a more considerable investment of resources.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	990	1350	1575
Tree	550	750	875
Shrub/Vine	440	600	700
Forb	220	300	350
Total	**2200**	**3000**	**3500**

Figure 16. Plant community growth curve (percent production by month). TX3769, Open Grassland with Juniper. Open Grassland with Juniper Encroachment having warm season grasses with minor cool season influence..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	5	15	25	20	7	5	13	5	2	1

Pathway 1.1A
Community 1.1 to 1.2

Removal of fire from the landscape and introduction of juniper seeds by wildlife initiates the shift toward the mid-shortgrass savannah. Excessive removal of herbaceous leaves shifts the sunlight energy to favor juniper and non-palatable plants as well as removes grass fuel to burn.

Pathway 1.2A
Community 1.2 to 1.1

The application of fire or individual plant treatment (IPT) of unwanted plants will restore the energy cycle, preserve the water cycle, and move the community back toward the mid-tallgrass savannah.

State 2
Juniper/Oak Woodland State

Community 2.1
Juniper/Oak Woodland Community

Figure 17. Photo 3. Rock outcrop Southern and Northern Exp.

Figure 18. Photo 4. Juniper/Oak Woodland Community.

Figure 19. Photo 5. Juniper/Oak Woodland, Southern Exp.

The elimination of fires, lack of prescribed grazing and browsing, plus the lack of brush management allowed Ashe juniper and other woody species to overtake this site. It is a dense woody canopy community where fractured geologic formations exist. Where the geology is non-fractured, the vegetative communities will produce somewhat shorter woody vegetation with lighter densities than the fractured sites. The dominant species is Ashe juniper but there is still usually live oak, Texas madrone, Texas oak, Lacey oak, white shin-oak, black cherry, and walnut species left in some amounts. Shrubs commonly growing in the area are sumac (Rhus spp.), algerita (*Mahonia trifoliolata*), Texas persimmon (*Diospyros texana*), Texas colubrina (*Colubrina texensis*), elbowbush (*Forestiera pubescens*), mountain laurel (*Sophora secundiflora*), and hawthorn (Crataegus spp.) species. This vegetative state will exhibit Ashe juniper 20 to 30 feet tall and taller, with canopies sometimes in excess of 50 percent. This density and structure of juniper is also a potential safety hazard from wildfire for homes or other structures built in this vegetative community. Not only does the terrain and density of trees make it difficult for firefighting equipment to respond, but the slope amplifies wildfire and the rate of spread. Ashe juniper, which originally occurred in varying amounts among the rocky, craggy fire-free outcrops is a dense canopy and suppresses other vegetation. Ashe juniper and other woody species significantly out-compete understory grasses and forbs for sunlight and moisture. In this vegetative state, cedar sedge (Carex spp.), hairy grama (*Bouteloua hirsuta*), hairy tridens (*Erioneuron pilosum*), Texas grama (*Bouteloua rigidiseta*), red threeawn (Aristida trifida), puffsheath dropseed (*Sporobolus neglectus*), and Evax (Evax spp.) are common in the understory and in the small openings. Grazing/browsing management alone will not shift this community back towards the reference community. Total restoration to the mid-tall grass savannah community may not even be possible if excessive erosion has removed what little soils exist. Implementing selective brush control measures such as individual plant treatments are needed to begin the restoration. Prescribed grazing/browsing is essential to allow the herbaceous plant community to recover. The length of time of reasonable recovery can be many years depending upon past history. Maintenance activities will be needed for juniper every few years as there is a large seed bank both on-site and from adjacent sites. Fire is an ecological driver that can sometimes be used depending upon local settings and conditions.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1320	1800	2100
Shrub/Vine	660	900	1050
Forb	110	150	175
Grass/Grasslike	110	150	175
Total	**2200**	**3000**	**3500**

State 3
Shortgrass Savannah State

Community 3.1
Shortgrass Savannah Community

Figure 21. Photo 6. Heavy continuous overgrazing

This plant community has crossed a threshold driven by the heavy and long term stocking of mixed classes of livestock. Droughts hasten the process. There is a 5 to 10 percent overstory of live oak and other trees with little understory. Heavy browsing has removed most all the plant material the animals can reach except for the most unpalatable shrubs. In this condition, there is not enough fine fuel to carry a prescribed burn. Even though there is a loss of fire, it is still difficult for any shrub to become established as long as heavy browsing pressure remains. Major increasing shrub species usually present are Texas persimmon, lotebush, algerita, mesquite, shin oak and Texas live oak. The dominant, little bluestem, and sub-dominants, big bluestem and Indiangrass are non-existent except where the crevasses in the rocks have offered refuge. The following species may also occur in this plant community: pricklypear cactus (Opuntia spp.), ragweed (Ambrosia confertifolia), broomweed (*Amphiachyris dracunculoides*), nightshades (Solanum spp.), milkweeds (Asclepias spp.), gray goldaster (Chrysopisis spp.), prairie coneflower (*Ratibida columnifera*), snow-on-the-mountain (Asclepias spp.), filaree (Erodium spp.), plantain (Plantago spp.), horehound (*Marrubium vulgare*), evax, twinleaf senna (*Senna bauhinioides*), and mealy cup sage (*Salvia farinacea*). Similarly, the following short grasses exist: sideoats grama (only in protected places), buffalograss (*Bouteloua dactyloides*), hairy tridens, slim tridens (*Tridens muticus*), hairy grama (*Bouteloua hirsuta*), red grama, Texas grama, feather bluestem, threeawn, and other annual grasses. The reference plant community (1.1) may no longer be an option for management in a reasonable amount of time. The ecological processes of the hydrologic cycle, energy flow, mineral cycling, and nutrient cycling have been lost. This is demonstrated by the loss of key plants and topsoil with which to recover. It is possible for some key plants to exist within the protected area of rocks and plant but recovery will be slow and will take prescribed grazing and possibly reseeding although reseeding is a questionable option as well. Soil depth is a limiting factor and the potential for recovery is couched on the amount of topsoil remaining. Soil compaction may also be a limitation. With prescribed grazing, and possibly seeding, the plant communities may begin to respond. The first need is to restore hydrologic function to hold rainfall on the land allowing it to soak in. Once this trend is established the natural functions of freezing, thawing, drying, and wetting and healthy plant roots may begin to restore health and function in the soil. This may take as much as 25 to 30 years under the best of conditions. Once plant cover has been restored, the plant community needs to be monitored to prevent the establishment of secondary plants such as Ashe juniper.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	1100	1500	1750
Grass/Grasslike	550	750	875
Forb	330	450	525
Shrub/Vine	220	300	350
Total	**2200**	**3000**	**3500**

Figure 23. Plant community growth curve (percent production by month). TX3776, Prairie Shrubland Community. Prairie Shrubland Community.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Transition T1A
State 1 to 2

Transition 1A is a scenario with some combination of no fire, heavy browsing by livestock and wildlife, no brush management, and the unmitigated increase of juniper. Wildlife contributes to the spread of seeds through droppings.

Transition T1B
State 1 to 3

This transition is caused by interruption of sunlight energy flowing through the system to only the overstory plants. The hydrologic cycle is severely impeded and the loss of top soil is a degradation of the mineral cycle.

Restoration pathway R2A
State 2 to 1

Recovery 2A represents some combination of juniper removal coupled with prescribed grazing and prescribed burning.

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Tall grasses**			800–1450	
	little bluestem	SCSC	*Schizachyrium scoparium*	600–900	–
	Indiangrass	SONU2	*Sorghastrum nutans*	100–250	–
	big bluestem	ANGE	*Andropogon gerardii*	100–250	–
	eastern gamagrass	TRDA3	*Tripsacum dactyloides*	0–50	–
2	**Midgrasses**			100–150	
	sideoats grama	BOCU	*Bouteloua curtipendula*	100–150	–
3	**Midgrasses**			80–125	
	cane bluestem	BOBA3	*Bothriochloa barbinodis*	25–50	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	25–50	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	25–50	–

	green sprangletop	LEDU	*Leptochloa dubia*	25–50	–
	composite dropseed	SPCOC2	*Sporobolus compositus var. compositus*	25–50	–
	vine mesquite	PAOB	*Panicum obtusum*	0–25	–
	Texas cupgrass	ERSE5	*Eriochloa sericea*	0–25	–
	tall grama	BOHIP	*Bouteloua hirsuta var. pectinata*	0–25	–
4	**Midgrasses**			80–100	
	Reverchon's bristlegrass	SERE3	*Setaria reverchonii*	25–100	25–50
	slim tridens	TRMU	*Tridens muticus*	25–50	–
	slim tridens	TRMUE	*Tridens muticus var. elongatus*	25–50	–
	threeawn	ARIST	*Aristida*	0–25	–
5	**Cool Season Grasses**			50–100	
	Canada wildrye	ELCA4	*Elymus canadensis*	50–100	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	75–100	–
	cedar sedge	CAPL3	*Carex planostachys*	50–75	–
Forb					
6	**Forbs**			220–350	
	cedar sedge	CAPL3	*Carex planostachys*	50–150	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	50–150	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	50–100	–
	eastern milkpea	GARE2	*Galactia regularis*	50–100	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	50–100	–
	trailing krameria	KRLA	*Krameria lanceolata*	50–100	–
	dotted blazing star	LIPU	*Liatris punctata*	50–100	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	50–100	–
	beardtongue	PENST	*Penstemon*	50–100	–
	snoutbean	RHYNC2	*Rhynchosia*	50–100	–
	awnless bushsunflower	SICA7	*Simsia calva*	50–100	–
	fuzzybean	STROP	*Strophostyles*	50–100	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	50–100	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	50–100	–
	Berlandier's sundrops	CABE6	*Calylophus berlandieri*	50–100	–
	prairie clover	DALEA	*Dalea*	50–100	–
	zarzabacoa comun	DEIN3	*Desmodium incanum*	50–100	–
	bundleflower	DESMA	*Desmanthus*	50–100	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	0–75	–
	Forb, annual	2FA	*Forb, annual*	0–1	–
Shrub/Vine					
7	**Shrubs/Vines**			330–525	
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	100–300	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	100–300	–
	yellow sundrops	CASE12	*Calylophus serrulatus*	100–300	–
	prairie clover	DALEA	*Dalea*	100–300	–
	bundleflower	DESMA	*Desmanthus*	100–300	

	bundleflower	DESMA	*Desmanthus*	100–300	–
	ticktrefoil	DESMO	*Desmodium*	100–300	–
	blacksamson echinacea	ECAN2	*Echinacea angustifolia*	100–300	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	100–300	–
	Maximilian sunflower	HEMA2	*Helianthus maximiliani*	100–300	–
	dotted blazing star	LIPU	*Liatris punctata*	100–300	–
	Nuttall's sensitive-briar	MINU6	*Mimosa nuttallii*	100–300	–
	scurfpea	PSORA2	*Psoralidium*	100–300	–
	snoutbean	RHYNC2	*Rhynchosia*	100–300	–
	awnless bushsunflower	SICA7	*Simsia calva*	100–300	–
	vetch	VICIA	*Vicia*	100–300	–
	creepingoxeye	WEDEL	*Wedelia*	100–300	–
	mescal bean	SOSE3	*Sophora secundiflora*	100–200	–
	ungnadia	UNGNA	*Ungnadia*	100–150	–
	yucca	YUCCA	*Yucca*	100–150	–
	Texas persimmon	DITE3	*Diospyros texana*	100–150	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	100–150	–
	stretchberry	FOPU2	*Forestiera pubescens*	100–150	–
	Lindheimer's silktassel	GAOVL	*Garrya ovata ssp. lindheimeri*	50–150	–
	western white honeysuckle	LOAL	*Lonicera albiflora*	50–150	–
	algerita	MATR3	*Mahonia trifoliolata*	100–150	–
	devil's shoestring	NOLI	*Nolina lindheimeriana*	100–150	–
	winged sumac	RHCO	*Rhus copallinum*	100–150	–
	gum bully	SILAO	*Sideroxylon lanuginosum ssp. oblongifolium*	50–150	–
	greenbrier	SMILA2	*Smilax*	100–150	–
Tree					
8	**Trees**			440–700	
	Texas live oak	QUFU	*Quercus fusiformis*	250–600	–
	Ashe's juniper	JUAS	*Juniperus ashei*	100–600	–
	mescal bean	SOSE3	*Sophora secundiflora*	150–350	–
	ungnadia	UNGNA	*Ungnadia*	150–350	–
	yucca	YUCCA	*Yucca*	150–350	–
	eastern redbud	CECA4	*Cercis canadensis*	150–350	–
	Texas persimmon	DITE3	*Diospyros texana*	150–350	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	150–350	–
	stretchberry	FOPU2	*Forestiera pubescens*	150–350	–
	Lindheimer's silktassel	GAOVL	*Garrya ovata ssp. lindheimeri*	150–350	–
	algerita	MATR3	*Mahonia trifoliolata*	150–350	–
	devil's shoestring	NOLI	*Nolina lindheimeriana*	150–350	–
	fragrant sumac	RHAR4	*Rhus aromatica*	150–350	–
	prairie sumac	RHLA3	*Rhus lanceolata*	150–350	–
	evergreen sumac	RHVI3	*Rhus virens*	150–350	–
	bully	SIDER2	*Sideroxylon*	150–350	–

	greenbrier	SMILA2	*Smilax*	150–350	–
	hackberry	CELTI	*Celtis*	100–250	–
	bastard oak	QUSIB	*Quercus sinuata var. breviloba*	100–250	–
	Nuttall oak	QUTE	*Quercus texana*	100–250	–
	sandpaper oak	QUVA5	*Quercus vaseyana*	100–250	–
	Lacey oak	QULA	*Quercus laceyi*	100–200	–
	bigtooth maple	ACGR3	*Acer grandidentatum*	0–150	–
	littleleaf leadtree	LERE5	*Leucaena retusa*	100–150	–
	black cherry	PRSE2	*Prunus serotina*	0–100	–
	walnut	JUGLA	*Juglans*	0–100	–
	Eve's necklacepod	STAF4	*Styphnolobium affine*	50–100	–
	elm	ULMUS	*Ulmus*	50–100	–

Animal community

This site is used for the production of domestic livestock and to provide habitat for native wildlife and certain species of exotic wildlife. The site is somewhat accessible to use by cattle but is more accessible to deer, sheep, Angora goats, and meat goats. Global Positioning Systems studies reveal slopes above 11 percent are generally less accessible to cattle while sheep and goats can utilize slopes up to 45 percent. Also revealed is that cattle will avoid a site once it contains about 30 percent surface rocks. (Hanselka, et al.)

Cow-calf operations are the primary livestock enterprise although stocker cattle are also grazed. Sheep and goats were formerly raised in large numbers and are still present in reduced numbers. Carrying capacity has declined drastically over the past 100 years due to the deterioration of the reference community. A field assessment of vegetation is needed to determine stocking rates based on the forage needs of desired animal species.

Many species, including domestic livestock, use more than one ecological site to meet their habitat needs.

Managing all the grazing and browsing animals is important to keep populations in balance and provide an economically important ranching enterprise. Achieving a balance between woodland and more open plant communities on this site is an important key to deer management. Competition among deer, sheep, and goats is an important consideration in livestock and wildlife management and can cause damage to preferred vegetation.

Smaller mammals include many kinds of rodents, jackrabbit, cottontail rabbit, raccoon, skunks, opossum, and armadillo. Mammalian predators include coyote, red fox, gray fox, bobcat, and mountain lion. Many species of snakes and lizards utilize the site.

Many species of birds can be found on this site including game birds, songbirds, and birds of prey. Major game birds that are economically important are Rio Grande turkey, bobwhite quail, and mourning dove. Turkey prefer plant communities with substantial amounts of shrubs and trees interspersed with grassland. Quail prefer plant communities with a combination of low shrubs, bunch grass, bare ground, and low successional forbs. The different species of songbirds vary in their habitat preferences. In general, a habitat that provides a large variety of grasses, forbs, shrubs, vines, and trees and a complex of grassland, savannah, shrubland, and woodland 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. The different plant communities of the site will sustain different species of raptors.

Various kinds of exotic wildlife have been introduced on the site including axis, sika, fallow and red deer, aoudad sheep, and blackbuck antelope. Some exotic species, such as axis deer have the ability to shift their diets to alternative plant groups which give them a competitive advantage over the native white-tailed deer. Their numbers should be managed in the same manner as livestock and white-tailed deer to prevent damage to the plant community. Feral hogs are present and can cause damage when their numbers are not managed.

Hydrological functions

The soils on this site are well drained with very low water holding capacity. Surface runoff is very rapid because of the slope of the site. Water erosion is potentially severe. Soils of the site are in Hydrologic Groups C and D. The water cycle on this site functions according to existing plant community composition and the management of the plant community. The water cycle is at optimum when the site is dominated by tall bunchgrasses. High infiltration capacity organic matter, and good soil structure and porosity are associated with a good bunchgrass cover. Higher organic matter and soil structure optimizes high water quality when runoff occurs and erosion and sedimentation rates will be minimal. Infiltration during periods of heavy rainfall can result in some deep percolation of water. Water will move below the root zone of grasses into the fractures in the limestone. As water percolates and moves downward, it contributes to aquifer recharge and helps provide sustained flow to downstream watersheds.

State 1

Return period analysis based on 50 years of climate

Storm Return
Period Precipitation
(in.) Runoff
(in.) Erosion
(t ac)
Average 50 yr 33.6 1.1 0.8
2.5 year 34.0 1.1 0.8
5 year 39.7 1.9 1.4
10 year 45.6 2.6 2.0
25 year 51.9 3.6 3.1
50 year 53.4 4.9 3.3

Based on 50 years of climate, there is a 98 percent chance there will be runoff, erosion, and sediment delivery (Rangeland Hydrology and Erosion Model Predictions—model calibrated from field data).

Return Period Analysis

To help interpret the table, note that a five-year value will be exceeded, on the average, about once every five years, or twice every ten years. There is a 1/5, or 20 percent, chance that a value equal to or greater than the five-year value will occur in a given year. There is a (100 - 20), or 80 percent, chance that the precipitation, runoff, erosion, or sediment yield will be less than the 5-year value. In the results shown in the table, there is a 20 percent chance that the annual erosion will exceed about 1.4 tons per acre. At best, any predicted runoff or erosion value, by any model, will be within only plus or minus 50 percent of the true value. Erosion rates are highly variable.

State 3

When heavy grazing causes loss or reduction of bunchgrass and ground cover, the water cycle becomes impaired. Infiltration is decreased and runoff is increased because of poor ground cover, rainfall splash, soil capping, low organic matter, and poor structure. With a combination of a sparse ground cover, excessive slopes, and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor, and sedimentation is increased.

Ashe juniper, Texas persimmon, Mexican buckeye, algerita, and other woody plants, which occurred in small amounts among the rocky, craggy outcrops in State 1, have increased to form a dense canopy. The understory in such conditions may consist of a sparse cover of cedar sedge, hairy tridens, and threeawn. Juniper also has a heavy duff layer at its base. This layer has been reported to capture and store as much as 33 percent of the annual rainfall at some locations (Thurow, 1994).

Return period analysis based on 50 years of climate

Storm Return
Period Precipitation
(in.) Runoff
(in.) Erosion

(t ac)
Average 50 yr 33.6 1.5 1.6
2.5 year 35.0 1.5 1.5
5 year 39.7 2.5 2.7
10 year 45.5 4.0 4.5
25 year 51.9 5.0 6.1
50 year 53.3 5.2 6.5

Based on 50 years of climate data, there is a 100 percent chance there will be runoff, erosion, and sediment delivery (Rangeland Hydrology and Erosion Model Predictions—model calibrated from field data).

When conditions have reached a threshold and woody invasion has reached maximum densities and beneficial native understory grasses are absent or at very low densities, a reversion to State 1 hydrology is not likely. Erosion has reduced the capacity of this site to recover.

Recreational uses

This site has potential for recreational use due to the diversity of wildlife which utilizes the site. The tall and mid grasses and scattered oaks produce beautiful fall color variations. The area is used for hunting, hiking, birding and other nature tourism-related enterprises.

Wood products

Oaks and Ashe juniper may be used for firewood, fencing material, and/or in the specialty wood industry. In some areas, the oil of the mature Ashe juniper heartwood is extracted for use in the fragrance industry.

Other products

None

Other information

Brilliant fall colors result from the mix of evergreen and deciduous woody species found on this site. Color changes of Texas oak and flame-leaf sumac blend beautifully with Ashe juniper and live oak. Many native plants, valuable for low-maintenance landscaping may be found on this site.

Inventory data references

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

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Approval

David Kraft, 9/20/2019

Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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.

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Date	08/23/2013
Approved by	Colin Walden
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, except following extremely high intensity storms when short flow patterns may appear.

3. **Number and height of erosional pedestals or terracettes:** None.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** 0 to 10 percent bare ground. Small and non-connected areas.

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):** Minimal and short.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability rating 5-6.

---

9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** Soil surface is very dark gray stony clay 8 inches thick that contains 60 percent by volume of cobbles and stone fragments of limestone. Moderately alkaline. Soil Organic Matter is 1-4 percent.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** High canopy, basal cover and density with small interspaces should make rainfall impact negligible. This site has well drained soils, moderately slow permeability, very low AWC, severe water erosion hazard, fertility is medium, and shallow root zone.

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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.

---

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 tallgrasses

    Sub-dominant: Warm-season midgrasses Cool-season grasses Trees

    Other: Forbs Shrubs

    Additional:

---

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** There should be little mortality or decadence for any functional groups.

---

14. **Average percent litter cover (%) and depth (in):** Litter is dominantly herbaceous.

---

15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** 3250# for below average moisture to 5750# for above average moisture.

---

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:** Ashe juniper is the primary invader.

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17. **Perennial plant reproductive capability:** All species should be capable of reproduction on the Steep Rocky ecological site except for periods of prolonged drought conditions, heavy natural herbivory, and wildfires.

USDA Natural Resources
Conservation Service

Ecological site R082AY378TX
Tight Sandy Loam 25-32 PZ

Last updated: 9/20/2019
Accessed: 10/26/2022

General information

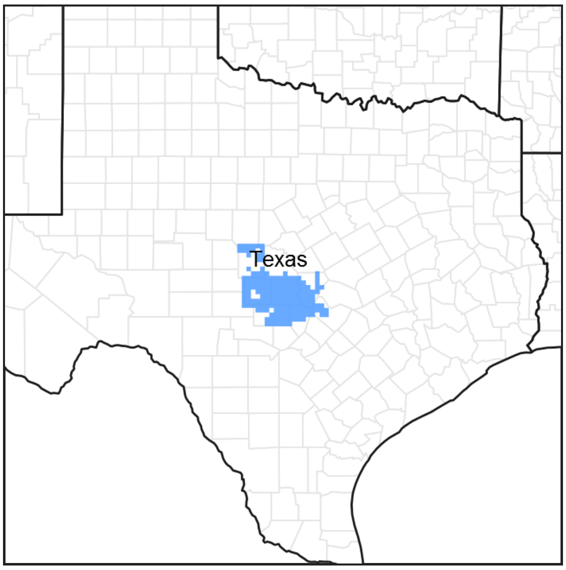

Figure 1. Mapped extent

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): 082A–Texas Central Basin

The 82A MLRA is underlain primarily by igneous, metamorphic, and sedimentary rocks. Igneous and metamorphic outcrops include the Valley Spring Gneiss, Packsaddle Schist, and Town Mountain Granite of Precambrian age. Sedimentary rocks include the Hickory Sandstone and Lion Mountain Sandstone of Cambrian Age and the Hensel Sand of Cretaceous age. Holocene alluvium is on flood plains.

Classification relationships

Major Land Resource Area (MLRA) and Land Resource Unit (LRU) (USDA-Natural Resources Conservation Service, 2006)

Ecological site concept

The Tight Sandy Loam ecological site consists of very deep, well drained, moderately slowly permeable soils that formed in loamy and clayey, calcareous sediments. Permeability is moderately slow. Runoff is negligible on slopes less than 1 percent, very low on 1 to 3 percent slopes, low on 3 to 5 percent slopes, and medium on 5 to 8 percent slopes.
The reference vegetation is a midgrass/oak savannah. The site is composed of four vegetative states: Savanna State, Shrubland State, Converted State, and a Highly Disturbed State.

Similar sites

R082AY369TX	**Red Sandy Loam 25-32 PZ** The Red Sandy Loam site is a higher producing site with larger trees.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

These soils are on nearly level to moderately sloping uplands. Slopes range from 0 to 8 percent. Elevation ranges from 700 to 1,700 feet.

Table 2. Representative physiographic features

Landforms	(1) Swale (2) Plain
Runoff class	Low to medium
Elevation	700–1,700 ft
Slope	0–8%
Aspect	Aspect is not a significant factor

Climatic features

The climate for MLRA 82A is humid subtropical and is characterized by hot summers and relatively mild winters. The average first frost should occur around November 11 and the last freeze of the season should occur around March 21.

The average relative humidity in mid-afternoon is about 50 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible during the summer and 50 percent in winter. The prevailing wind direction is from the south.

Approximately two-thirds of the annual rainfall occurs during the April to September period. Rainfall during this period generally falls as thunderstorms, and fairly large amounts of rain may fall in localized areas for a short period of time.

Table 3. Representative climatic features

Frost-free period (characteristic range)	192-193 days
Freeze-free period (characteristic range)	233-242 days
Precipitation total (characteristic range)	28-29 in
Frost-free period (actual range)	192-193 days
Freeze-free period (actual range)	231-244 days
Precipitation total (actual range)	28-29 in
Frost-free period (average)	193 days
Freeze-free period (average)	238 days
Precipitation total (average)	28 in

Climate stations used

- (1) LLANO [USC00415272], Llano, TX
- (2) MASON [USC00415650], Mason, TX

Influencing water features

These upland sites may shed some water via runoff during heavy rain events. The presence of good ground cover and deep-rooted grasses can help facilitate infiltration and reduce sediment loss.

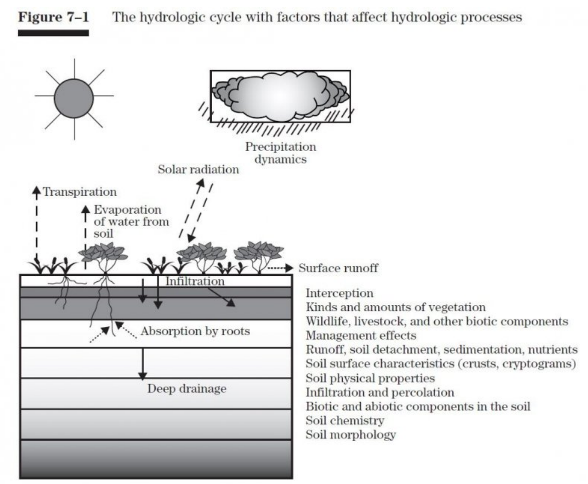

Figure 8.

Soil features

The Tight Sandy Loam ecological site consists of very deep, well drained, moderately slowly permeable soils that formed in loamy and clayey, calcareous sediments. Permeability is moderately slow. Runoff is negligible on slopes less than 1 percent, very low on 1 to 3 percent slopes, low on 3 to 5 percent slopes, and medium on 5 to 8 percent slopes.

There is essentially no bare soil in this community, with plant basal cover, litter, and rock fragments comprising the ground cover. Soils are fertile and hold moderately amounts of soil moisture. This is a productive site with moderately high yields of good quality forage.

The representative soil for this site is Pedernales.

Table 4. Representative soil features

Parent material	(1) Residuum–calcareous sandstone (2) Slope alluvium–calcareous sandstone
Surface texture	(1) Fine sandy loam (2) Loamy fine sand
Drainage class	Somewhat poorly drained to well drained
Permeability class	Very slow to slow
Soil depth	60–80 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6.1–7.8

Subsurface fragment volume <=3" (Depth not specified)	0–15%

Ecological dynamics

The Tight Sandy Loam 25-32” PZ reference site is a fire-influenced Midgrass/Oak Savannah interspersed with perennial forbs and mixed shrubs. The site consists of four stable states: Savannah State (1.0), Shrubland State (2.0), Converted State (3.0), and Highly Disturbed State (4.0).

The Texas Central Basin (MLRA 82A) is a unique geological region within Texas. It is composed largely of Pre-Cambrian granite, gneiss and schist (Bureau of Economic Geology 1981). Depending upon the parent material and topography, a great variety of soils have developed that vary from shallow, fissured, rocky outcrops with minimal soil development to relatively deep, well-developed soils with textures that vary from fine sandy loams to sands to gravelly clay loams to cobbly clay loams and stony clay loams (Goerdel 2000).

Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing a die-off of seedlings, less drought-tolerant species, and some woody species. Droughts also reduce biomass production and create open space that is colonized by opportunistic species when precipitation increases. Wet periods allow little bluestem, sideoats grama, and hardwoods to increase in dominance. The site also tends to have many opportunistic plants such as three-awns (Aristida spp.) and annuals that take advantage of the short flush of available water.

The vegetation of the region developed under a humid, subtropical climate. Weather variation is great; precipitation is highly variable with seasonal, annual, and multi-year droughts (3-6 years) common as well as seasons and years with well above average precipitation; average conditions rarely exist. Typically the spring and fall are periods of highest precipitation while mid to late summer is usually a hot, droughty period. Winters are moderate with scattered precipitation sometimes in the form of short-lived snow and ice storms (Carr 1969, Bomar 1983).

Climatic variation and topographic variability interact to influence vegetation responses to disturbances such as fire and grazing. The herbaceous savannah species adapted to fire and grazing disturbances by maintaining below-ground perennating tissues. Prior to European settlement, fires would likely have been frequent (approximately every 7-12 years) (Scifres and Hamilton 1993, Frost 1998) and burned any time of year when there were ample fuels, dry conditions, and an ignition source.

Fire was a major influence on vegetation structure and composition prior to settlement. Lightning and Native Americans were primary ignition sources, and the latter is considered to have increased the frequency and extent of fire as their populations increased. Fires occurred at all seasons but those that occurred during the hot, dry, late-summer season following fine fuel (grass) accumulation in the spring and early summer were perhaps the most intense and had the greatest influence on the character of the vegetation. Fires were frequent, and any area may have burned once within each 7-12 year interval (Scifres and Hamilton 1993, Frost 1998). Fire generally favors the herbaceous component of the community and hinders the establishment and growth of woody species under intense hot, dry conditions. Some individuals of trees (e.g. oak species) and resprouting shrubs (e.g. mesquite) were able to escape fires, and as they matured, they became fire-resistant components of the vegetation except for infrequent stand-replacing crown fires. These woody species became effectively uncoupled from the herbaceous and shrub layer even if the herbaceous species composition was substantially altered by grazing or other factors. If, however, the oaks were killed or removed it is very difficult for them to reestablish into mature single-stemmed trees due to the resprouting nature of the tree, particularly under current land use conditions. While fire had influenced these communities for millennia, as the land was settled with homesteads and crops were established, fires were purposely prevented or stopped. Most of the remaining rangeland was overgrazed, which reduced fuel loads and hence effectively fire-proofed the plant communities from the effect of fires. This was a primary factor in the increase of woody species within the Central Basin.

While shrublands within MRLA 82 have traditionally been viewed as “degraded” relative to livestock production, it is important to recognize that they are not necessarily degraded from the ecological perspective of primary productivity, biomass accumulation, nutrient cycling, and biodiversity. The productivity of shrublands may be equal to or greater than that of the grassland they replaced. In addition, shrubs modify soils and microclimate to increase levels of organic matter and nutrients in the upper soils horizons (Boutton et al. 2009, Boutton & Liao 2010). This nutrient enhancement by shrubs can offset grazing-induced losses of soil nutrients and contribute to enhance grass production when shrub cover is reduced. While shrub communities may have adverse impacts on grasses and grassland fauna, other plants and animals may benefit (Archer & Smeins 1991, Bestelmeyer et al. 2003). Thus, while ecosystem biodiversity certainly changes, it does not necessarily decrease with a shift from grass to woody dominance on these sites.

Soil and topographic variation interact with weather variation and land use to produce diverse plant communities across the Central Basin and on the Tight Sandy Loam Site. Accounts of earlier explorers and settlers suggest the Central Basin was likely a mosaic of grassland, savannah, and woodlands (Foster 1917). In the historic climax plant community, midgrasses dominated the shortgrasses due to their ability to capture the sunlight and shade as well as being favored by the frequent fires. Plant communities vary from open grassland to savannah/parkland to shrubland/woodland. Almost all sites have a two or three-layered structure of over-story trees, mid-story shrubs and a ground layer of grasses and forbs.

Historical photographs suggest the nature of the vegetation structure depending on topography, soil properties, and time since the last major disturbances (such as drought or fire). However, the occurrence of extensive grasslands and grassland fauna (pronghorn, for example) is mentioned in numerous historical accounts.

Grasses that historically dominate Central Basin sites include little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), meadow dropseed (*Sporobolus compositus*), plains lovegrass (*Eragrostis intermedia*), plains bristlegrass (*Setaria vulpiseta*), Arizona cottontop (*Digitaria californica*), and sand dropseed (*Sporobolus cryptandrus*). Locally abundant tallgrasses include Indiangrass (*Sorghastrum nutans*) and switchgrass (*Panicum virgatum*). Shortgrasses that occur in the understory of mid- and tallgrasses or on shallow soils or disturbed areas include buffalograss (*Bouteloua dactyloides*), common curly-mesquite (*Hilaria belangeri*), hairy grama (*Bouteloua hirsuta*), and red grama (*B. trifida*) (Whitehouse 1933, Riskind and Diamond 1988). The composition and productivity of grassland communities would have varied with annual rainfall, soil depth, and the extent of argillic horizon development.

Historically, overstory species composition consisted of post oak (*Quercus stellata*), blackjack oak (*Q. marilandica*), live oak (*Q. virginiana*), honey mesquite (*Prosopis glandulosa* var. glandulosa), Texas hickory (*Carya texana*), elm species (Ulmus spp.) and others. The shrub layer was potentially diverse with saplings of the tree layer along with whitebrush (*Aloysia gratissima*), lotebush (*Ziziphus obtusifolia*), algerita (Mahonia trifoliata), Texas persimmon (*Diospyros texana*), prickly pear cactus (Opuntia spp.) and others.

With the exception of Ashe juniper, all native woody species found in the Central Basin readily resprout following fire. This trait has frustrated managers and played an important role in driving sites towards the Shrubland State. High numbers of fire sprouting shrubs make shrubland communities very resilient.

An important aspect of this site is the relationship of mature hardwood trees to each of the communities. Mature hardwoods are very resilient and remain constant whether surrounded by reference community grasslands, degraded grasslands, native-dominated shrublands, or invasive-dominated shrublands. Their presence or absence is not driven by grazing management and generally only slightly by prescribed fire. They remain relatively stable over a short management period (5-10 years) unless removed by mechanical or chemical means. Throughout this ecological site, mature oaks can occur in any of the communities if they were not historically removed. They are most likely to occur in mottes and remain relatively constant regardless of what is occurring in the rest of the community, particularly in the understory. Communities will have an absence of hardwoods if the hardwoods were harvested, burned, chained, or sprayed at some point. Once the hardwoods are removed, it is not easy to return to the Savannah State due to the difficulty, expense, and time involved.

Hardwoods were frequently removed from this site during the European settlement period due to their high value for construction and firewood. Additionally, many examples exist where hardwoods were removed as part of a broadscale brush removal program. This was done with chaining, herbicides, rootplowing, and other general means.

Oak mottes on this site formed under different conditions than currently found. This may be due to climate shift or increased competition from aggressive shrub species. However, while reestablishment is slow, there are many examples of second-growth hardwood woodlands on this site. Hardwoods eventually reestablish when there is a lack of fire or tree clearing.

Infection of live oak by oak wilt (Ceratocystis fagacearum) has lead to the death of many individuals and mottes. An increase in tree density and the grafting of roots amongst individuals has facilitated the spread of the pathogen, which is transmitted primarily through root connections (Appel 1995).

Ashe juniper (*Juniperus ashei*), which is very abundant on the surrounding limestone derived soils of the Edwards Plateau, is relatively uncommon in the Central Basin, but it is found scattered across the Central Basin as infrequent individuals or mottes. Observation indicates that it has been increasing in population and extent within the Central Basin during the past two decades (Walter and Wyatt 1982). Juniper has the ability to take over large tracts of land as near monocultures, known as “cedar breaks.”

Even reference sites show the influence of introduced species. King Ranch bluestem (*Bothriochloa ischaemum*) has become almost ubiquitous, occurring on sites where it has not been seeded. It tends to replace little bluestem (*Schizachyrium scoparium*) and can function similarly in the community as far as structure, size and soil-holding capacity. However, unlike little bluestem, King Ranch bluestem acts like an invader and moves to unoccupied areas.

The large ungulate fauna of the region prior to settlement consisted of bison (Bos bison), pronghorn antelope (Antilocarpa americana) and white-tailed deer (Odocoileus virginianus). Bison and pronghorn occasionally occurred in large numbers and may have intensively grazed the rangelands for short periods. However, they were largely migratory and free-roaming, so that when the forage became limited they moved on, often not to return for long periods. Their long-term impacts on the plant communities were considered to be relatively minor and may have had positive influences on production and diversity (Knapp et al. 1999, Fuhlendorf and Engle 2001).

While archeological evidence indicates that bison occurred in the region, there is also evidence of centuries of absence (Dillehay 1974). In addition, their numbers may have varied seasonally as herds migrated. When present, bison may have grazed certain areas heavily and then moved on. The infrequent but intense, short-duration grazing by these species suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). After a burn, they would intensely graze the burn until no forages remained. Then, they moved off, probably not returning until the next fire cycle, which could have been 5 – 10 years. This suggests heavy short-term grazing followed by long rest periods. Activities of other native herbivores (termites, cutter ants, soil nematodes, kangaroo rats) also influenced vegetation productivity and dynamics.

Currently, white-tailed deer are the primary native large herbivores. At settlement, large numbers of deer occurred, but as human populations increased (with unregulated harvest) their numbers declined substantially. Eventually, laws and restrictions on deer harvest were put in place which assisted in the recovery of the species. Females were not harvested for several decades following the implementation of hunting laws, which helped create population booms. In addition, suppression of fire favored woody plants which provided additional browse and cover for the deer. Due to their impacts on livestock production, large predators (red wolves (Canis rufus), mountain lions (Felis concolor), black bears (Ursus americanus) and eventually coyotes (Canis latrins)) were reduced in numbers or eliminated (Schmidly 2002).

The screwworm (Cochilomyia hominivorax) was essentially eradicated by the mid-1960s, and while this was immensely helpful to the livestock industry, this removed a significant control on deer populations (Teer, Thomas & Walker 1965, Bushland 1985).

Recent increased management of the deer herd, because of their economic importance through lease hunting, has decreased deer populations with the objectives of improving individual deer quality and improving habitat. High fences, controlled harvest based on numbers, sex ratios, condition and monitoring of habitat quality have been effective in managing the deer herd on individual properties. However, across the Central Basin, excess numbers still exist which may lead to habitat degradation and significant die-offs during stress periods such as extended droughts.

The Central Basin is home to a variety of non-indigenous (exotic) ungulates, mostly introduced for hunting (Schmidly 2002). These animals are important sources of income to some landowners, but as with the white-tailed deer, their populations must be managed to prevent degradation of the habitat for themselves as well as for the diversity of native wildlife in the area. Many other species of medium and small sized mammals, birds, and insects can have significant influences on the plant communities in terms of pollination, herbivory, seed dispersal, and creation of local disturbance patches, all of which contribute to the plant species diversity.

Supplemental feeding of deer and exotics can also contribute to range degradation if it allows survival of excess numbers of animals.

Feral hogs have become well established within the Central Basin. Hogs use all of the ecological sites within MLRA 82. They cause considerable damage to soils and vegetation.

The faunal array of the Central Basin changed radically with the introduction of domestic species. Early on, wild mustangs released from early Spanish settlements roamed in large herds and had significant impacts on the vegetation. Later in the 19th century, cattle, sheep, goats, mules, and hogs were introduced. The pristine rangeland appeared to provide unlimited forage but as the ranges were fenced and overstocked they were degraded. Productivity of the rangeland began to decline, carrying capacity was reduced, and periodic die-offs of livestock occurred. Generally, the mid and taller grasses were replaced by short grasses and perennial grasses, and forbs were replaced by annuals. These changes not only reduced production but also in many instances caused permanent alteration of the ecological sites due to soil erosion, organic matter loss, compaction, moisture regime change, and other factors which altered many soil and hydrologic processes. This often precluded their recovery to pre-European conditions (Smith 1899, Smeins, Fuhlendorf and Taylor 1997). Not only did livestock overgraze the forage, but they also contributed to seed dispersal of some woody plants, particularly honey mesquite, which exacerbated its increase on the rangelands.

Historical accounts prior to the 1800s also identify grazing by herds of wild horses, followed by heavy grazing by sheep and cattle as settlement progressed. Grazing on early ranches changed natural graze-rest cycles to continuous grazing and stocking rates exceeded the carrying capacity. By the early 1800s cattle, sheep, and goat numbers appear to have been quite high in the Central Basin, resulting in heavy, year-round grazing (Lehman 1969). Sheep numbers peaked at 10.8 million head in 1943 and stood at about 1.2 million in 2000. Goat numbers in Texas around 1900 were around 100,000. They peaked in 1965 at 4.6 million and were 345,000 in 2000 (Texas Online). The Central Basin and Edwards Plateau region, because of its climate and diverse vegetation, was the mainstay of the Texas sheep and goat industry.

Today, beef cattle and horses are the primary grazers in the area. Goats used primarily for meat production are locally important, and their numbers have increased. Sheep remain a minor but still important part of livestock grazing in the Central Basin. White-tailed deer, wild turkey, bobwhite quail, and doves are major commercial wildlife species, and hunting leases are a major source of income for many landowners. While the Central Basin ecological sites have changed in many ways since settlement, opportunities exist to produce products and provide income while conserving and sustaining the long-term stability and productivity of the area.

Homesteads and communities developed along with ranching, and many ecological sites within MLRA 82 were converted to cropland for wheat (Triticum spp.), oats (Avena spp.), forage, and peanuts (*Arachis hypogaea*), and other products needed for local consumption or for cash crops. This conversion effectively eliminated the native plant communities due to land clearing and the harvest of larger trees, used for building construction among other uses.

Over time, as many of the croplands became degraded, and along with the rangeland that had been overused, introduced forages were brought in to assist with soil and water conservation and to increase productivity. Coastal Bermudagrass (*Cynodon dactylon*), Kleingrass (*Panicum coloratum*), Wilman lovegrass (*Eragrostis superba*) and King Ranch bluestem were widely planted on many acres of old cropland and in areas with deeper soils. The latter, while effective as a soil stabilizer, has become invasive in many areas where it is unwanted and is difficult to control.

In the 1940s, mechanical and herbicide treatments began to replace fire as a control of increasing density of woody plants on the rangeland. This activity was common practice for several decades until the 1980s, when these treatments became less cost-effective. It was clear that brush management practices were treating symptoms rather than underlying problems in addition to their undesirable environmental and wildlife consequences. Sites cleared of brush regenerated rapidly and often formed thickets that were denser and of lower diversity than the original stands. This realization coupled with the fact that brush management treatments were typically expensive and short-lived, lead to the development of Integrated Brush Management Systems (Scifres et al. 1985). This approach takes a holistic, large-scale, long-term, socioeconomic, ecosystem-based approach to brush management and recognizes multiple-use options for rangeland resources including alternate classes of livestock, lease hunting, exotic game ranching, carbon credits and ecotourism.

Grazing and fire are two factors that critically influence the relative abundance of grasses and woody plants through time. The resulting reduction in abundance of late seral grasses lead to a decline in soil organic matter, a reduction in fire frequency/intensity (due to lack of fine fuels), and a shift in dominance from midgrasses (little bluestem and sideoats grama) to shortgrasses (hooded windmillgrass (*Chloris cucullata*) and buffalograss) and forbs (Mexican sagewort (*Artemisia ludoviciana* ssp. mexicana) and croton (Croton spp.)). These changes would have favored woody plants, most of which are unpalatable to livestock, and enabled them to establish and maintain dominance.

Mesquite, whitebrush, juniper, lotebush, algerita, persimmon, prickly pear, and lime pricklyash (Zanthoxylum fagar) now dominate much of the Central Basin. These woody plants are not 'new arrivals' but rather, are native to the region and have increased in size and abundance within their historic ranges. Factors promoting their increase in abundance since European settlement are the subject of active debate. Such factors may involve an interactive combination of changes in climate, intensification of grazing, follow up brush management, and reductions in fire frequency/intensity accompanied by increases in atmospheric CO2 concentrations and nitrogen deposition since the industrial revolution (Archer 1994).

Rangeland Health Reference Worksheets have been posted for this site on the Texas NRCS website (www.tx.nrcs.usda.gov) in Section II of the eFOTG under (F) Ecological Site Descriptions (ESD's).

State and Transition Model:
A State and Transition Model for the Tight Sandy Loam Ecological Site (R082AY378TX) is depicted in Figure 1. Thorough descriptions of each state, transition, plant community, and pathway follow the model. Experts base this model on available experimental research, field observations, professional consensus, and interpretations. It is likely to change as knowledge increases.

Plant communities will differ across the MLRA due to the naturally occurring variability in weather, soils, and aspect. The Savannah State is the reference state for this site. It is not necessarily the management goal but can be. Other vegetative states may be desired plant communities as long as the Range Health assessments are in the moderate and above category. The biological processes on this site are complex. Therefore, representative values are presented in a land management context. The species lists are representative and are not botanical descriptions of all species occurring, or potentially occurring, on this site. They are not intended to cover every situation or the full range of conditions, species, and responses for the site.

Both percent species composition by weight and percent canopy cover are used in this ESD. Most observers find it easier to visualize or estimate percent canopy for woody species (trees and shrubs). Canopy cover drives the transitions between communities and states because of the influence of shade and interception of rainfall. Species composition by dry weight is used for describing the herbaceous community and the community as a whole. Woody species are included in species composition for the site. Calculating similarity index requires the use of species composition by dry weight.

The following diagram suggests some pathways that the vegetation on this site might take. There may be other states not shown in the diagram. This information is intended to show what might happen in a given set of circumstances; it does not mean that this would happen the same way in every instance. Local professional guidance should always be sought before pursuing a treatment scenario.

State and transition model

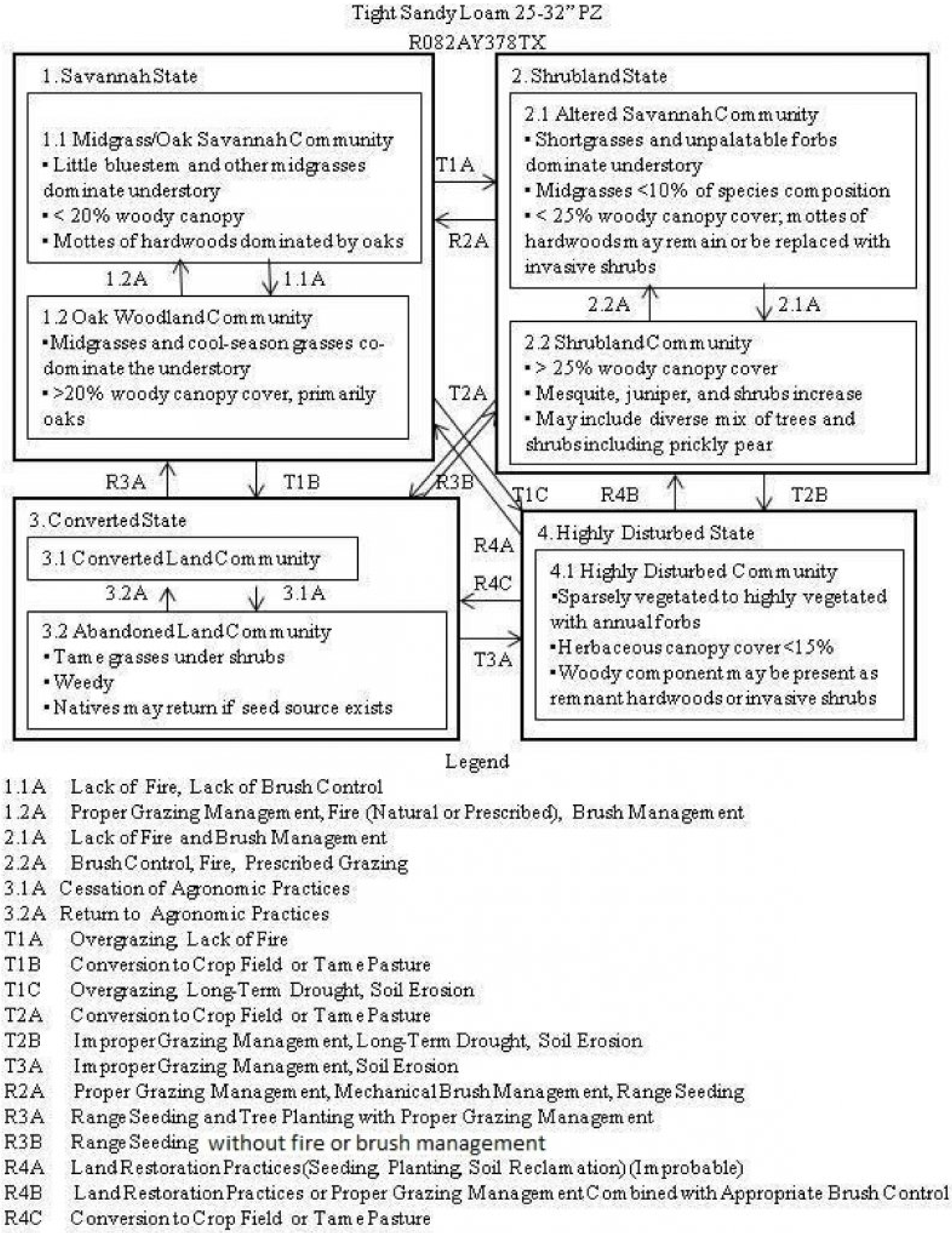

Figure 9.

State 1
Savannah State

There are two communities in the Savannah State: the Midgrass/Oak Savannah Community (1.1) and the Oak

Woodland Community (1.2). The Midgrass/Oak Savannah Community occurred over the majority of this ecological site in a dynamically shifting mosaic over time with the Oak Woodland Community. Prior to settlement, the Tight Sandy Loam ecological sites had a savannah appearance with open areas dominated by mid grasses (little bluestem and sideoats grama) interspersed with scattered mottes dominated by oaks. The Midgrass Savannah Community (1.1) may have up to 20 percent canopy cover while the Oak Woodland Community will have more than 20% woody canopy. Relatively frequent fires (7-12 year mean fire return interval) (Frost 1998) maintained the open areas by killing shrubs that were not yet to a fire resistant height. Mature hardwoods found in the mottes were long-lived and resistant to ground fires. Fires are natural or human-induced. When fires were frequent on the savannah, most fires burned only the understory, leaving mottes of trees. Even with proper grazing and favorable climate conditions, lack of fire for 7-12 years will allow trees and shrubs to increase in the canopy to reach the 20 percent level that indicates the shift to the Oak Woodland Community. This transition is not dependent on the degradation of the herbaceous community, but on the lack of some form of brush control. Shrub species would increase within the grassland portion of the savannah and within the understory of the mottes following fire. Fine fuels were continuous and of sufficient quantity to allow fire to reduce the cover of young brush and trees but not of sufficient quantity to create crown fires that would reduce the cover of single-stemmed mature trees. Therefore, the savannah would be relatively open for a short period following a fire, then shrubs would reestablish, reducing the savannah appearance. Fire would return in 10 years or less; this fire would reduce the cover of young shrubs and trees without reducing mature trees returning the savannah appearance and shifting species composition back to dominance by little bluestem and other grasses. Occasionally a site would not burn for a period long enough for trees to grow to a fire resistant stage within the grassland portion of the savannah. As these trees matured, the fine fuel understory would decrease, reducing the ability of fires to grow large enough (and hot enough) to kill mature trees. This long-term lack of fire (25 - 50 years) would allow large trees to fill in open areas shifting the site to a woodland appearance. Once the site had dense tree cover, the site would be resistant to fires and a very resilient woodland community would develop. In the absence of fire, the Oak Woodland Community (1.2) dominated the site with a nearly closed canopy stand of hardwoods, including oak (Quercus spp.) and pecan (Carya spp.). The two communities in the Savannah State shifted between one another depending on the frequency and intensity of fire, grazing, and drought. The primary influence on the understory is grazing management and the primary influence on the overstory is fire. This allows the understory and overstory to react independently, i.e., trees can increase to the point where they dominate a site even if the understory component remains vigorous and intact. Grazing management alone cannot maintain the site in the Midgrass/Oak Savannah Community (1.1). It was rare that a dense woodland community would shift to a grassland or savannah community. In order to do so, something would have to cause widespread die-off of mature trees. This could occur due to disease or to a very hot fire that spread to the tree crowns that reduced the canopy cover of the mature single-stemmed trees, events that typically only occur every 300 to 1,000 years. Following a severe fire, the site would have a grassland appearance for a few years as shrubs and trees resprouted or grew from seed. Shrubs and trees comprise a portion of both plant communities in the Savannah State (1.0), hence woody propagules are present. The Savannah State always has the potential for shrub dominance without fire. Mann (2004) discussed the importance of human-caused fire as an important factor in maintaining open grasslands before European settlement. The relationship between the two communities in the Savannah State remains similar post-settlement. However, natural fires become less frequent and less widespread as human population density increases. “Cool”, slow-burning wildfires have become basically non-existent, because they are relatively easy to put out using modern firefighting equipment and techniques. Without fire, the reference savannah community becomes less resilient. Unless managers practice some method of brush control, shrub species will increase in the grassland portion of the savannah and in the understory of the oak mottes. Brush control can play the role that natural fires played pre-settlement. However, it is difficult to manage in an ecological and economic matter on a small scale, as this site is rapidly repopulated by shrubs and trees without fire or brush management. Brush control may be prescribed fire, mechanical, chemical, or biological control, or targeted grazing (generally by goats, although some instances exist in the Central Basin where exotic wildlife species or overpopulated white-tailed deer reduce woody cover). The savannah is more often observed with mowing or haying than with grazing management. There are examples of this site being maintained as a savannah with introduced hay meadows and mottes of trees.

Community 1.1
Midgrass/Oak Savannah Community

Figure 10. 1.1 Midgrass/Oak Savannah Community

The Midgrass/Oak Savannah Community (1.1) reference community is a savannah characterized by expanses of grassland dominated by little bluestem and sideoats grama interspersed with mottes of mature live oak and post oak. This community requires relatively frequent fire and/or brush control (every 5 to 10 years) to maintain the savannah appearance. Without fire or some form of long-term brush management, shrubs will begin to dominate the open areas eventually resulting in a nearly closed canopy of shrubs and trees. The Midgrass/Oak Savannah Community remains the presumed reference community. It is possible to have a reference community understory with a savannah appearance but the woody portion of the savannah is populated by low-growing shrubs and second growth native hardwoods. The community can be maintained through the implementation of fire and brush management, combined with properly managed grazing that provides adequate growing season deferment to allow the establishment of midgrass propagules and/or the recovery of the vigor of stressed plants. Little bluestem, sideoats grama, meadow dropseed, vine mesquite, and plains lovegrass dominate the herbaceous component of the site. Forbs commonly found on the site include Mexican sagewort, bundleflower, Engelmann’s daisy, western ragweed, orange zexmenia, and sensitive briar. Shrub and tree species found in the Midgrass/Oak Savannah Community (1.1) include species of oaks, whitebrush, pricklypear, and honey mesquite. Shrubs continually increase in the open areas of the savannah and in the understory of the mottes. This pressure to move towards a woodland or shrubland community if further increased when aggressive, invasive shrubs become a part of the community. Although large, land-clearing crown fires are relatively rare, similar impacts to the mature hardwoods occur when trees are cleared from the site by logging, chaining, or spraying. If a manager combines woodland removal with proper grazing management and ongoing, maintenance level brush control, a woodland community could shift to a grassland community, mimicking the natural shift that occurred with large land-clearing fires. Maintaining the grassland would require diligent brush control. There are examples where intensive targeted grazing with goats has maintained a grassland or savannah community on this site. The grassland and open savannah communities have proven to be difficult to manage on this site. This is due to the difficulty in combining effective brush management with grazing management that provides for grazing events of proper intensity and sufficient periods of deferment.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	1725	2160	2590
Forb	95	120	145
Tree	80	95	115
Shrub/Vine	20	25	30
Total	**1920**	**2400**	**2880**

Figure 12. Plant community growth curve (percent production by month). TX4411, Midgrass Savannah with Woody Encroachment. Midgrass Savannah with Woody Encroachment..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Community 1.2
Oak Woodland Community

Figure 13. 1.2 Oak Woodland Community

The Oak Woodland Community is presumed to have historically covered a minority of this ecological site. Over time the oak/ mottes would expand while mature trees and shrubs increased in canopy cover responding to the fire/grazing/rest dynamics. The understory vegetation in the openings between trees would remain similar in composition to that of the Midgrass/Oak Savannah Community (1.1). However, as tree density increased, cool-season grasses and forbs would increase in species composition. Cool-season species increase as the distance to drainages decreases due to increased tree cover and shade near drainages. Dominant species in the Oak Woodland Community are similar to those found in the Midgrass/Oak Savannah Community, but species composition shifts to dominance by trees and shrubs. There is also an increase in cool-season grasses and forbs. Texas wintergrass (*Nassella leucotricha*) and Canada wildrye (*Elymus canadensis*) increase in production. There also tends to be an increase in the amount of shrubs growing in the understory of the hardwoods and in the open areas of the savannah.

Table 6. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Tree	765	960	1155
Grass/Grasslike	480	600	720
Shrub/Vine	385	480	575
Forb	290	360	430
Total	**1920**	**2400**	**2880**

Figure 15. Plant community growth curve (percent production by month). TX4422, Oak Woodland Community. Oak woodland community with >20% woody canopy, primarily oaks.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3	3	5	13	22	15	5	3	15	7	5	4

Pathway 1.1A
Community 1.1 to 1.2

Midgrass/Oak Savannah Community

Oak Woodland Community

The driver for community shift 1.1A is lack of fire and/or brush control to maintain the woody component as mottes of mature oak and other hardwoods. Native woody species canopy exceeding 20 percent indicates a shift to the Oak Woodland Community (1.2). The Midgrass/Oak Savannah Community requires fire and/or brush control to maintain the savannah appearance with woody species cover below 20 percent. Regardless of the composition and vigor of the herbaceous component, this community will shift to the Oak Woodland Community without effective brush control. This shift can occur even with proper grazing management and if the herbaceous component remains vigorous. Brown and Archer (1999) concluded that even with a healthy and dense stand of grasses, woody species would populate the site and eventually dominate the community.

Pathway 1.2A
Community 1.2 to 1.1

Oak Woodland Community

Midgrass/Oak Savannah Community

Fire/brush control and proper grazing management drive community shift 1.2A. The shift from Oak Woodland Community (1.2) to Midgrass/Oak Savannah Community (1.1) is thought to have been infrequent historically, as large, crowning fires would be required to remove mature trees found in the Oak Woodland Community. Smaller repeated fires over long periods of time would result in some bark damage to older oaks and subsequent introduction of disease to the tree, resulting in hollow or dead trees. The Oak Woodland Community can return to the Midgrass/Oak Savannah Community with fire and/or brush management combined with proper grazing management that provides sufficient critical growing season deferment in combination with proper grazing intensity. Favorable moisture conditions will facilitate or accelerate this transition.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing

State 2
Shrubland State

The Shrubland State is characterized by trees, a significant shrub cover, and a shortgrass- understory. Two communities represent this state and are distinguished by the amount of shrubs present. The Altered Savannah Community (2.1) is characterized by having less than 25% canopy cover by woody species. The Shrubland Community (2.2) is characterized by having more than 25% woody canopy cover. The understory may similar in both. The Shrubland State has typically lost the savannah appearance. The hardwoods that made up a portion of the plant community in the Savannah State (1.0) may or may not be present in the Shrubland State (2.0). The transition to the Shrubland State will not cause a decrease in the number of hardwoods. However, the Shrubland State often occurs on lands that have been cleared of brush and trees at some point in the past. Trees were removed for lumber or firewood, in some cases to clear the land for pasture or farming. Rootplowing had the same effect as tillage, converting the site to grassland immediately following plowing but leaving the site subject to rapid invasion by fast-growing shrub species. This transition may respond like agricultural conversion and may have been accompanied by shifts in soil chemistry and structure. Rootplowing is likely to shift the community to the Oak Woodland Community (2.2). Once invasive woody species begin to establish, returning fully to the native community is difficult, but it is possible to return to a similar plant community. The understory of the Shrubland State tends to be dominated by shortgrasses and lower-palatability forbs. The communities in the Shrubland State have a degraded herbaceous community when compared to the Savannah State. This is generally a result of long-term improper grazing management.

Community 2.1

Altered Savannah Community

Figure 16. 2.1 Altered Savannah Community

Figure 17. 2.1 Altered Savannah Community (2)

The Altered Savannah Community is characterized by woody canopy cover less than 25 percent. The community loses its savannah appearance with introduced and native shrubs beginning to fill the open grassland portion of the savannah. Shade from overstory is a driving factor in maintaining a degraded understory. Production of the overstory canopy has increased by a similar amount to the decrease in herbaceous production. Unpalatable woody species have increased in size and density. This community results from the lack of effective brush control and improper livestock grazing management over a long period. One factor that creates overgrazing is the failure to adjust the stocking rate downward as woody cover increases. Increased woody cover results in less forage being available. Unless stocking rates are reduced, the stocking pressure on the remaining forage increases, which increases the likelihood of palatable plants being overgrazed, losing vigor, and being grazed out of the community. At the same time, less palatable plants gain a comparative advantage and increase their representation in species composition. The Altered Savannah Community (2.1) supports a lower diversity of uses than the Midgrass Savannah Community (1.1) it replaces. Generally, the shrubs preclude the establishment of remnant reference community plants. In this plant community, annual production is dominated by woody species. Goats and deer can find fair food value if browse plants have not been grazed excessively. Forage quantity and quality for cattle is low. Grazeable acreage is only 30 to 50 percent of the total area. Drought interacts with grazing to trigger midgrass to shortgrass transitions. Heavy continuous grazing will reduce plant cover, litter, and mulch. Bare ground will increase and expose the soil to erosion. Litter and mulch will move off-site as plant cover declines. The Altered Savannah Community requires some form of brush control (fire, mechanical, chemical, or grazing) for maintenance. Without brush control, it will shift to the Shrubland Community in a relatively short time (5-15 years). The open areas of the Altered Savannah Community will have shrubs sprout every year. As these plants mature, they will fill in the open areas. Once canopy cover of woody species reaches 25 percent, the site has shifted to the Woodland Community. The Altered Savannah Community (2.1) is much less productive than the communities in the Savannah State (1.0). Because grazing causes reductions in root production and rooting depth, aboveground production becomes more erratic and more dependent on rainfall as plants are less effective at accessing stored soil water. Reductions in aboveground cover and root biomass make this community more prone to runoff and erosion. Reduction in ground cover leads to higher soil temperatures that, in conjunction with a reduction in leaf and root biomass inputs, cause declines in soil organic matter. This reduces soil water holding capacity and fertility that create feedback to further affect species composition and production. Woody plants may not increase in size or density but will increase in relative species composition due to the decline in production of the herbaceous component. Examples of the Altered Savannah Community within the Central Basin that have remained in this community have frequently been maintained with a combination of fire and goat grazing.

Table 7. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Grass/Grasslike	480	600	720
Shrub/Vine	360	450	540
Tree	240	300	360
Forb	120	150	180
Total	**1200**	**1500**	**1800**

Figure 19. Plant community growth curve (percent production by month). TX4417, Altered Savannah Community, 15-30% canopy. Shortgrasses dominate after midgrasses decline. Woody canopy approaches 15-30%..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	2	5	10	18	15	5	9	15	9	5	5

Community 2.2
Shrubland Community

Figure 20. 2.2 Shrubland Community

Figure 21. 2.2 Shrubland Community (2)

The Shrubland Community (2.1) has over 25 percent woody plant canopy, dominated by hardwoods and shrubs.

The community loses its savannah appearance with native shrubs beginning to fill the open grassland portion of the savannah. Shade from the overstory is the driving factor. This community results from the lack of effective brush control. Production of the overstory canopy has increased by a similar amount to the decrease in herbaceous production. Unpalatable woody species have increased in size and density. The Shrubland Community typically has multiple shrub species: Texas persimmon, mesquite, whitebrush, catclaw, yucca, and/or juniper. Heavy continuous grazing will cause midgrasses to give way to shortgrasses such as red grama and sod-forming grasses. Texas wintergrass, three-awns (Aristida spp.) and annuals increase in the shade of the trees. Unpalatable invaders may occupy the interspaces between trees and shrubs. Plant vigor and productivity of grass species is reduced due to shade. Shade is a driving factor for the understory plant community. Without brush control, tree canopy will continue to increase until canopy cover approaches 80 percent. The Shrubland Community is currently the most common community on Tight Sandy Loam sites. Unless managers practice effective, ongoing brush control this community will remain or reestablish. In the absence of fire and brush management, a highly stable and resilient Woodland Community (2.2) develops as woody patches increase in abundance and coalesce with each other. Shrubs mix with oaks to create a canopy cover of greater than 30 percent. Ground cover and herbaceous production beneath shrub canopies is minimal, but soil organic carbon and nitrogen levels are enhanced. A sparsely vegetated community is not stable on this site. Shrubs and invasive grasses and forbs reestablish relatively quickly following disturbance. Because of the availability of invasives with low palatability, this site rarely stays barren. There are examples that are degraded but not yet dominated by brush but these examples tend to be quickly reinvaded by brush. In this plant community, annual production is dominated by woody species. Goats and deer can find fair food value if browse plants have not been grazed excessively. Forage quantity and quality for cattle is low. Intensive treatment is required to affect restoration back to the Savannah State (1.0). Prescribed burning may not be possible until the woody cover is reduced by herbicides or mechanical treatments to the point that grasses (fine fuels) can establish. Brush treatment tends to be short-lived. Observation shows that even effective treatment will require constant maintenance to suppress brush reestablishment. Without maintenance, canopy cover may exceed 30 percent in 3 to 5 years.

Table 8. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	640	800	960
Tree	400	500	600
Grass/Grasslike	400	500	600
Forb	160	200	240
Total	**1600**	**2000**	**2400**

Figure 23. Plant community growth curve (percent production by month). TX4416, Shrubland Community, 30+% Woody Canopy. Shrubs dominate the site with heavy continuous grazing and no brush management. Woody canopy exceeds 30%. Grasses are in further decline..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	2	5	10	18	15	5	9	15	9	5	5

Pathway 2.1A
Community 2.1 to 2.2

Altered Savannah Community

Shrubland Community

The drivers for community shift 2.1A are lack of fire and/or brush control and overgrazing. Without brush control (including fire), the Altered Savannah Community (2.1) will shift to the Shrubland Community (2.2). Shrubs will continue to increase until they reach 25 percent canopy cover. Once shrubs have more than 25 percent canopy cover, management back to the Altered Savannah Community becomes more difficult due to the amount of energy required to remove dense brush. Overgrazing and/or long-term drought (or other growing season stress) will accelerate this shift from the Altered Savannah Community (2.1) to a Shrubland Community (2.2). Increasing growing season stress will reduce the density and vigor of the herbaceous component, which will allow additional opportunity for shrub seedlings and sprouts to establish. The understory may be a mix of shortgrasses and cool-season grasses. Even with proper grazing, in the absence of fire, the woody component will increase to the point that the herbaceous component will decline in production and shift in composition toward sedges, short grasses, cool-season grasses and forbs suited to growing in shaded conditions with reduced available soil moisture.

Pathway 2.2A
Community 2.2 to 2.1

Shrubland Community

Altered Savannah Community

The driver for community shift 2.2A is fire and/or brush control and reseeding. Extensive and selective brush management can reduce the woody component of the Shrubland Community (2.2) below the community shift level of 25 percent woody canopy cover. It may be difficult to shift back to the Altered Savannah Community (2.1) with fire alone due to the lack of fuel provided by the understory and height of the canopy cover. Fire can reduce seedlings of brush species if the seedling is younger than 2 years or the budding zone has not transitioned below the soil surface (Kramp et al 1999). Fire and/or brush management will be required to maintain woody canopy cover below the 25 percent level. The limitations with fire are amplified if the understory transitions to cool-season grasses. If the herbaceous component has transitioned to shortgrasses and low forbs, proper grazing management (combined with favorable moisture conditions and adequate seed source) will be necessary to facilitate the shift of the understory component in the Shrubland Community (2.2) to the Altered Savannah Plant Community (2.1).

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing
Range Planting
Planned Grazing System
Native Plant Community Restoration and Management

State 3
Converted State

The Converted State (3.0) includes cropland, tame pasture, hayland, rangeland, and go-back land. Agronomic practices are used with non-native forages in the Converted State and to make changes between the communities in the Converted State (3.0). Cropland and tame pasture require repeated and continual inputs of fertilizer and weed control to maintain the Converted State.

Community 3.1
Converted Land Community

The Converted Land Community (3.1) occurs when the site, either the Savannah State (1.0) or Shrubland State (2.0), is cleared and plowed for planting to cropland, hayland, native grasses, tame pasture, or use as non-agricultural land. The native component is usually lost when seeding non-natives. Even when reseeding with natives, the ecological processes defining the past states of the site can be permanently changed. Some Tight Sandy Loam sites were converted to cropland or tame pasture sites because of its fertile soils, favorable soil/water/plant relationship, and gently rolling terrain when producers' objectives were to provide alternative forages during specific times of the year. Small grains are the principal crop, and bermudagrass is the primary introduced pasture species on tight sandy loam soils in this area. The site can be a productive forage producing site with the application of optimum amounts of fertilizer. Refer to Forage Suitability Group Descriptions for specific management recommendations, estimated production potentials, and species adaptation. Cropland, pastureland, and hayland rely on the use of herbicides, pesticides, and commercial. Both crop and pasturelands require weed and shrub control because their seeds remain on the site or are transported there. Common introduced species include hybrid bermudagrass, Kleingrass, Wilman lovegrass, and Old World bluestems (Bothriochloa spp.). Newly seeded stands are prone to invasion by annual and perennial weeds and woody plants, so proper grazing and brush/weed management are required for their maintenance. The rate of woody plant re-establishment will depend on the brush management practice initially used to clear the site, seedbed preparation technique, proximity to undisturbed shrub stands and the rate of livestock and wildlife transporting seeds. Stands seeded to native grasses are also susceptible to invasion by non-native, aggressive pasture grasses such as King Ranch bluestem and seeded bermudagrass. These exotic species, while providing forage and soil stability, may be very difficult to eliminate once established. Production of these introduced forage grasses may exceed that of native grasses when fertilized. However, the extent to which introduced grasses provide better forage than native grasses is debatable, especially when their adverse effects on wildlife are taken into account. Conversion of introduced pasture back to native grassland is difficult and typically requires aggressive and costly management intervention. Given the potentially adverse long-term effects of exotic grasses on native grassland flora and fauna, their use should be critically and carefully considered.

Figure 24. Plant community growth curve (percent production by month). TX4400, Cool-season Small Grain. Community planted into cool-season grasses such as wheat and oats..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5	5	10	10	5	0	0	0	20	25	15	5

Figure 25. Plant community growth curve (percent production by month). TX4401, Warm-Season Cropland. Community planted into warm-season crops such as forage sorghum..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	8	20	25	20	10	10	5	2	0	0

Community 3.2
Abandoned Land Community

Figure 26. 3.2 Abandoned Land Community

The Abandoned Land Community (3.2) occurs when the Converted Land Community (3.1) is abandoned or mismanaged. Mismanagement can include poor crop or haying management and no brush control. Pastureland can transition to the Abandoned Land Community when subjected to improper grazing management (typically long-term overgrazing). Heavily disturbed soils allowed to “Go Back” return to the Shrubland State (2.0). Abandoned croplands and land seeded with introduced or native grasses are prone to encroachment by woody plants. These areas will revert to shrublands with no fire or brush management. These changes seem to be triggered by recruitment and growth of shrub plants in periods following drought. The shrub ‘seedlings’ that appear in seeded pastures may be true seedlings established from seeds dispersed to the site by wind, water or animals or from seeds which persist in the soil seed bank long after the woody cover has been reduced by brush management practices. Other ‘seedlings’ may actually be sprouts arising from woody plant stems, roots and burls that remain following brush management. These resprout ‘seedlings’ tend to grow faster and have higher establishment rates than true seedlings. Many shrubs on this site have this capability of vegetative regeneration which allows plants to re-establish following brush management. Proper grazing and brush management are required to prevent woody plant ‘seedlings’ from dominating the site. However, once established, grazing alone will not prevent the brush from overtaking. Goats may have some value in maintaining brush but even they may not browse on all brush to the point of control. Long-term cropping can create changes in soil chemistry and structure that make restoration to the reference state very difficult and/or expensive.

Table 9. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	300	375	450
Forb	120	150	180
Grass/Grasslike	120	150	180
Tree	60	75	90
Total	**600**	**750**	**900**

Figure 28. Plant community growth curve (percent production by month). TX4415, Abandoned Converted Land Community. Warm-season tame pasture with peak biomass production in April, May and June with a lesser peak in September and October..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	2	18	23	17	6	4	16	6	3	2

Pathway 3.1A
Community 3.1 to 3.2

The Converted Land Community (3.1) will transition to the Abandoned Land Community (3.2) if improperly managed as cropland, hayland, or pastureland. The driver of this transition is the lack of management inputs necessary to maintain cropland, hayland, or pastureland.

Pathway 3.2A
Community 3.2 to 3.1

The Abandoned Land Community (3.2) will transition to the Converted Land Community (3.1) with proper management inputs. The drivers for this transition are weed control, brush control, tillage, proper grazing management, prescribed burning, and range or pasture planting.

Conservation practices

Brush Management
Conservation Crop Rotation
Prescribed Burning
Forage and Biomass Planting
Prescribed Grazing
Grazing Land Mechanical Treatment
Range Planting
Nutrient Management
Integrated Pest Management (IPM)
Planned Grazing System

State 4
Highly Disturbed State

This state is characterized by a single community, the Highly Disturbed Community (4.1). The Highly Disturbed State has the potential to be a terminal state. Due to the relatively high risk of severe soil erosion of the sandy loam soils, this site can erode to the point where there is a loss of soil functionality. When this level of erosion occurs, the site loses soil structure, soil fertility, organic matter, and/or soil microflora. There are examples of the loss of the A and B horizons and some with the soil eroded to bedrock. Once the site loses soil horizons or soil functions, it is very difficult or impossible to return the site to one of the other States, resulting in State 4 being a terminal state.

Community 4.1
Highly Disturbed Community

Figure 29. 4.1 Highly Disturbed Community

The Highly Disturbed Community (4.1) is characterized by a variety of thick shrubs and a small component of the herbaceous community with few palatable perennial species present. The shrubs may be dense in areas where shrubs can find adequate moisture in the eroded soils. This community occurs only where significant loss of soil depth, function, or fertility has occurred. Due to their aggressive nature, invasive shrubs, grasses, and forbs reestablish relatively quickly following disturbance if there is adequate soil left. This community is frequently associated with significant soil erosion and/or disturbance. Erosion creates a loss of soil structure and fertility and in severe conditions may expose bedrock. Soils may erode to the point that they can no longer be managed back to any of the other states.

Figure 30. Plant community growth curve (percent production by month). TX4414, Sparsely Vegetated Community. Vegetation loss and increase of bare ground..

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	2	5	10	18	15	5	9	15	9	5	5

Transition T1A
State 1 to 2

The driver for Transition T1A is lack of brush management coupled with overgrazing. Overgrazing, lack of fire, and/or improper brush management will result in the site crossing a threshold to the Shrubland State (2.0) characterized by shortgrasses, unpalatable grasses and forbs, annual grasses and forbs, and shrubby species. Bare ground, erosion, and water flow patterns will increase, and forage production will decline. Without regular fire, woody species will increase in size, density, and canopy cover, reducing production from herbaceous species. Woody species composition may vary greatly depending largely on management. Trees will be present if they were not historically removed. More frequently, the woody component is made up of many species of widely scattered shrubs. Overgrazing causes a loss of dominant midgrasses and forbs from the savannah. This transition is indicated by a decrease of little bluestem and sideoats grama to less than 10 percent of species composition of the herbaceous community. Once these species are lost from the community or present only in trace amounts (typically with low vigor), grazing management alone cannot create a shift back to the reference community. At this point, a threshold has been crossed indicating a change in state. Degradation of the herbaceous community combined with the aggressive nature of shrubs creates a loss in the savannah appearance of the site. The grassland portion is reduced and the trees exist in competition with aggressive shrubs. This competition limits the ability of trees to reproduce and increase. The aggressive nature of shrubs keeps the Savannah State (1.0) at high risk of transition to the Shrubland State (2.0). The possible exception would be the skilled use of goats to target and suppress the shrubs. The trigger for this transition comes when shrubs reach reproductive capacity. Overgrazing, prolonged drought, no fire or brush management and a warming climate will provide a competitive advantage to shrubs.

Transition T1B
State 1 to 3

The threshold for this transition is the land-clearing to remove the woody plant community. The transition to the Converted State from the Savannah State (1.0) occurs when the grassland is cleared and planted to cropland or hayland. The Converted State includes cropland, hayland, tame pasture, and go-back land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return of native plants or escaped introduced plants.

Transition T1C
State 1 to 4

This transition occurs when the Tight Sandy Loam site is subject to aggressive brush control, drought, and overgrazing. Broadcast brush control includes chaining, rootplowing, and chemical treatment. Seeding may or may not be done. The effects may be seen as a loss of vegetative cover, loss of soil, and destruction of soil structure or soil health. In some cases, this erosion can be extreme enough to result in the loss of the A (and even B) horizons.

Restoration pathway R2A
State 2 to 1

The driver for Restoration Pathway R2A is fire and/or brush control combined with the restoration of the herbaceous community or active management of the herbaceous restoration process (range seeding). Restoration may require aggressive treatment of invader species. Restoration of the Shrubland State to the Savannah State (R2A) requires substantial energy input. An integrated approach of biological, mechanical and chemical brush control in combination with prescribed fire, proper grazing, and favorable growing conditions is the most economical means of creating and maintaining the desired plant community. A long-term prescribed fire program may sufficiently reduce brush density to a level below the threshold of the Savannah State (1.0). However, the fire program will have to be aggressive because many of the woody species on this site are resprouters following fire and fuel loading is marginal. Establishment of native grasses is difficult and dependent upon natural seeding from remnant patches and seed banks. If remnant populations of midgrasses and desirable forbs are not present at sufficient levels, range planting will be necessary to restore a desirable herbaceous plant community. Proper grazing management and stocking rates maintain the herbaceous layer in this state. With proper grazing management, midgrasses can regain dominance on the site and undesirable trends in soil organic matter, fertility, temperature, and erosion can be arrested and reversed. Re-growth of established woody plants will slow and it will become more difficult for new plants to establish. The extent to which the original Midgrass/Oak Savannah Community (1.1) can be re-established will depend on the extent to which soil physical and chemical properties were altered during retrogression (Heitschmidt and Stuth 1991).

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing
Planned Grazing System
Native Plant Community Restoration and Management

Transition T2A
State 2 to 3

The Shrubland State (2.0) is a very stable state, and transition to the Converted State (T2A) will require high energy input. The threshold for this transition is the plowing of the soil and removal of the woody plant community. The size and density of brush will require heavy equipment and energy-intensive practices (i.e. rootplowing, raking, roller-chopping, or heavy disking) to prepare a seedbed. The Converted State includes cropland, tame pasture, hayland and “go-back” land. The site is considered “go-back land” during the period between cessation of active cropping, fertilization, and weed control and the return to the “native” states, even though the returning vegetation may be introduced plants.

Transition T2B
State 2 to 4

The driver for this transition is non-selective brush control through chaining, rootplowing, or broadcast herbicides. This action removes the trees. Contributing drivers include heavy browsing by wildlife, sheep, and goats and overgrazing by cattle. The resprouting shrubs are generally not palatable forage. Severe soil degradation can result. A loss of vegetative cover can be followed by a loss of soil. In some cases, this erosion can be extreme enough to result in the loss of the A (and even B) horizons. Mottes of trees may or may not survive this transition.

Restoration pathway R3A
State 3 to 1

Restoration from the Converted State can occur in the short term through active restoration or over the long-term due to the cessation of agronomic practices. *Restoration to the Savannah State (1.0) is unlikely. Return to native communities in the Savannah State is more likely to be successful if soil chemistry and structure have not been heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference-like conditions as does remnant seed sources. Converted sites may be returned to a community similar to the Savannah State through active restoration, including seedbed preparation and seeding of native grass and forb species.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing
Grazing Land Mechanical Treatment
Range Planting
Planned Grazing System
Native Plant Community Restoration and Management

Transition T3B
State 3 to 2

Restoration from the Converted State can occur in the short term through active restoration or over the long-term due to the cessation of agronomic practices. Heavily disturbed soils are more likely to return to the Shrubland State (2.0) if prescribed fire or brush management is not implemented. Restoration to the Savannah State (1.0) is unlikely. Return to native communities in the Savannah State is more likely to be successful if soil chemistry and structure have not been heavily disturbed. Preservation of favorable soil microbes increases the likelihood of a return to reference conditions as does remnant seed sources.

Transition T3A
State 3 to 4

The driver for this transition is severe soil erosion and loss of soil properties. In some cases, this erosion can be extreme enough to result in the loss of the A (and even B) horizons. Mottes of trees may or may not survive this transition. Converted sites may be returned to the Savannah State through active restoration, including seedbed preparation and seeding of native grass and forb species.

Restoration pathway R4A
State 4 to 1

Due to the loss of soil, the likelihood of returning to the Savannah State (1.0) is improbable and would require extensive and intensive restoration efforts. Range restoration techniques have been used in restoration efforts on high-value lands such as those in mining reclamation. This will likely require replacement of topsoil and planting with native species. A return to reference conditions should not be expected, and savannah conditions are only possible with continued inputs and management over a long period of time.

Conservation practices

Brush Management
Prescribed Burning
Prescribed Grazing
Range Planting
Planned Grazing System
Native Plant Community Restoration and Management

Additional community tables

Table 10. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm-season Midgrasses**			1055–1580	
	little bluestem	SCSC	*Schizachyrium scoparium*	750–1500	–
	Grass, perennial	2GP	*Grass, perennial*	50–250	–
2	**Warm-season Midgrasses**			480–715	
	composite dropseed	SPCO16	*Sporobolus compositus*	300–750	–
	sideoats grama	BOCU	*Bouteloua curtipendula*	350–700	–
	silver beardgrass	BOLAT	*Bothriochloa laguroides ssp. torreyana*	200–600	–
	plains lovegrass	ERIN	*Eragrostis intermedia*	300–500	–
	vine mesquite	PAOB	*Panicum obtusum*	300–500	–
	plains bristlegrass	SEVU2	*Setaria vulpiseta*	200–500	–
	Arizona cottontop	DICA8	*Digitaria californica*	200–400	–
3	**Warm-season Shortgrasses**			95–140	
	hooded windmill grass	CHCU2	*Chloris cucullata*	90–120	–
	fall witchgrass	DICO6	*Digitaria cognata*	75–100	–
	curly-mesquite	HIBE	*Hilaria belangeri*	75–100	–
	Hall's panicgrass	PAHA	*Panicum hallii*	75–100	–
	sand dropseed	SPCR	*Sporobolus cryptandrus*	75–100	–
	threeawn	ARIST	*Aristida*	75–100	–
	buffalograss	BODA2	*Bouteloua dactyloides*	75–100	–

	hairy grama	BOHI2	*Bouteloua hirsuta*	75–100	–
	red grama	BOTR2	*Bouteloua trifida*	75–100	–
4	**Cool-season Grasses**			55–75	
	Scribner's rosette grass	DIOLS	*Dichanthelium oligosanthes var. scribnerianum*	55–75	–
	Canada wildrye	ELCA4	*Elymus canadensis*	55–75	–
	Texas wintergrass	NALE3	*Nassella leucotricha*	55–75	–
5	**Grasslikes**			40–55	
	sedge	CAREX	*Carex*	40–55	–
	flatsedge	CYPER	*Cyperus*	40–55	–
6	**Warm-season Tallgrasses**			0–25	
	switchgrass	PAVI2	*Panicum virgatum*	0–25	–
	Indiangrass	SONU2	*Sorghastrum nutans*	0–25	–
Forb					
7	**Forbs**			95–145	
	Forb, annual	2FA	*Forb, annual*	75–145	–
	Cuman ragweed	AMPS	*Ambrosia psilostachya*	75–145	–
	white sagebrush	ARLUM2	*Artemisia ludoviciana ssp. mexicana*	75–145	–
	croton	CROTO	*Croton*	75–145	–
	bundleflower	DESMA	*Desmanthus*	75–145	–
	Engelmann's daisy	ENPE4	*Engelmannia peristenia*	75–145	–
	sensitive plant	MIMOS	*Mimosa*	75–145	–
	smartweed leaf-flower	PHPO3	*Phyllanthus polygonoides*	75–145	–
	Texas snoutbean	RHSE4	*Rhynchosia senna*	75–145	–
	awnless bushsunflower	SICA7	*Simsia calva*	75–145	–
Shrub/Vine					
8	**Shrubs/Vines**			20–30	
	whitebrush	ALGR2	*Aloysia gratissima*	20–30	–
	Texas persimmon	DITE3	*Diospyros texana*	20–30	–
	Texas kidneywood	EYTE	*Eysenhardtia texana*	20–30	–
	algerita	MATR3	*Mahonia trifoliolata*	20–30	–
	pricklypear	OPUNT	*Opuntia*	20–30	–
	honey mesquite	PRGL2	*Prosopis glandulosa*	20–30	–
	western soapberry	SASAD	*Sapindus saponaria var. drummondii*	20–30	–
	bully	SIDER2	*Sideroxylon*	20–30	–
Tree					
9	**Trees**			80–115	
	pecan	CAIL2	*Carya illinoinensis*	50–100	–
	blackjack oak	QUMA3	*Quercus marilandica*	50–100	–
	post oak	QUST	*Quercus stellata*	50–100	–
	live oak	QUVI	*Quercus virginiana*	50–100	–
	elm	ULMUS	*Ulmus*	50–100	–

Animal community

The Tight Sandy Loam site provides at least a portion of the habitat for many species of reptiles, birds, mammals, and insects. Game birds, songbirds, and birds of prey were indigenous or frequent users, and most are still plentiful. Quail and doves frequent this site depending upon the vegetative community. Small mammals that use the site include armadillos, opossum, raccoons, rodents, jackrabbits, cottontail rabbits, and skunks. Its use by deer is limited by browse and cover in climax condition. As ecological condition declines and woody plants increase and invade, it becomes more habitable for deer. Deer prefer many of the forbs and legumes that grow on the site.

Feral hogs (Sus scrofa) can be found on most Ecological Sites in Texas. Damage is caused by feral hogs each year including, crop damage by rutting up crops, destroyed fences, livestock watering areas, and predation on native wildlife, domestic livestock (small calves, goats, and sheep) and ground-nesting birds. Feral hogs have no natural predators other than humans, thus allowing their population to grow to high numbers (Cearley 2009 & Mapston 2004). Feral hogs have naturalized to rangelands across the state.

Predators including bobcats, coyotes, foxes, and mountain lions can also be found on the site.

The site is suitable for the production of livestock, including cattle, sheep and goats. In reference condition, the site is very suited to primary grass eaters such as cattle. As retrogression occurs and woody plants invade, the Oak Woodland (1.2) and Altered Savannah (2.1) plant communities become a good habitat for sheep, goats, deer and other wildlife because of the desirable browse and cool season grasses. Cattle, sheep and goats should be stocked in proportion to the available grass, forb and browse forage, keeping deer competition for forbs and browse in mind. Deer populations must also be kept within limits of the habitat sustainability even if the site is managed exclusively for deer. If the animal numbers are not kept in balance with herbage and browse production through prescribed grazing management and good wildlife population management, the Shrubland Community (2.2) will have little to offer as habitat except cover.

Plant Preference by Animal Kind:
This rating system provides general guidance as to animal forage preference for plant species. It also indicates possible competition between kinds of herbivores for various plants. Grazing preference changes from time to time, especially between seasons, and between animal kinds and classes. Grazing preference does not necessarily reflect the ecological status of the plant within the plant community. For wildlife, plant preferences for food, and plant suitability for cover are rated. Refer to habitat guides for a more complete description of a species habitat needs.

Legend: P=Preferred D=Desirable U=Undesirable N=Not Consumed T=Toxic X=Used, but not degree of utilization unknown
Preferred – Percentage of plant in animal diet is greater than it occurs on the land
Desirable – Percentage of plant in animal diet is similar to the percentage composition on the land
Undesirable – Percentage of plant in animal diet is less than it occurs on the land
Not Consumed – Plant would not be eaten under normal conditions. It is only consumed when other forages not available. This can also include plants that are unavailable during parts of the year.
Toxic – Rare occurrence in diet and, if consumed in any tangible amounts results in death or severe illness in animal (Hart, 2003). (Note: many plants can be good forage but toxic at certain doses or at certain times of the year. Animals in poor condition are most susceptible.)

Hydrological functions

Tight Sandy Loam sites tend to be well vegetated with high levels of canopy cover and low level of bare ground in all communities. Therefore, most examples are functioning hydrologically. Abusive management can create bare soils (particularly in the case of mismanaged brush control or abandoned farming). Bare soils are subject to erosion. Once the organic layer erodes in the A horizon, soils function less well hydrologically and the risk of further erosion increases.

Soils on this site are well drained and water movement to underground layers is moderately high. Well-drained soils make almost 100 percent of soil water available to plants. However, sandy soils drain quickly and have less soil moisture available for much of the growing season.

The Midgrass/Oak Savannah (1.1) and Oak Woodland (1.2) Communities tend to retain a highly functioning water cycle. As long as the understory remains intact, bare ground remains very low. Infiltration will be high and runoff low.

A shift to the Altered Savannah Community (2.1) may reduce canopy cover and increase bare ground. If bare ground stays low, the water cycle is expected to function similarly to the Midgrass Savannah Community (1.1). If bare ground increases, infiltration will decrease and runoff will increase due to reduced ground cover, rainfall splash, soil capping, reduced organic matter, and poor structure. With a combination of a sparse ground cover and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed.

Domination of the site by woody species may degrade the water cycle in the Shrubland Community (2.2). Interception of rainfall by tree canopies increases, which reduces the amount of rainfall reaching the surface and being available to understory plants. Increased stem flow, due to the funneling effect of the canopy, increases soil moisture at the base of trees, especially on mesquite. Evergreen species, such as live oak, create increased transpiration which provides less water for deep percolation. Increases in woody canopy create declines in grass cover, which creates similar causes impacts as those described for overgrazing above. Under the dense canopy of the shrubland, leaf litter builds up. This increases soil organic matter, builds structure, improves infiltration, and reduces surface erosion. These conditions improve the function of the water cycle compared to lower levels of canopy cover.

The hydrological function of the Converted State (3.0) is dependent on the amount of cover on the site during rainfall events and the conservation practices used. If bare soil is left exposed during rainfall events, the site is subject to high runoff, high erosion, and little infiltration. Sandy sites planted to tame pasture tend to have a good hydrological function.

The Highly Disturbed State (4.0) tends to have a poor hydrologic function. Runoff is high and infiltration low. This state is caused by loss of soil which creates conditions that increase the risk of the remaining soil eroding. With a combination of a sparse ground cover and intensive rainfall, this site can contribute to an increased frequency and severity of flooding within a watershed. Soil erosion is accelerated, quality of surface runoff is poor and sedimentation increases.

Recreational uses

Recreational uses include recreational hunting, hiking, camping, equestrian, and bird watching.

Wood products

Honey mesquite and some oak are used for firewood, charcoal, and other specialty wood products.

Other products

Jams and jellies are made from many fruit-bearing species, such as algerita. Seeds are harvested from many plants for commercial sale. Many grasses and forbs are harvested by the dried-plant industry for sale in dried flower arrangements. Honeybees are utilized to harvest honey from many flowering plants, such as honey mesquite.

Inventory data references

Information presented was derived from the site's previous Range Site Description, NRCS clipping data, literature, field observations, and personal contacts with range-trained personnel.

Other references

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Approval

David Kraft, 9/20/2019

Acknowledgments

Site Development and Testing Plan:

Future work, as described in a Project Plan, to validate the information in this Provisional Ecological Site Description is needed. This will include field activities to collect low, medium and high intensity sampling, soil correlations, and analysis of that data. Annual field reviews should be done by soil scientists and vegetation specialists. A final field review, peer review, quality control, and quality assurance reviews of the ESD will be needed to produce the final document. Annual reviews of the Project Plan are to be conducted by the Ecological Site Technical Team.

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)	Synergy Resource Solutions, Belgrade, Montana
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Date	03/08/2011
Approved by	Mark Moseley, ESI Specialist, NRCS, Texas
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

Indicators

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

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2. **Presence of water flow patterns:** None, except following extremely high intensity storms when short flow patterns may appear.

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3. **Number and height of erosional pedestals or terracettes:** None.

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4. **Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are not bare ground):** 0 to 5 percent bare ground. Very small (<1 square foot) and non-connected areas.

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

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

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7. **Amount of litter movement (describe size and distance expected to travel):** Very little litter movement under normal rainfall intensity. Litter is well distributed and stays in place beneath plant canopies.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil surface is very stable (average soil stability values of > 5).

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9. **Soil surface structure and SOM content (include type of structure and A-horizon color and thickness):** 0-28

inches thick, sandy loam, fine sandy loam, brown, weak fine and very fine subangular blocky structure. SOM 0-3%.

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10. **Effect of community phase composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** High canopy, basal cover and density with small interspaces should make rainfall impact negligible. This site has well drained soils, deep with level to gently sloping (0 to 3 percent slopes) which produces negligible runoff and erosion.

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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 >>

    Sub-dominant: Warm-season shortgrasses >

    Other: Cool-season grasses > Forbs > Shrubs > Trees > Warm-season tallgrasses

    Additional: Forbs make up 5 percent of species composition, shrubs and trees compose up to 5 percent species composition.

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Grasses due to their growth habit will exhibit some mortality and decadence, though very slight. Little mortality evident on woody species.

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14. **Average percent litter cover (%) and depth (in):** Tree litter may be up to 6 inches deep.

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15. **Expected annual annual-production (this is TOTAL above-ground annual-production, not just forage annual-production):** Representative value for production = 2400 lbs/ac.

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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:** Mesquite, huisache and cacti are the primary invaders.

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17. **Perennial plant reproductive capability:** All species should be capable of reproducing except for periods of prolonged drought conditions, heavy natural herbivory and fires.
