

# Ecological site R042CY902NM Limestone Hills

Accessed: 05/05/2024

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## General information

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

### 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): 042C—Central New Mexico Highlands

To view this ESD in its most complete form refer to the PDF Version found in the New Mexico NRCS Field Office Technical Guide, section 2.

The Limestone Hills Ecological Site predominantly occurs in LRU 42.8, which is a subunit of MLRA 42 (Southern Desertic Basins, Plains, and Mountains)

MLRA Notes: LRU 42.8 was carved out of the Guadalupe Mountains portion of what used to be MLRA 70D. This Limestone Hills Ecological Site has mostly taken the place of the Limestone Hills Ecological Site that was traditionally used in MLRA 70D.

It is possible, though very rare, that the Limestone Hills Ecological Site may occur outside of this LRU boundary.

To identify locations where this ESD has been mapped, refer to the most current natural resource soil survey data on Web Soil Survey or contact your local NRCS Conservation District field office

## Classification relationships

NRCS & BLM: Limestone Hills Ecological Site < LRU 42.8 Northeastern Chihuahuan Desert Hills < Major Land Resource Area 42, Southern Desertic Basins, Plains, and Mountains < Land Resource Region D, Western Range and Irrigated Region (United States Department of Agriculture, Natural Resources Conservation Service, 2006).

USFS: Limestone Hills Ecological Site < Artesia Plains Desert Grass-Shrubland Subsection < Pecos Valley Section < Southwest Plateau and Plains Dry Steppe and Shrub Province (Cleland, et al., 2007).

EPA: Limestone Hills Ecological Site<24b Chihuahuan Desert Grasslands<24 Chihuahuan Deserts (Griffith, 2006).

## Ecological site concept

The soils are skeletal (greater than 35% by volume rock fragments greater than 2 mm). Soil depth is very shallow to shallow (1-50 cm). The root restrictive layer is bedrock (limestone, dolomite, sandstone). Slopes are greater than 25% and are typically around 30-60%. These are exemplified by hillsides that exist along the Guadalupe Ridge from Calsbad to White City.

## Associated sites

R042CY901NM	<b>Very Shallow</b> The very shallow site has slopes < 25%, which make up hill summits adjacent to the Limestone Hills Site.
R042CY003NM	<b>Shallow</b> The shallow ecological site forms on alluvial fans below the limestone hills, and has slopes < 30%
R042CY002NM	<b>Limestone Mountains</b> The limestone hills site transitions into the cooler, limestone mountains, above 5,000 feet on north facing slopes.

**Table 1. Dominant plant species**

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

## Physiographic features

The Limestone Hills ecological site is on hill slopes within LRU 42.8. Elevation ranges from 3500 to 5500 feet. Soil depth can range from very shallow to shallow to limestone and dolomite bedrock. Slopes are greater than 25 percent and are generally between 30 and 60. Aspect is very important to ecological site dynamics.

The Limestone Hills ecological site occurs on slopes of hills, ridges, and mesas and is most closely associated with the Very Shallow Ecological Site, which occurs on summit positions. The Limestone Hills is also closely associated with the Shallow Ecological Site which occurs on lower alluvial fans where a shallow petrocalcic layer has formed. The Limestone Hills site includes, on average, about 15 percent rock outcrop.

**Geology:** The primary geologic formations that make up the parent material for the Limestone Hills Ecological Site include the Seven Rivers, Tansil, Yates, and to a lesser extent the Capitan Limestone. During Guadalupian time of the Permian Period, dynamic sedimentation of carbonate and evaporite rocks occurred around the rim of the Delaware basin creating an ideal environment for the development of a large coral reef. The rim was topographically high; the waters were shallow, well-ventilated, agitated, and warm. In this excellent marine-life environment the great Capitan Reef began to form. The Capitan Reef grew rapidly and flourished throughout Guadalupian time, surrounding the Delaware basin, controlling environments and influencing sedimentation (Kelley, 1971).

On the landward side of the reef (the backreef) the Seven Rivers, Yates, and Tansil formations developed. The first was the Seven Rivers Formation. The sediments of the Seven Rivers deposited at a time when conditions became drier, and the basin tended toward hypersalinity. The Seven Rivers contain gray to white dolomitic limestone, white to red gypsum, orange-red siltstone, and shale. Within the LRU, the Seven Rivers Formation is considered the surface layer on Azotea Mesa, Seven Rivers Hills, and West Hess Hills. The Seven Rivers Formation tends to contain more erodible sediments than the Tansil and Yates. Therefore, less bedrock is exposed where the Limestone Hills ESD occurs on the Seven Rivers Formation.

Deposited above the Seven Rivers during a quiet period within an unrestricted lagoon is the Yates Formation. The Yates is characterized by layers of very pale orange to yellowish-gray fine-grained, laminated dolomite, alternating with grayish-orange to pale yellowish-orange, calcareous quartz siltstone or very fine-grained sandstone. The Yates is the surface formation over much of Carlsbad Caverns National Park (CCNP), starting at Walnut Canyon and extending North through the Cueva Escarpment and up to Living Desert State Park.

Landward of the unrestricted lagoon was a restricted lagoon, (the Tansil Formation). Here freshwater mixed with seawater. Large amounts of sediments were carried in by streams causing a hostile environment for marine organisms. Like the Yates, the Tansil is characterized by clastic sediments such as siltstone and sandstone as well as layers of dolomite. Unlike the Yates, however, the Tansil contains many thin clay layers (Burger, 2007). The Tansil Formation is the surface layer at the Carlsbad Caverns Visitor Center.

About 15 million years ago, the ancient reef rock that had been buried by younger layers of rock began to rise, creating the Guadalupe Ridge and Mountains while exposing the Seven Rivers, Tansil, and Yates Formations. Over

the years, at the hill slope positions, much of the more clastic layers of the Tansil, Yates, and Seven Rivers have eroded away, leaving the very shallow soils mixed and exposed dolomitic limestone rock outcrop which make up the Limestone Hills Ecological Site.

#### Ecological Site Key for LRU 42.8 and 42.9, Northeastern Chihuahuan Hills and Mountains

1. Site is within LRU 42.8, which is within the ustic-aridic soil moisture regime, and the thermic soil temperature regime. (Often contains redberry juniper)
2. Soils are loamy and not skeletal, and reside in low areas that are stream terraces and fan remnants. - Loamy Terrace ESD
2. Soils are skeletal (Greater than 35% by volume rock fragments greater than 2 mm)
3. Soils are deep to very deep. (Greater than 100 cm to root restrictive layer)
4. Site exists in an active floodplain.-Draw ESD
4. Site exists on a stream terrace or alluvial fan-Gravelly ESD
4. Site exists on steep slopes on limestone colluvium over gypsum residuum.-Limy Gyp Escarpment
3. Soils are very shallow to moderately deep (5-100 cm).
5. Root restrictive layer is a petrocalcic horizon.-Shallow ESD
5. Root restrictive layer is bedrock.
6. Slopes are less than 25%-Very Shallow ESD
6. Slopes are greater than 25%- Limestone Hills ESD
1. Site is located within LRU 42.9, and is represented by the aridic-ustic soil moisture regime, and the mesic soil temperature regime. (It often contains alligator juniper and pinon pine.)
7. Slopes are less than 25%- Shallow Limestone ESD
7. Slopes are greater than 25%- Limestone Mountains ESD

#### ESD Key Glossary

##### Glossary:

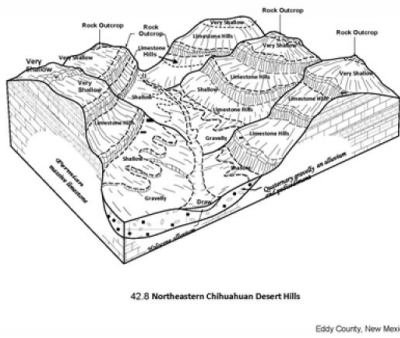
**Colluvium:** "Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g. direct gravitational action) and by local, concentrated runoff" (Schoenberger, et al., 2012).

**Petrocalcic Horizon:** The petrocalcic horizon is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to the extent that the horizon is cemented or indurated (Keys to Soil Taxonomy, 2010).

**Residuum:** "Unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place" (Schoenberger, et al., 2012).

**Soil moisture regime:** Refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in specific horizons during periods of the year. Water held at a tension of 1500 kPa or more is not available to keep most mesophytic plants alive. Major differences in soil moisture are often reflected in different vegetative communities. The two major soil moisture regimes for the Guadalupe Mountains are Aridic and Ustic (Keys to Soil Taxonomy, 2010).

**Soil Temperature Regime:** This is the range of temperatures experienced by a soil at a depth of 50 cm. When the average temperature of a soil falls between 46 degrees F and 59 degrees, it falls into the mesic soil temperature regime. The thermic soil temperature regime falls between 59 degrees F and 72 degrees (Keys to Soil Taxonomy, 2010).



**Figure 2. 42.8 Northeastern Chihuahuan Desert Hills**

**Table 2. Representative physiographic features**

Landforms	(1) Hill (2) Escarpment
Flooding frequency	None
Elevation	1,067–1,676 m
Slope	25–100%
Aspect	Aspect is not a significant factor

### Climatic features

The mean annual precipitation is 10.4 inches to 18.3 inches, occurring mostly as high intensity, short-duration afternoon thunderstorms from July through September. Mean annual air temperature is 55 to 70 degrees F, and the frost-free season is 207 to 243 days.

Annual weather patterns, influenced by global climate events, such as El Nino and La Nina, affect and alter production and composition across the Limestone Hills Ecological Site. In general, because precipitation is minimal through the winter but increases during the summer, warm-season (C4) plants dominate the landscape. However, from year to year the production and composition can greatly shift due to variable weather patterns. The years that produce the most species richness and production are those that get slow, steady moisture through the months of May, June, and July. Late summer thunderstorms may induce heavy runoff on this site, creating flash-flooding in the draws, drainages, and canyons below.

The climate trend of the area is one toward warmer temperatures and lower precipitation. According to the Carlsbad Caverns Climate Station, during the years 2001-2011, five years received less than 10 inches of rain. Three of those years, (2003, 2005, and 2011) were below 5 inches of rain. And 2011 was both the lowest rainfall and hottest year on record. Similarly, in 1947-1957, 6 out of 11 years were below the mean low of 10.4 inches. But in that stretch, only one year, 1951, was below 5 inches. To put this in perspective, in the dry 1930's only 2 years were below the mean low of 10.4 and none were below 5 inches. The 2001-2011 decade has been much warmer and drier than any in recorded history. In addition, during the two years of 2010 and 2011, Carlsbad Caverns National Park experienced extreme events of drought, wildfire, and flash flooding which have led to shifts in plant communities

**Table 3. Representative climatic features**

Frost-free period (average)	243 days
Freeze-free period (average)	263 days
Precipitation total (average)	457 mm

## Influencing water features

The Limestone Hills Ecological Site is not associated with a wetland or riparian system; it is an upland ecological site.

## Soil features

Every ecological site and associated soil component has static soil properties that help define the physical, chemical, and biological characteristics that make the site unique. The following soil profile information is a description of those unique soil properties for the Limestone Hills Ecological Site. To learn about the dynamic processes of the soil component, refer to the "plant communities" section of the ESD.

The Limestone Hills Ecological Site is tied to the Lechuguilla and rock outcrop components from map units CC2, CC9, LK1, RB1, and BL1 within LRU 42.8 Northeastern Chihuahuan Hills. The CC2 and LK1 map units are very similar, and consist of complexes of components which are dominated by about 70 percent Lechuguilla, 15 percent Kimrose, and 15 percent rock outcrop. The BL1 map unit consists of about 45 percent Bogle, 20 percent Lechuguilla, and 15 percent Badlands. The Lechuguilla component has formed from mostly colluvium and residuum which has been derived from limestone and dolomite parent material. Soil depth ranges from very shallow to shallow (20-40 cm) over bedrock.

In normal years this soil is driest during the winter. It is moist in the upper part for over 90 cumulative days, but fewer than 90 consecutive days during the growing season. The soil moisture regime is aridic bordering on ustic. The mean annual soil temperature is 59 to 66 degrees F, which is classified as the thermic temperature regime.

This soil is well drained with high runoff. At the surface, the saturated hydraulic conductivity ranges from 1.0 to 10 m/second over impermeable bedrock. The Lechuguilla taxonomic class is: Loamy-skeletal mixed, superactive, calcareous, thermic Lithic Ustic Torriorthents.

Typical Pedon: Lechuguilla hill slopes; Geographic Coordinate System: 32° 7' 12.76" north, 104° 33' 54.52" west

A1--0 to 2.5 inches (0 to 6 cm); brown (10YR 4/3) very cobbly loam, very dark grayish brown (10YR 3/2), moist; 20 percent clay; moderate coarse granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine roots and common fine roots; common fine interstitial pores; 30 percent gravel and 15 percent cobble and 5 percent stone; violently effervescent, 33 percent calcium carbonate equivalent; moderately alkaline, pH 7.9; clear smooth boundary.

A2--2.5 to 9 inches (6 to 23 cm); brown (10YR 4/3) very gravelly loam, very dark grayish brown (10YR 3/2), moist; 22 percent clay; weak medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common very fine roots and common fine roots; common fine interstitial pores; 10 percent fine gravel and 5 percent coarse gravel and 10 percent cobble and 5 percent stone; violently effervescent, 29 percent calcium carbonate equivalent; slightly alkaline, pH 7.7; clear smooth boundary.

Bk--9 to 12.5 inches (23 to 32 cm); brown (10YR 5/3) very stony loam, very dark grayish brown (10YR 3/2), moist; 23 percent clay; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; few medium roots and common very fine and fine roots; common fine interstitial pores; common fine prominent irregular carbonate masses throughout and few medium prominent irregular weakly cemented carbonate nodules on bottom of rock fragments; 10 percent fine gravel and 5 percent coarse gravel and 10 percent cobble and 15 percent stone; violently effervescent, 39 percent calcium carbonate equivalent; moderately alkaline, pH 7.9; abrupt smooth boundary.

R--12.5 to 78.5 inches (32 to 200 cm); indurated limestone or dolomite bedrock.

Typical Surface Fragments <=3" (% Cover): 20-30%

Typical Surface Fragments > 3" (% Cover): 20-30%

Typical Subsurface Fragments  $\leq 3$ " (% Volume): 20-30%

Typical Subsurface Fragments  $> 3$ " (% Volume): 30-50%

Typical Soil Depth: 20-40 cm

Calcium Carbonate Equivalent (percent):

A & A2 horizons-0 to 5

Bk horizon-0 to 25

Total Average Available Water Capacity (cm H<sub>2</sub>O/cm soil): 2.73 cm



Figure 5. Lechuguilla Hill Slope Component

Table 4. Representative soil features

Parent material	(1) Residuum–dolomite (2) Eolian deposits–limestone and sandstone
Surface texture	(1) Gravelly loam (2) Very gravelly silt loam (3) Cobbly silty clay loam
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Slow to moderate
Soil depth	5–51 cm
Surface fragment cover $\leq 3$ "	10–45%
Surface fragment cover $> 3$ "	5–35%
Available water capacity (0-101.6cm)	1.98–3 cm
Calcium carbonate equivalent (0-101.6cm)	0–25%
Electrical conductivity (0-101.6cm)	0–1 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–1
Soil reaction (1:1 water) (0-101.6cm)	7–7.8
Subsurface fragment volume $\leq 3$ " (Depth not specified)	5–50%

Subsurface fragment volume >3" (Depth not specified)	10–70%
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## Ecological dynamics

The Limestone Hills Ecological Site contains a mix of grass, shrubs, forbs, and succulents. It is often dry due to its shallow depth, high runoff potential, and exposure to many dry, windy days. Due to the dryness, and very shallow depth of the soil, succulents such as lechuguilla, yucca, prickly pear, and sotol are very abundant on this site, sometimes causing difficulty with walking. Also, as typical with desert communities, wet springs and summers can cause swings in species richness causing an abundance of forbs to express themselves in a show of color.

There are numerous variables which influence plant communities, these variables include: elevation, aspect, percent slope, soil depth, slope shape, fracturing of bedrock, and fire frequency. The first basic variable is a combination of elevation and aspect. At the lower end of the range, (about 3500 feet on south facing slopes), the climate is warmest and driest and tends to promote more succulents and Chihuahuan desert species, such as ocotillo, mariola, tanglehead, and various cacti. As elevation increases to the upper extreme, (at about 6000 feet on south facing slopes, and 5000 on north facing slopes), grass communities change: black grama phases into curly leaf muhly, and shrub species change from mariola dominant, to redberry juniper dominant, and at the upper end, sandpaper oak dominant. Between 5000 and 5500 feet on this landform, this site transitions into the cooler, moister LRU 42.9 Limestone Mountains site.

Soil depth plays a role in determining species production and diversity. The underlying bedrock varies in depth from being exposed at the surface to a depth of 40 cm in a few places. The deeper the soil, the greater the ability for different plant species to access water and utilize other resources. Species such as blue grama and Wrights' beebrush prefer somewhat deeper soil, while curly leaf muhly and lechuguilla prefer the very shallow soils. According to Duniway, "Cracks and fissures in the bedrock also trap water and facilitate access to water contained within the matrix of the bedrock" (Duniway, et al., 2010). Sotol can dominate where higher levels of fracturing occur.

Percent slope affects water runoff and retention, generally, the steeper the slope, the higher the runoff. In the Tansil and Yates formations, bedding plains are often exposed where dolomitic limestone resists weathering. Often these bedding plains produce a terrace like structure that collects soil and promotes productive plant communities. As water collects and travels through cracks and fissures in the bedding plain, a spring may develop, creating a very productive plant community or even a woodland cove.

Fire is a consistent disturbance regime that reduces succulents and a few shrubs while stimulating grasses and forbs. Not all fires are equal. According to Gebow, "Fire effects in the same location will vary, especially with fire timing, both seasonally and within the scheme of year-to-year moisture variation. Precipitation during seasons before and after fire has a major effect on recovery of plants. Fire researchers in the area and region suggest a 10- to-15-year fire regime is common" (Gebow, 2001).

Small and more frequent fires were more common before the mid-1800's, with the Apache likely responsible for many small burns. Following colonization by Europeans, intervals between fires have lengthened and the average fire size has increased (Ahlstrand, 1981). Small fires are important for creating a patchy mosaic across the landscape, which provides beneficial habitat for many wildlife species.

## State and transition model

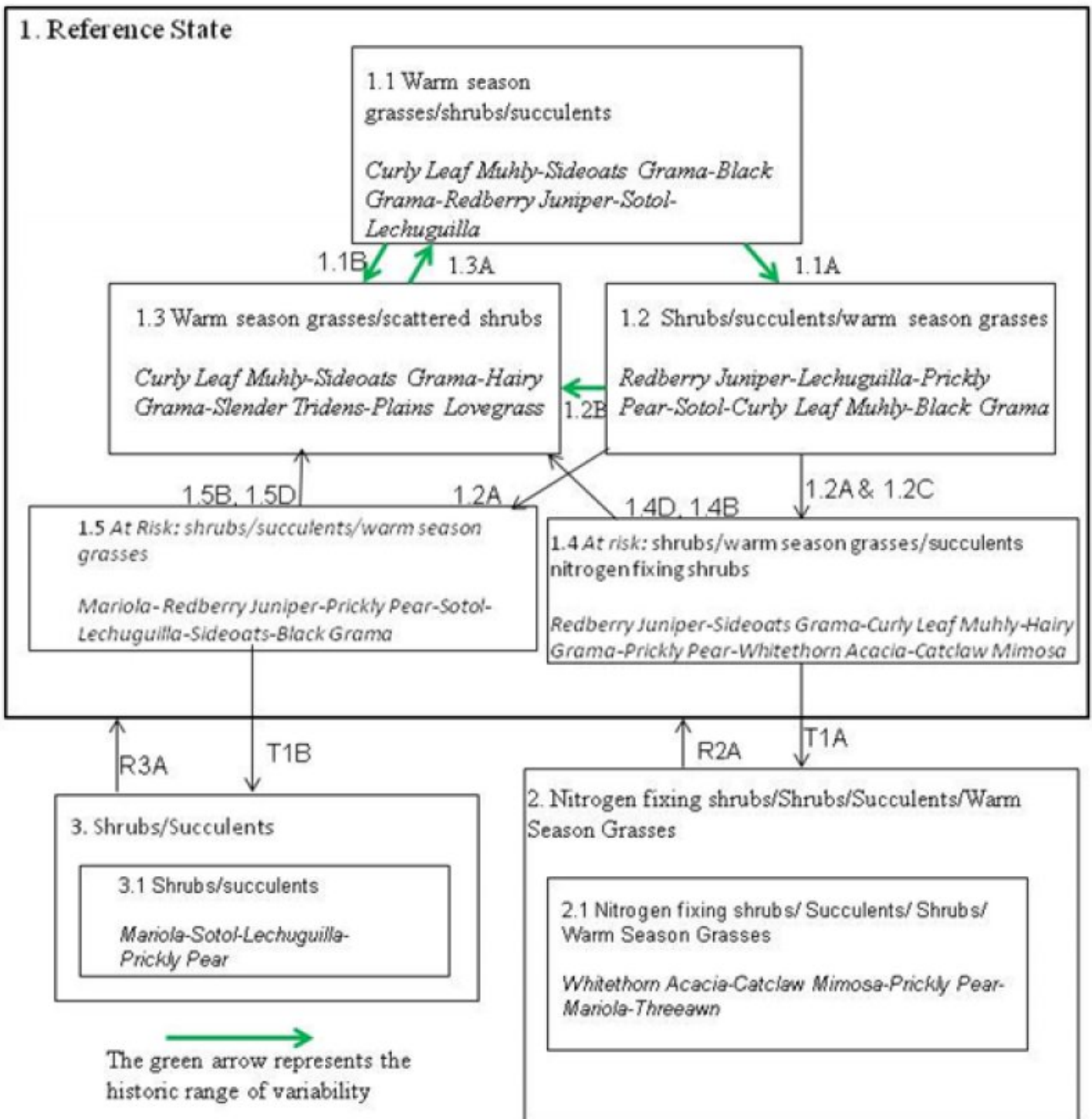


Figure 6. Limestone Hills

**State 1  
Reference State**

1.1 Warm season grasses/shrubs/succulents (diagnostic plant community) A mix of grasses, shrubs and succulents are present. Total foliar cover is > 65%, depending on the amount of rock outcrop. 1.1A Community Pathway: This pathway represents time between fires, during which natural processes increase shrub and succulent vigor and decrease grass production and composition. 1.1B Community Pathway: This pathway represents fire. Fire suppresses succulents and many shrubs, giving grasses a competitive advantage. 1.2 Shrubs/succulents/warm season grasses: Over time, foliar cover of shrubs and succulents increases and that of warm season grasses decreases. 1.2A Community Pathway: This pathway represents intervals between fires which are longer than the historic range of variability. Fire suppression, whether through loss of fuel load due to herbivory or from fighting natural wildfires, has increased shrub and succulent vigor and decreased grass production and percent



composition. 1.2B Community Pathway: This pathway represents fire. Fire suppresses succulents and many shrubs, giving grasses a competitive advantage. 1.2C Community Pathway: This pathway represents a growing competitive advantage for nitrogen fixing shrubs due to slow changes in soil chemistry and hydrology. 1.3 Warm season grasses/scattered shrubs: This plant phase exists after fire. Grasses respond well to fire, while many shrubs and succulents decrease. 1.3A Community Pathway: This pathway represents intervals between fires, during which natural processes increase shrub and succulent vigor and decrease grass production and composition. Over time, plant community 1.3 shifts to 1.1. 1.4 At risk: shrubs/warm season grasses/succulents/nitrogen fixing shrubs: Due to gradual changes in hydrologic function and soil chemistry, succulents and shrubs increase over time. The increased abundance of native nitrogen fixing shrubs such as whitethorn and catclaw mimosa is a key indicator that this community phase is "at risk." 1.4B Community Pathway: This pathway represents fire. Fire sets back succulents and many shrubs, giving grasses a competitive advantage. 1.4D Community Pathway: A change in livestock grazing management promotes grass vigor and decreases shrub competition. This accelerates the turnover of fine roots, causing an increase in labile carbon, acceleration in decomposition, and a resulting increase in plant available water. T1A Transition one: Slow variables: Continued encroachment by whitethorn acacia, coupled with the loss of herbaceous plant species, causes a decrease in soil organic matter, leading to a decrease in plant available water. Trigger event: A severe drought causes loss of soil organic carbon. Threshold: A hydrologic function/soil chemistry threshold is crossed. 1.5 At risk: shrubs/succulents/warm season grasses: This plant phase is the result of gradual changes in species composition to a shrub and succulent dominated community. There has been a decrease in hydrologic function as grasses are weakened in this community. This is a different plant community than 1.4, as nitrogen fixing plants are not present. 1.5B Community Pathway: This pathway represents fire. Fire sets back succulents and many shrubs, giving grasses a competitive advantage. 1.5D Community Pathway: A change in livestock grazing management to allow for decreased shrub competition, improved litter accumulation, an increase in labile carbon, and acceleration in decomposition resulting in an increase in plant available water. T1B Transition two: Slow variables: Continued decrease in grasses and overall canopy cover, causing a decrease in soil organic matter, leading to a decrease in plant available water, decomposition, and plant available nutrients. Trigger event: A severe drought, causing a loss of organic carbon. Threshold: A hydrologic function threshold was crossed. 2.0 Nitrogen fixing shrubs/succulents/shrubs/warm season grasses state 2.1 Whitethorn Acacia/succulents/shrubs/warm season grasses: Whitethorn acacia has become a prominent plant on the site. Foliar cover has decreased to < 40%. A higher Nitrogen turnover rate increases the invasiveness and stability of whitethorn. This community has a mix of shrubs, succulents, and warm season grasses. R2A Restoration Process: An increase in the competitive advantage of non-nitrogen fixing species through physical, chemical, and biological management practices. 3.0 Shrubs/succulents state 3.1 Shrubs/succulents: This plant community has crossed a threshold where shrubs and succulents dominate the canopy and grasses are very limited. Due to fire suppression and continuous herbivory a change in the hydrologic cycle has occurred. This community is very similar to 2.1 except for the presence of whitethorn and other nitrogen fixing shrubs. R3B Restoration Process: Organic matter needs to be increased in the system to stimulate decomposition, mineral cycling, and water storage. Fine root systems from grass species are important for increasing organic matter.

## Community 1.1

### Warm season grasses/shrubs/succulents (diagnostic plant community)



Figure 7. Community 1.1; Rattlesnake Trail; Carlsbad Caverns

This community phase combines a mix of warm season grasses, shrubs, and succulents. Foliar cover is between

70 and 80 percent, basal cover is between 15 and 20 percent, and bare ground is minimal due to over 55 percent of the surface covered in rock fragments. Warm season grasses make up about 45 percent foliar cover; shrubs, 14 percent; and succulents, including sotol and lechuguilla, around 14 percent. The average surface soil stability rating is a 5 under canopy and a 4.5 in the interspaces. Annual production averages around 900 lbs/ac, but can span between 600 and 1200 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth, slope, and annual weather patterns. This community exists approximately 5-7 years after low intensity fire. Curly leaf muhly is the dominant grass in mid to upper elevations, while “thermic” species, such as black grama, slim tridens and hairy tridens, are more dominant at lower elevations. Mariola tends to be a dominant shrub at lower to mid elevations, followed by redberry juniper at mid to upper elevations and sandpaper oak at the highest elevations. Lechuguilla is the dominant succulent and is present at all elevations, especially around rock outcrop. Sotol can be a dominant shrub in this community, especially in areas where heavy fracturing of the bedrock occurs. This plant community optimizes energy flow, hydrologic function and nutrient cycling. The diverse root systems take advantage of moisture from both close to the surface as well as deep in the rock strata. Decomposition is active, creating soil organic matter, which enhances “plant available water” needed for plant vigor.

**Table 5. Annual production by plant type**

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	504	764	1020
Shrub/Vine	135	194	258
Forb	34	50	67
<b>Total</b>	<b>673</b>	<b>1008</b>	<b>1345</b>

**Table 6. Ground cover**

Tree foliar cover	1%
Shrub/vine/liana foliar cover	25-30%
Grass/grasslike foliar cover	40-50%
Forb foliar cover	5-10%
Non-vascular plants	1%
Biological crusts	1%
Litter	40-60%
Surface fragments >0.25" and <=3"	35-45%
Surface fragments >3"	10-20%
Bedrock	10-20%
Water	0%
Bare ground	0-2%

**Table 7. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	1-3%	3-7%	1-3%
>0.15 <= 0.3	–	3-7%	15-25%	1-3%
>0.3 <= 0.6	–	6-10%	15-25%	1-1%
>0.6 <= 1.4	–	8-12%	–	–
>1.4 <= 4	–	2-6%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Figure 9. Plant community growth curve (percent production by month).  
NM4282, Limestone Hills Reference State.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	3	5	10	10	25	30	12	5	0	0

## Community 1.2 Shrubs/succulents/warm season grasses



Figure 10. Community 1.2; Concave Slope; Shrub dominated; Sla

This community phase consists of a mix of shrubs, succulents, and warm season grasses. This plant community can manifest itself in two ways, either shrub dominated on concave slopes or succulent dominated on convex slopes. It is common, on the Limestone Hills Ecological Site, for the slope shape to undulate from convex to concave showing a gradient from shrub dominated to succulent dominated. There is generally less soil development on convex slopes with more exposed rock outcrop, creating a harsher environment and a competitive advantage for succulents such as lechuguilla and ocotillo. Foliar cover is between 70 and 80 percent, basal cover is between 15 and 35 percent, and bare ground is around 1 to 3 percent. Warm season grasses make up about 26 percent foliar cover; shrubs, 29 percent; succulents, 17 percent; and forbs, 4 percent. The average surface soil stability rating is 5 under canopy and 4.5 in the inter-spaces. Annual production averages around 800 lbs/ac, but can span between 500 and 1000 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth and annual weather patterns. This community exists approximately 14-18 years after fire. Curly leaf muhly is the dominant grass in mid to upper elevations, while “thermic” species, such as black grama, slim tridens and hairy tridens, are more dominant at lower elevations. Mariola tends to be a dominant shrub at lower to mid elevations, followed by redberry juniper at mid to upper elevations and sandpaper oak at the highest elevations. Lechuguilla is the dominant succulent and is present at all elevations, especially around rock outcrop. Sotol can be a dominant shrub in this community, especially in areas where heavy fracturing of the bedrock occurs. This plant community has developed due to an increase in shrub and succulent vigor and a decrease in grass vigor. As shrubs increase they gain a competitive advantage, primarily by out-competing the grass for water and nutrients. As

grasses and fine root turnover decrease, energy flow begins to lessen due to a decrease in soil organic matter, caused by a slowdown in decomposition. Fire is the natural event that keeps mature shrub species from gaining a competitive advantage and stimulates colonization by grasses.

**Table 8. Annual production by plant type**

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	308	493	616
Shrub/Vine	230	363	460
Forb	22	40	45
<b>Total</b>	<b>560</b>	<b>896</b>	<b>1121</b>

**Table 9. Ground cover**

Tree foliar cover	0-1%
Shrub/vine/liana foliar cover	40-50%
Grass/grasslike foliar cover	20-30%
Forb foliar cover	3-5%
Non-vascular plants	1%
Biological crusts	1-3%
Litter	40-60%
Surface fragments >0.25" and <=3"	35-45%
Surface fragments >3"	10-20%
Bedrock	10-20%
Water	0%
Bare ground	1-3%

**Table 10. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	1-2%	3-7%	1-3%
>0.15 <= 0.3	–	2-4%	15-25%	1-3%
>0.3 <= 0.6	–	3-7%	–	–
>0.6 <= 1.4	–	6-10%	–	–
>1.4 <= 4	1-2%	7-11%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

### Community 1.3

#### Warm season grasses/scattered shrubs



Figure 12. Community 1.3; Cueva Escarpment; 3-14-12

This community phase consists of a mix of warm season grasses, shrubs, and succulents. This plant phase exists shortly after fire has burned the site, suppressing succulents and shrubs and creating a competitive advantage for grasses. Foliar cover is between 60 and 80 percent, depending on how recent and how severe the fire had been. Also, precipitation following fire is needed for growth to resume. Basal cover is between 15 and 30 percent depending on post-fire precipitation, and bare ground is around 2 to 4 percent. Warm season grasses make up about 55 percent foliar cover; shrubs, 10 percent; and succulents, 5 percent. The average surface soil stability rating is 5 under canopy and 4.8 in the interspaces. Annual production averages around 900 lbs/ac, but can span between 600 and 1200 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth, and annual weather patterns. This community exists approximately 1-6 years after fire. It is a grass dominated site, with basal sprouting shrubs scattered across the site. Curly leaf muhly is the dominant grass at mid to upper elevations, while “thermic” species; such as black grama, slim tridens, and hairy tridens are more dominant at lower elevations. Mariola tends to be a dominant shrub at lower to mid elevations, followed by redberry juniper at mid to upper elevations and sandpaper oak in the highest elevations. Lechuguilla and sacahuista are the dominant succulents and are present at all elevations. This plant community is the ecological site’s response to fire within the reference state. Fire is the natural event that keeps shrub species from gaining a competitive advantage and stimulates colonization by grasses. As grasses respond with greater density following fire, decomposition speeds up, creating greater soil organic matter, infiltration, and plant available water. Over time, shrubs and succulents move back onto the site.

Table 11. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	504	757	1009
Shrub/Vine	121	182	242
Forb	47	71	94
<b>Total</b>	<b>672</b>	<b>1010</b>	<b>1345</b>

Table 12. Ground cover

Tree foliar cover	1%
Shrub/vine/liana foliar cover	15-25%
Grass/grasslike foliar cover	50-60%
Forb foliar cover	3-7%
Non-vascular plants	1%
Biological crusts	1-3%
Litter	55-75%
Surface fragments >0.25" and <=3"	35-45%
Surface fragments >3"	10-20%

Bedrock	10-20%
Water	0%
Bare ground	1-3%

**Table 13. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	1-3%	5-15%	1-3%
>0.15 <= 0.3	–	4-8%	25-35%	2-4%
>0.3 <= 0.6	–	5-9%	10-20%	–
>0.6 <= 1.4	–	–	–	–
>1.4 <= 4	–	–	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

## Community 1.4

**At risk: shrubs/warm season grasses/succulents/nitrogen fixing shrubs:**



**Figure 14. Community 1.4; Mosley Canyon; 3-14-12**

This community phase consists of a mix of shrubs, warm season grasses, and succulents, along with an increase in nitrogen fixing shrubs. It is no longer within the “historic range of variability” as management has created an “at risk” community phase. However it is still within the reference state, meaning it has not crossed a threshold, and that intensive management (i.e., accelerating practices) is not yet required to push the system back into the historic range of variability (Bestelmeyer, et al., 2010). Foliar cover is between 40 and 70 percent, basal cover is between 15 and 25 percent, and bare ground is around 2 to 8 percent. Warm season grasses make up about 20 percent foliar cover; shrubs, 23 percent; and succulents, 7 percent. The average surface soil stability rating is 4.5 under canopy and 3.5 in the interspaces. Annual production averages around 600 lbs/ac, but can span between 300 and 900 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth, and annual weather patterns. This community exists due to past management and disturbance, primarily fire suppression coupled with loosely managed livestock grazing over many years. This plant community usually exists within close proximity of a livestock watering facility where continuous, season-long grazing occurs and a seed source for nitrogen fixing shrubs, such as whitethorn acacia and catclaw mimosa are available. A greater percentage of short, warm season grass species occur in this community phase along with a greater percentage of nitrogen fixing shrubs. This plant community phase has developed over time due to a number of slow ecological variables. One management practice that influences ecology is fire suppression. Shrubs gain a competitive advantage through fire suppression. Through deeper root systems, shrubs can take advantage of moisture stored in cracks and fissures in

the bedrock, while grasses struggle with the slow decline of soil organic matter and the decrease of plant available water. Also, due to the decrease in soil organic matter, aggregate stability diminishes, causing a decrease in infiltration and an increase in runoff. Another factor in creating this community is the loose management of livestock over many years. Livestock contribute to the distribution of nitrogen fixing plant seed and can lessen plant vigor and soil organic matter through continuous grazing and over-utilization. As the vigor of grasses and some shrubs decreases, nitrogen fixing plants start to increase and begin to change the chemistry and hydrology of the site. This site is "at risk" of crossing a threshold into state two.

**Table 14. Annual production by plant type**

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	185	370	555
Shrub/Vine	135	269	404
Forb	17	34	50
<b>Total</b>	<b>337</b>	<b>673</b>	<b>1009</b>

**Table 15. Ground cover**

Tree foliar cover	1%
Shrub/vine/liana foliar cover	25-35%
Grass/grasslike foliar cover	15-25%
Forb foliar cover	3-7%
Non-vascular plants	1%
Biological crusts	1-3%
Litter	20-50%
Surface fragments >0.25" and <=3"	35-45%
Surface fragments >3"	10-20%
Bedrock	10-20%
Water	0%
Bare ground	3-5%

**Table 16. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	1-1%	2-6%	5-15%	1-3%
>0.15 <= 0.3	–	5-9%	6-10%	2-4%
>0.3 <= 0.6	–	7-12%	1-3%	–
>0.6 <= 1.4	–	8-9%	–	–
>1.4 <= 4	–	2-4%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

## Community 1.5

**At risk: shrubs/succulents/warm season grasses**



Figure 16. Community 1.5; Mariola-succulent dominated; Walnut

This community phase consists of a mix of shrubs, succulents, and warm season grasses. This plant community is much like 1.4, except it does not contain the presence of nitrogen fixing shrubs. It is an “at risk” plant community because it is no longer within the historical range of variability, mainly due to long years of fire suppression. This plant community, much like 1.2, can manifest itself in different ways, depending on elevation, aspect, and slope shape. Shrubs become dominant in cooler positions, with deeper soils. Succulents become dominant along warmer aspects with thinner soils. There is generally less soil development on convex slopes with more exposed rock outcrop, creating a harsher environment and a competitive advantage for succulents such as prickly pear, lechuguilla, and ocotillo. Thus, one can observe a gradient from shrub-dominated to succulent-dominated as slopes transition from concave to convex. Foliar cover is between 40 and 80 percent, basal cover is between 10 and 30 percent, and bare ground is around 2 to 8 percent. Warm season grasses make up about 18 percent foliar cover; shrubs, 25 percent; succulents, 14 percent; and forbs, 4 percent. The average surface soil stability rating is 4.5 under canopy and 3.5 in the interspaces. Annual production averages around 600 lbs/ac, but can span between 400 and 800 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth, and annual weather patterns. This community exists after about 20 years of fire suppression. Curly leaf muhly is the dominant grass in mid to upper elevations while “thermic” species such as black grama, slim tridens, and hairy tridens are more dominant at lower elevations. Mariola tends to be a dominant shrub at lower to mid elevations, followed by redberry juniper at mid to upper elevations and sandpaper oak at the highest elevations. Lechuguilla and prickly pear are the dominant succulents present, especially around rock outcrop. Sotol can be a dominant shrub in this community, especially in areas where heavy fracturing of the bedrock occurs. This plant community has developed due to an increase in shrub and succulent vigor and a decrease in grass vigor. As shrubs increase they gain a competitive advantage, primarily by out-competing the grass for water and plant available nutrients. As grasses decrease, energy flow begins to lessen due to a decrease in soil organic matter, caused by a slowdown in decomposition. Fire is the natural event that keeps mature shrub species from gaining a competitive advantage and stimulates colonization by grasses.

Table 17. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	224	336	448
Grass/Grasslike	202	303	404
Forb	22	34	45
<b>Total</b>	<b>448</b>	<b>673</b>	<b>897</b>

Table 18. Ground cover

Tree foliar cover	1%
Shrub/vine/liana foliar cover	35-45%
Grass/grasslike foliar cover	15-25%
Forb foliar cover	2-6%



Non-vascular plants	1%
Biological crusts	1-3%
Litter	40-60%
Surface fragments >0.25" and <=3"	35-45%
Surface fragments >3"	10-20%
Bedrock	10-20%
Water	0%
Bare ground	3-7%

**Table 19. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	3-7%	2-6%	1-3%
>0.15 <= 0.3	–	6-10%	5-9%	1-3%
>0.3 <= 0.6	–	7-11%	5-9%	–
>0.6 <= 1.4	–	7-11%	–	–
>1.4 <= 4	–	3-7%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

### Pathway 1.1A Community 1.1 to 1.2



Warm season  
grasses/shrubs/succulents  
(diagnostic plant community)



Shrubs/succulents/warm  
season grasses

This pathway is the slow movement, over time from Community 1.1 to Community 1.2. This pathway represents time between fires within the natural range of variability, as it will take 10 to 14 years, after fire, for shrubs and succulents to achieve foliar cover > 25 percent. Shrub and succulent vigor increase as grass vigor decreases due to various ecological processes. The first is through direct competition for resources. Shrubs have greater access to nutrients and moisture deep in cracks and fissures within the bedrock strata. The second is a slow decrease in labile carbon, thus decreasing organic matter which leads to a decrease in water-holding capacity and a resulting decrease in grass vigor.

### Pathway 1.1B Community 1.1 to 1.3



Warm season  
grasses/shrubs/succulents  
(diagnostic plant community)



Warm season  
grasses/scattered shrubs

This pathway represents a single fire event driving plant Community 1.1 to 1.3. Grasses respond fairly quickly after fire, while shrubs and succulents are suppressed. This pathway occurs within the range of historic variability. Many shrubs and succulents take a while to respond after a fire event. They must re-grow from below ground root systems or from seed. Grasses can colonize quickly, through tillering, especially when precipitation follows closely after fire. Note: This species list reflects the model concept of the diagnostic plant phase. Inventory data from multiple plots and sources were used to compile this list. Note: Ranges reflect variability based on soils, temperature and moisture caused by factors such as elevation, aspect, and slope shape based on average moisture year conditions. Note: Species annual production is given in pounds per acre. Note: A zero in the species production column indicates that the species does not occur at the high or low elevation range of the ecological site. (I.e. tanglehead does not occur at 5500 feet)

### Pathway 1.2B Community 1.2 to 1.3



Shrubs/succulents/warm season grasses



Warm season grasses/scattered shrubs

This pathway represents a single fire event driving plant Community 1.2 to 1.3. Grasses respond fairly quickly after fire, while shrubs and succulents are suppressed. This pathway occurs within the range of historic variability. Many shrubs and succulents take a while to respond after a fire event. They must re-grow from below ground root systems or come back from seed. Grasses can colonize quickly, through tillering after a fire event, especially when precipitation follows closely after fire.

### Pathway 1.2C Community 1.2 to 1.4



Shrubs/succulents/warm season grasses



At risk: shrubs/warm season grasses/succulents/nitrogen fixing shrubs:

This pathway represents a growing competitive advantage from nitrogen fixing shrubs due to slow changes in soil chemistry and hydrology. Nitrogen fixing shrubs such as whitethorn acacia, catclaw acacia, and catclaw mimosa will start to increase in vigor, creating immediate competition with grasses and eventually other shrubs.

### Pathway 1.2A Community 1.2 to 1.4



Shrubs/succulents/warm season grasses



At risk: shrubs/warm season grasses/succulents/nitrogen fixing shrubs:

This pathway is the slow movement, over time from Community 1.2 to Community 1.4 or 1.5. This pathway represents time between fires, which are longer than the historic range of variability. Fire suppression, whether through loss of fuel load due to herbivory or from fighting natural wildfires, has increased shrub and succulent vigor and decreased grass production and composition. Shrub and succulent vigor increases as grass vigor decreases due to various ecological processes. One such process is direct competition for resources. Shrubs have greater access to nutrients and moisture deep in cracks and fissures within the bedrock strata. Another process is the slow

decrease in labile carbon, thus decreasing organic matter. This, in turn, leads to a decrease in water-holding capacity and a consequential decrease in grass vigor.

### Pathway 1.3A Community 1.3 to 1.1



Warm season  
grasses/scattered shrubs



Warm season  
grasses/shrubs/succulents  
(diagnostic plant community)

This pathway is the slow movement from Community 1.3 to Community 1.1. This pathway represents intervals between fires during which natural processes increase shrub and succulent vigor and decrease grass production and grass species composition. Shrub and succulent vigor increases as grass vigor decreases due to various ecological processes. The first of these is direct competition for resources. Shrubs have greater access to moisture and nutrients deep in cracks and fissures within the bedrock strata. The second is a slow decrease in labile carbon, thus decreasing soil organic matter which leads to a decrease in grass vigor.

### Pathway 1.4B Community 1.4 to 1.3



At risk: shrubs/warm season  
grasses/succulents/nitrogen  
fixing shrubs:



Warm season  
grasses/scattered shrubs

pathway represents a single fire event driving plant Community 1.4 to 1.3. Grasses respond fairly quickly after fire, while shrubs and succulents are suppressed. This pathway coupled with a change in livestock grazing will lead back to the historic range of variability.

### Pathway 1.4D Community 1.4 to 1.3



At risk: shrubs/warm season  
grasses/succulents/nitrogen  
fixing shrubs:



Warm season  
grasses/scattered shrubs

A change in livestock grazing management promotes grass vigor and decreases shrub competition. This accelerates the turnover of fine roots, causing an increase in labile carbon, acceleration in decomposition, and an increase in plant available water.

### Pathway 1.5B Community 1.5 to 1.3



At risk:  
shrubs/succulents/warm  
season grasses



Warm season  
grasses/scattered shrubs

This pathway represents a single fire event driving plant Community 1.5 to 1.3. Grasses respond fairly quickly after fire, while shrubs and succulents are suppressed. This pathway will lead back to the historic range of variability

### Pathway 1.5D Community 1.5 to 1.3



At risk:  
shrubs/succulents/warm  
season grasses



Warm season  
grasses/scattered shrubs

A change in livestock grazing management promotes grass vigor and decreases shrub competition. This accelerates the turnover of fine roots, causing an increase in labile carbon, acceleration in decomposition, and an increase in plant available water.

### State 2 Nitrogen fixing shrubs/succulents/shrubs/warm season grasses state

Whitethorn acacia has become a prominent plant on the site. Foliar cover has decreased to < 40%. A higher Nitrogen turnover rate increases the invasiveness and stability of whitethorn. This community has a mix of shrubs, succulents, and warm season grasses.

### Community 2.1 Whitethorn Acacia/succulents/shrubs/warm season grasses



Figure 18. Community 2.1; Seven Rivers Hills; 4-16-12

This community phase consists of a mix of shrubs, succulents, and warm season grasses along with an increase in nitrogen fixing shrubs, especially whitethorn acacia. It is no longer within the reference state, as the site has crossed a threshold into a degraded state. Because the site has crossed a threshold, intensive management (i.e., accelerating practices) is required to restore the system. Foliar cover is between 30 and 50 percent, basal cover is between 3 and 12 percent, and bare ground is around 5 to 15 percent. Warm season grasses make up about 10 percent foliar cover; shrubs, 20 percent; and succulents, 8 percent. The average surface soil stability rating is 3.5 under canopy and 3 in the interspaces. Annual production averages around 300 lbs/ac, but can span between 150

and 450 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth and annual weather patterns. This community exists due to past management and disturbance, primarily fire suppression coupled with grazing management that decreases grass competition. After many years of slow retrogression, a trigger event such as a severe drought could cause this site to cross a threshold where ecological processes and soil properties keep it in a degraded state. With fire suppression, shrubs gain a competitive advantage due to deeper root systems, which take advantage of moisture stored in cracks and fissures in the bedrock, while grasses struggle with the slow decline of soil organic matter and the decrease of plant available water. Also, due to the decrease in soil organic matter, aggregate stability diminishes, creating a decrease in infiltration and an increase in runoff. Livestock may contribute to the distribution of shrub seed and can lessen grass vigor and soil organic matter through continuous grazing and over-stocking. As grass vigor decreases, shrubs gain a competitive advantage. As nitrogen fixing shrubs, especially whitethorn, increase a change in the chemistry and hydrology of the system occurs. This site suffers from low labile carbon and high nitrogen turnover, ultimately slowing the nutrient cycle and reducing plant available water. Over time, without a change in management, it is possible for this plant community to degrade further where only whitethorn, a few scattered shrubs, and fluffgrass exist.

**Table 20. Annual production by plant type**

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	92	185	277
Grass/Grasslike	67	135	202
Forb	9	17	26
<b>Total</b>	<b>168</b>	<b>337</b>	<b>505</b>

**Table 21. Ground cover**

Tree foliar cover	1%
Shrub/vine/liana foliar cover	25-35%
Grass/grasslike foliar cover	5-15%
Forb foliar cover	2-4%
Non-vascular plants	1%
Biological crusts	2-6%
Litter	25-35%
Surface fragments >0.25" and <=3"	35-45%
Surface fragments >3"	10-20%
Bedrock	10-20%
Water	0%
Bare ground	4-12%

**Table 22. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	1-1%	2-4%	6-10%	1-3%
>0.15 <= 0.3	–	4-8%	1-3%	1-2%
>0.3 <= 0.6	–	7-11%	–	–
>0.6 <= 1.4	–	4-8%	–	–
>1.4 <= 4	–	2-4%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

### State 3 Shrubs/succulents state

This plant community in this state has crossed a threshold where shrubs and succulents dominate the canopy and grasses are very limited. Due to fire suppression and continuous herbivory a change in the hydrologic cycle has occurred. This community is very similar to 2.1 except for the presence of whitethorn and other nitrogen fixing shrubs.

#### Community 3.1 Shrubs/succulents



Figure 20. Community 3.1; Mariola dominated community; Walnut

This community phase combines a mix of shrubs, succulents and some warm season grasses. It is no longer within the reference state as the site has crossed a threshold into a degraded state. Because the site has crossed a threshold, intensive management (i.e., accelerating practices) are required to restore the system. Foliar cover is between 30 and 70 percent, basal cover is between 5 and 20 percent, and bare ground is around 5 to 15 percent. Warm season grasses make up about 10 percent foliar cover; shrubs, 30 percent; and succulents, 8 percent. The average surface soil stability rating is 4.0 under canopy and 3.5 in the interspaces. Annual production averages around 400 lbs/ac, but can span between 200 and 600 lbs/ac, depending on the percentage of rock outcrop, cracks and fissures in the bedrock, soil depth and annual weather patterns. This community exists due to past management and disturbance, primarily fire suppression coupled with grazing management that decreases grass competition. After many years of slow retrogression a trigger event such as a severe drought could cause this site to cross a threshold where ecological processes and soil properties keep it in a degraded state. This state is different than state two due to the scarcity or absence of nitrogen fixing shrubs. With fire suppression, shrubs gain a competitive advantage due to deeper root systems, which take advantage of moisture stored in cracks and fissures in the bedrock, while grasses struggle with the slow decline of soil organic matter and the decrease of plant available water. Also, due to the decrease in soil organic matter, aggregate stability diminishes leading to a decrease in infiltration and an increase in runoff. Livestock may contribute to the degradation of this site as they can

lessen plant vigor and soil organic matter through continuous grazing and over-stocking. As grass vigor decreases, shrubs gain a competitive advantage. This site suffers from low labile carbon and soil organic matter, ultimately slowing the nutrient cycle and reducing plant available water. Over time, without a change in management, it is possible for this plant community to degrade further.

**Table 23. Annual production by plant type**

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Shrub/Vine	123	247	370
Grass/Grasslike	90	179	269
Forb	11	22	34
<b>Total</b>	<b>224</b>	<b>448</b>	<b>673</b>

**Table 24. Ground cover**

Tree foliar cover	1%
Shrub/vine/liana foliar cover	35-45%
Grass/grasslike foliar cover	8-12%
Forb foliar cover	1-5%
Non-vascular plants	1%
Biological crusts	2-6%
Litter	25-35%
Surface fragments >0.25" and <=3"	34-45%
Surface fragments >3"	10-20%
Bedrock	10-20%
Water	0%
Bare ground	4-12%

**Table 25. Canopy structure (% cover)**

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	–	3-7%	6-10%	1-3%
>0.15 <= 0.3	–	7-11%	1-3%	1-2%
>0.3 <= 0.6	–	9-13%	–	–
>0.6 <= 1.4	–	7-11%	–	–
>1.4 <= 4	–	2-6%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

## Transition T1A State 1 to 2

This transition moves the site across a threshold to state two. Slow variables: Continued encroachment by whitethorn acacia, and catclaw mimosa, coupled with the loss of the herbaceous plant community. Both chemical and hydrological shifts occur as the C:N decreases creating an increase in the nitrogen turnover rate and creating an on-going competitive advantage for nitrogen fixing shrubs. Trigger event: A severe drought, causing a loss of

organic carbon. Threshold: A hydrologic function/soil chemistry threshold is crossed.

## Transition T1B

### State 1 to 3

This transition moves the site across a threshold to state three. Slow variables: A continued competitive advantage and increase of shrubs and succulents, coupled with the loss of the herbaceous plant community. A hydrological shift occurs as shrubs and succulents out-compete herbaceous plants for water resources. Trigger event: A severe drought, causing a loss of organic carbon. Threshold: A hydrologic function threshold is crossed.

## Restoration pathway R2A

### State 2 to 1

An increase in the competitive advantage of non-nitrogen fixing species through physical, chemical, and biological management practices. Various facilitating and management practices can be used to restore this ecological site back to reference. Chemical, mechanical, and biological practices can all be used to suppress whitethorn and other leguminous thorny plants in the plant community. Also, range seeding, winter feeding, browsing, and high intensity-short duration livestock grazing can help bring grass seed and organic matter back into the system and start restoring soil carbon and microbial levels. Eventually, prescribed burning will also help reduce shrub competition and improve grass vigor, once fuel loads can carry fire. Monitoring foliar cover by species will help inform the land manager if plant composition is responding to management.

## Restoration pathway R3A

### State 3 to 1

An increase in the competitive advantage of herbaceous species through prescribed burning and grazing management practices. Various facilitating and management practices can be used to restore this ecological site back to reference. Prescribed burning is important to help reduce shrub competition for nutrients and water resources. Chemical, mechanical, and biological practices can also be used to suppress shrub competition. Also, range seeding, winter feeding, browsing, and high intensity-short duration livestock grazing can help bring grass seed and organic matter back into the system and start restoring soil carbon and microbial levels. Monitoring foliar cover by species will help inform the land manager if plant composition is responding to management.

## Additional community tables

Table 26. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Tallgrasses</b>			22–78	
	cane bluestem	BOBA3	<i>Bothriochloa barbinodis</i>	10–50	1–3
	silver beardgrass	BOLA2	<i>Bothriochloa laguroides</i>	10–30	1–2
	little bluestem	SCSC	<i>Schizachyrium scoparium</i>	1	1
2	<b>Warm Season Midgrasses</b>			392–504	
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	101–222	2–18
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	71–111	4–6
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	61–81	3–5
	slim tridens	TRMU	<i>Tridens muticus</i>	30–71	2–4
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	10–50	1–5
	tanglehead	HETER6	<i>Heteropogon</i>	0–40	1–4
	green sprangletop	LEDU	<i>Leptochloa dubia</i>	10–30	1–2
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	6–16	1
	bullgrass	MUEM	<i>Muhlenbergia emersleyi</i>	0–1	0–1



3	<b>Warm Season Shortgrasses</b>			224–280	
	black grama	BOER4	<i>Bouteloua eriopoda</i>	20–121	1–9
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	50–91	4–8
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	10–50	1–4
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	6–36	1–2
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	6–36	1–2
	red grama	BOTR2	<i>Bouteloua trifida</i>	0–20	0–2
	sand muhly	MUAR2	<i>Muhlenbergia arenicola</i>	0–20	0–2
	common wolfstail	LYPH	<i>Lycurus phleoides</i>	6–16	1
	streambed bristlegrass	SELE6	<i>Setaria leucopila</i>	6–16	1
	tobosagrass	PLMU3	<i>Pleuraphis mutica</i>	0–1	0–1
	low woollygrass	DAPU7	<i>Dasyochloa pulchella</i>	0–1	0–1
	Carolina crabgrass	DIPU9	<i>Digitaria pubiflora</i>	0–1	0–1
	nineawn pappusgrass	ENDE	<i>Enneapogon desvauxii</i>	0–1	0–1
4	<b>Cool Season Tallgrasses</b>			0–40	
	New Mexico feathergrass	HENE5	<i>Hesperostipa neomexicana</i>	0–40	0–2
<b>Forb</b>					
5	<b>Perennial Forbs</b>			22–78	
	threadleaf phlox	PHME2	<i>Phlox mesoleuca</i>	6–16	1–2
	croton	CROTO	<i>Croton</i>	6–16	1–2
	hawkweed buckwheat	ERHI3	<i>Eriogonum hieraciifolium</i>	6–16	1–2
	Davis Mountain mock vervain	GLBIC	<i>Glandularia bipinnatifida var. ciliata</i>	6–16	1–2
	hairy false goldenaster	HEVI4	<i>Heterotheca villosa</i>	0–1	0–1
	Fendler's bladderpod	LEFE	<i>Lesquerella fendleri</i>	0–1	0–1
	Lewis flax	LILE3	<i>Linum lewisii</i>	0–1	0–1
	plains blackfoot	MELE2	<i>Melampodium leucanthum</i>	0–1	0–1
	James' nailwort	PAJA	<i>Paronychia jamesii</i>	0–1	0–1
	ivyleaf groundcherry	PHHE4	<i>Physalis hederifolia</i>	0–1	0–1
	cryptantha	CRYPT	<i>Cryptantha</i>	0–1	0–1
	silver prairie clover	DABIA	<i>Dalea bicolor var. argyrea</i>	0–1	0–1
	Wright's prairie clover	DAWR	<i>Dalea wrightii</i>	0–1	0–1
	spreading fleabane	ERDI4	<i>Erigeron divergens</i>	0–1	0–1
	nodding onion	ALCE2	<i>Allium cernuum</i>	0–1	0–1
	white sagebrush	ARLU	<i>Artemisia ludoviciana</i>	0–1	0–1
	Hartweg's sundrops	CAHA14	<i>Calylophus hartwegii</i>	0–1	0–1
	wholeleaf Indian paintbrush	CAIN14	<i>Castilleja integra</i>	0–1	0–1
	twinleaf senna	SEBA3	<i>Senna bauhinioides</i>	0–1	0–1
	Douglas' ragwort	SEFLD	<i>Senecio flaccidus var. douglasii</i>	0–1	0–1
	resurrection plant	SEPI	<i>Selaginella pilifera</i>	0–1	0–1
	early shaggytuft	STBA	<i>Stenandrium barbatum</i>	0–1	0–1
	stemmy four-nerve daisy	TESC2	<i>Tetraneuris scaposa</i>	0–1	0–1
6	<b>Annual Forbs</b>			0–1	

12	<b>Fern</b>			6–16	
	Cochise scaly cloakfern	ASCO42	<i>Astrolepis cochisensis</i>	6–16	0–1
	star cloak fern	NOST	<i>Notholaena standleyi</i>	0–1	0–1
<b>Shrub/Vine</b>					
7	<b>Shrubs</b>			84–140	
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	10–50	2–6
	pungent oak	QUPU	<i>Quercus pungens</i>	0–40	0–6
	mariola	PAIN2	<i>Parthenium incanum</i>	6–36	1–5
	resinbush	VIST	<i>Viguiera stenoloba</i>	10–30	1–3
	littleleaf ratany	KRER	<i>Krameria erecta</i>	6–16	1–2
	algerita	MATR3	<i>Mahonia trifoliolata</i>	6–16	1–2
	Wright's beebrush	ALWR	<i>Aloysia wrightii</i>	6–16	1–2
	javelina bush	COER5	<i>Condalia ericoides</i>	6–16	1–2
	featherplume	DAFO	<i>Dalea formosa</i>	6–16	1–2
	longleaf jointfir	EPTR	<i>Ephedra trifurca</i>	0–1	0–1
	desert myrtlecroton	BEOB	<i>Bernardia obovata</i>	0–1	0–1
	creosote bush	LATR2	<i>Larrea tridentata</i>	0–1	0–1
	catclaw acacia	ACGR	<i>Acacia greggii</i>	0–1	0–1
	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	0–1	0–1
	lotebush	ZIOB	<i>Ziziphus obtusifolia</i>	0–1	0–1
	prairie sumac	RHLA3	<i>Rhus lanceolata</i>	0–1	0–1
	skunkbush sumac	RHTRT	<i>Rhus trilobata</i> var. <i>trilobata</i>	0–1	0–1
	evergreen sumac	RHVI3	<i>Rhus virens</i>	0–1	0–1
8	<b>Half Shrubs</b>			17–28	
	dyssodia	DYSSO	<i>Dyssodia</i>	6–16	1–2
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	6–16	1–2
	rough menodora	MESC	<i>Menodora scabra</i>	0–1	0–1
	five needle pricklyleaf	THPEP	<i>Thymophylla pentachaeta</i> var. <i>pentachaeta</i>	0–1	0–1
	hairy crinklemat	TIHI	<i>Tiquilia hispidissima</i>	0–1	0–1
	desert zinnia	ZIAC	<i>Zinnia acerosa</i>	0–1	0–1
	damianita	CHME3	<i>Chrysactinia mexicana</i>	0–1	0–1
9	<b>Cactus</b>			17–28	
	purple pricklypear	OPMAM	<i>Opuntia macrocentra</i> var. <i>macrocentra</i>	16–26	1–3
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	0–1	0–1
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var. <i>imbricata</i>	0–1	0–1
	pitaya	ECEN2	<i>Echinocereus enneacanthus</i>	0–1	0–1
	devilshead	ECHO	<i>Echinocactus horzonthalonius</i>	0–1	0–1
	rainbow cactus	ECPE	<i>Echinocereus pectinatus</i>	0–1	0–1
	horse crippler	ECTE	<i>Echinocactus texensis</i>	0–1	0–1
	kingcup cactus	ECTR	<i>Echinocereus triglochidiatus</i>	0–1	0–1
	nylon hedgehog cactus	ECVI2	<i>Echinocereus viridiflorus</i>	0–1	0–1
	ocotillo	FOSP2	<i>Fouquieria splendens</i>	0–1	0–1

10	<b>Yucca</b>			0–1	
	soaptree yucca	YUEL	<i>Yucca elata</i>	0–1	0–1
	Torrey's yucca	YUTO	<i>Yucca torreyi</i>	0–1	0–1
11	<b>Yucca-Like Plants</b>			45–56	
	green sotol	DALE2	<i>Dasyliirion leiophyllum</i>	20–40	3–9
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	6–16	3–5
	Texas sacahuista	NOTE	<i>Nolina texana</i>	6–16	1–3
<b>Tree</b>					
13	<b>Tree</b>			0–1	
	Texas madrone	ARXA80	<i>Arbutus xalapensis</i>	0–1	0–1

Table 27. Community 1.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Tallgrasses</b>			22–45	
	cane bluestem	BOBA3	<i>Bothriochloa barbinodis</i>	9–27	1–2
	silver beardgrass	BOLA2	<i>Bothriochloa laguroides</i>	9–27	1–2
	little bluestem	SCSC	<i>Schizachyrium scoparium</i>	1	1
2	<b>Warm Season Midgrasses</b>			163–325	
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	72–108	3–5
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	18–108	1
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	36–54	1–3
	slim tridens	TRMU	<i>Tridens muticus</i>	27–45	1–3
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	4–31	1–2
	tanglehead	HETER6	<i>Heteropogon</i>	0–18	0–2
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	4–13	1
	bullgrass	MUEM	<i>Muhlenbergia emersleyi</i>	0–1	0–1
3	<b>Warm Season Shortgrasses</b>			112–224	
	black grama	BOER4	<i>Bouteloua eriopoda</i>	18–108	1–5
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	27–63	1–3
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	9–63	1–3
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	9–45	1–2
	common wolfstail	LYPH	<i>Lycurus phleoides</i>	4–13	1–2
	tobosagrass	PLMU3	<i>Pleuraphis mutica</i>	0–1	0–1
	nineawn pappusgrass	ENDE	<i>Enneapogon desvauxii</i>	0–1	0–1
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	0–1	0–1
4	<b>Cool-season Tallgrasses</b>			0–18	
	New Mexico feathergrass	HENE5	<i>Hesperostipa neomexicana</i>	0–18	0–2
<b>Forb</b>					
5	<b>Perennial Forbs</b>			22–45	
	threadleaf phlox	PHME2	<i>Phlox mesoleuca</i>	4–13	1–2
	white sagebrush	ARLU	<i>Artemisia ludoviciana</i>	4–13	1–2
	Davis Mountain mock vervain	GLBIC	<i>Glandularia bipinnatifida</i> var. <i>ciliata</i>	4–13	1–2

	hairy false goldenaster	HEVI4	<i>Heterotheca villosa</i>	4–13	1–2
	Hartweg's sundrops	CAHA14	<i>Calylophus hartwegii</i>	1	1–2
	wholeleaf Indian paintbrush	CAIN14	<i>Castilleja integra</i>	1	1–2
	croton	CROTO	<i>Croton</i>	1	1–2
	Havard's buckwheat	ERHA	<i>Eriogonum havardii</i>	1	1–2
	hawkweed buckwheat	ERHI3	<i>Eriogonum hieraciifolium</i>	1	1–2
	early shaggytuft	STBA	<i>Stenandrium barbatum</i>	1	1–2
	nodding onion	ALCE2	<i>Allium cernuum</i>	1	1–2
	twinleaf senna	SEBA3	<i>Senna bauhinioides</i>	1	1
	spreading fleabane	ERDI4	<i>Erigeron divergens</i>	0–1	0–1
	James' nailwort	PAJA	<i>Paronychia jamesii</i>	1	1
	ivyleaf groundcherry	PHHE4	<i>Physalis hederifolia</i>	0–1	0–1
6	<b>Annual Forbs</b>			1	
12	<b>Fern</b>			4–13	
	Cochise scaly cloakfern	ASCO42	<i>Astrolepis cochisensis</i>	4–13	1–2
	star cloak fern	NOST	<i>Notholaena standleyi</i>	0–1	0–1
<b>Shrub/Vine</b>					
7	<b>Shrubs</b>			151–303	
	mariola	PAIN2	<i>Parthenium incanum</i>	45–135	2–8
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	0–108	1–9
	pungent oak	QUPU	<i>Quercus pungens</i>	0–54	0–4
	featherplume	DAFO	<i>Dalea formosa</i>	1–54	1–3
	skunkbush sumac	RHTRT	<i>Rhus trilobata</i> var. <i>trilobata</i>	0–36	0–2
	resinbush	VIST	<i>Viguiera stenoloba</i>	9–27	1–3
	Wright's beebrush	ALWR	<i>Aloysia wrightii</i>	1–18	1–3
	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	4–13	1–2
	littleleaf ratany	KRER	<i>Krameria erecta</i>	4–13	1–2
	algerita	MATR3	<i>Mahonia trifoliolata</i>	4–13	1–2
	catclaw mimosa	MIACB	<i>Mimosa aculeaticarpa</i> var. <i>biuncifera</i>	4–13	1–2
	javelina bush	COER5	<i>Condalia ericoides</i>	4–13	1–2
	prairie sumac	RHLA3	<i>Rhus lanceolata</i>	0–1	0–1
	desert myrtlecroton	BEOB	<i>Bernardia obovata</i>	1	1
	longleaf jointfir	EPTR	<i>Ephedra trifurca</i>	0–1	0–1
	whitethorn acacia	ACCO2	<i>Acacia constricta</i>	1	1
	catclaw acacia	ACGR	<i>Acacia greggii</i>	1	1
8	<b>Half-Shrubs</b>			17–39	
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	1–36	2–4
	desert zinnia	ZIAC	<i>Zinnia acerosa</i>	1–35	1
	dyssodia	DYSSO	<i>Dyssodia</i>	4–13	1
	hairy crinklemat	TIHI	<i>Tiquilia hispidissima</i>	1	1
	damianita	CHME3	<i>Chrysactinia mexicana</i>	0–1	0–1
9	<b>Cactus</b>			22–45	

	purple pricklypear	OPMAM	<i>Opuntia macrocentra</i> var. <i>macrocentra</i>	9–27	2–4
	ocotillo	FOSP2	<i>Fouquieria splendens</i>	0–18	0–2
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	4–13	1–3
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var. <i>imbricata</i>	0–1	0–1
	rainbow cactus	ECPE	<i>Echinocereus pectinatus</i>	1	1
	horse cripper	ECTE	<i>Echinocactus texensis</i>	0–1	0–1
	kingcup cactus	ECTR	<i>Echinocereus triglochidiatus</i>	0–1	0–1
	nylon hedgehog cactus	ECVI2	<i>Echinocereus viridiflorus</i>	0–1	0–1
10	<b>Yucca</b>			6–13	
	Torrey's yucca	YUTO	<i>Yucca torreyi</i>	4–13	1–2
	soaptree yucca	YUEL	<i>Yucca elata</i>	0–1	0–1
11	<b>Yucca-like plants</b>			34–67	
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	9–27	1–7
	green sotol	DALE2	<i>Dasyilirion leiophyllum</i>	9–27	2–6
	Texas sacahuista	NOTE	<i>Nolina texana</i>	9–27	1–5

Table 28. Community 1.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Tallgrasses</b>			27–54	
	cane bluestem	BOBA3	<i>Bothriochloa barbinodis</i>	10–30	1–3
	silver beardgrass	BOLA2	<i>Bothriochloa laguroides</i>	10–30	1–3
	little bluestem	SCSC	<i>Schizachyrium scoparium</i>	1	1
2	<b>Warm Season Midgrasses</b>			303–605	
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	50–293	4–24
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	91–131	6–8
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	50–91	1–5
	slim tridens	TRMU	<i>Tridens muticus</i>	36–54	2–4
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	10–50	1–3
	tanglehead	HETER6	<i>Heteropogon</i>	0–40	1–4
	green sprangletop	LEDU	<i>Leptochloa dubia</i>	9–27	1–2
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	6–16	1
3	<b>Warm Season Shortgrasses</b>			168–336	
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	61–121	5–9
	black grama	BOER4	<i>Bouteloua eriopoda</i>	30–91	2–10
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	10–30	1–3
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	10–30	1–3
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	10–30	1–3
	red grama	BOTR2	<i>Bouteloua trifida</i>	0–20	0–1
	sand muhly	MUAR2	<i>Muhlenbergia arenicola</i>	0–20	0–1
	streambed bristlegrass	SELE6	<i>Setaria leucopila</i>	6–16	1–2
	common wolfstail	LYPH	<i>Lycurus phleoides</i>	6–16	1–2

	low woollygrass	DAPU7	<i>Dasyochloa pulchella</i>	0–1	0–1
	Carolina crabgrass	DIPU9	<i>Digitaria pubiflora</i>	0–1	0–1
	nineawn pappusgrass	ENDE	<i>Enneapogon desvauxii</i>	0–1	0–1
4	<b>Cool-season Tallgrasses</b>			0–20	
	New Mexico feathergrass	HENE5	<i>Hesperostipa neomexicana</i>	0–20	0–3
<b>Forb</b>					
5	<b>Perennial Forbs</b>			27–54	
	Davis Mountain mock vervain	GLBIC	<i>Glandularia bipinnatifida var. ciliata</i>	10–30	1–3
	white sagebrush	ARLU	<i>Artemisia ludoviciana</i>	6–16	1–2
	spreading fleabane	ERDI4	<i>Erigeron divergens</i>	6–16	1–2
	threadleaf phlox	PHME2	<i>Phlox mesoleuca</i>	6–16	1–2
	polygala	POLYG	<i>Polygala</i>	0–1	0–1
	Douglas' ragwort	SEFLD	<i>Senecio flaccidus var. douglasii</i>	0–1	0–1
	early shaggytuft	STBA	<i>Stenandrium barbatum</i>	0–1	0–1
	Havard's buckwheat	ERHA	<i>Eriogonum havardii</i>	0–1	0–1
	croton	CROTO	<i>Croton</i>	0–1	0–1
	James' nailwort	PAJA	<i>Paronychia jamesii</i>	0–1	0–1
	nodding onion	ALCE2	<i>Allium cernuum</i>	0–1	0–1
6	<b>Annual Forbs</b>			2–16	
	common sunflower	HEAN3	<i>Helianthus annuus</i>	2–16	1–3
12	<b>Fern</b>			0–1	
	Cochise scaly cloakfern	ASCO42	<i>Astrolepis cochisensis</i>	0–1	1
<b>Shrub/Vine</b>					
7	<b>Shrubs</b>			87–175	
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	0–61	0–5
	mariola	PAIN2	<i>Parthenium incanum</i>	10–50	1–3
	pungent oak	QUPU	<i>Quercus pungens</i>	0–30	0–3
	featherplume	DAFO	<i>Dalea formosa</i>	10–30	1–2
	resinbush	VIST	<i>Viguiera stenoloba</i>	6–16	1–2
	javelina bush	COER5	<i>Condalia ericoides</i>	6–16	1–2
	lotebush	ZIOB	<i>Ziziphus obtusifolia</i>	0–1	0–1
	skunkbush sumac	RHTRT	<i>Rhus trilobata var. trilobata</i>	0–1	0–1
	longleaf jointfir	EPTR	<i>Ephedra trifurca</i>	0–1	0–1
	littleleaf ratany	KRER	<i>Krameria erecta</i>	0–1	0–1
	algerita	MATR3	<i>Mahonia trifoliolata</i>	0–1	0–1
	catclaw mimosa	MIACB	<i>Mimosa aculeaticarpa var. biuncifera</i>	0–1	0–1
	catclaw acacia	ACGR	<i>Acacia greggii</i>	0–1	0–1
	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	0–1	0–1
	Wright's beebrush	ALWR	<i>Aloysia wrightii</i>	0–1	0–1
8	<b>Half-Shrubs</b>			20–40	
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	10–30	1–3
	dyssodia	DYSSO	<i>Dyssodia</i>	6–16	1–2
	rough menodora	MESC	<i>Menodora scabra</i>	0–1	0–1

	fineneedle pricklyleaf	THPEP	<i>Thymophylla pentachaeta</i> var. <i>pentachaeta</i>	0–1	0–1
	hairy crinklemat	TIHI	<i>Tiquilia hispidissima</i>	0–1	0–1
	desert zinnia	ZIAC	<i>Zinnia acerosa</i>	0–1	0–1
9	<b>Cactus</b>			6–16	
	purple pricklypear	OPMAM	<i>Opuntia macrocentra</i> var. <i>macrocentra</i>	6–16	1–3
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	0–1	0–1
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var. <i>imbricata</i>	0–1	0–1
	devilshead	ECHO	<i>Echinocactus horizonthalonius</i>	0–1	0–1
	horse crippler	ECTE	<i>Echinocactus texensis</i>	0–1	0–1
	kingcup cactus	ECTR	<i>Echinocereus triglochidiatus</i>	0–1	0–1
	nylon hedgehog cactus	ECVI2	<i>Echinocereus viridiflorus</i>	0–1	0–1
	ocotillo	FOSP2	<i>Fouquieria splendens</i>	0–1	0–1
	cactus apple	OPEN3	<i>Opuntia engelmannii</i>	0–1	0–1
10	<b>Yucca</b>			6–16	
	Torrey's yucca	YUTO	<i>Yucca torreyi</i>	6–16	1–2
	soaptree yucca	YUEL	<i>Yucca elata</i>	0–1	1
11	<b>Yucca-like-plants</b>			6–16	
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	6–16	1–2
	Texas sacahuista	NOTE	<i>Nolina texana</i>	6–16	1–2
	green sotol	DALE2	<i>Dasyliirion leiophyllum</i>	0–1	1

Table 29. Community 1.4 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Tallgrasses</b>			7–20	
	cane bluestem	BOBA3	<i>Bothriochloa barbinodis</i>	7–20	1–2
2	<b>Warm Season Midgrasses</b>			87–262	
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	61–87	2–5
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	13–67	1–3
	slim tridens	TRMU	<i>Tridens muticus</i>	20–34	1–2
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	13–27	1–2
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	7–20	1–2
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	3–10	1–2
3	<b>Warm Season Shortgrasses</b>			81–242	
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	47–74	2–5
	black grama	BOER4	<i>Bouteloua eriopoda</i>	7–61	1–3
	nineawn pappusgrass	ENDE	<i>Enneapogon desvauxii</i>	3–24	1–2
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	7–20	1–2
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	7–20	1–2
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	7–20	1–2
	common wolfstail	LYPH	<i>Lycurus phleoides</i>	3–10	1–2
	streambed brietgrass	SEI E6	<i>Setaria leuconila</i>	3–10	1

	streambed bluestgrass	SELE5	<i>Setaria leucophaea</i>	3-10	1
	low woollygrass	DAPU7	<i>Dasyochloa pulchella</i>	3-10	1
	Carolina crabgrass	DIPU9	<i>Digitaria pubiflora</i>	0-1	0-1
4	<b>Cool-season Tallgrasses</b>			3-10	
	New Mexico feathergrass	HENE5	<i>Hesperostipa neomexicana</i>	3-10	1
<b>Forb</b>					
5	<b>Perennial Forbs</b>			17-50	
	croton	CROTO	<i>Croton</i>	3-10	1-2
	hawkweed buckwheat	ERHI3	<i>Eriogonum hieraciifolium</i>	3-10	1-2
	Davis Mountain mock vervain	GLBIC	<i>Glandularia bipinnatifida var. ciliata</i>	3-10	1-2
	James' nailwort	PAJA	<i>Paronychia jamesii</i>	3-10	1-2
	threadleaf phlox	PHME2	<i>Phlox mesoleuca</i>	3-10	1-2
	polygala	POLYG	<i>Polygala</i>	3-10	1-2
	resurrection plant	SEPI	<i>Selaginella pilifera</i>	0-1	0-1
	spreading fleabane	ERDI4	<i>Erigeron divergens</i>	0-1	0-1
	whitemargin sandmat	CHAL11	<i>Chamaesyce albomarginata</i>	0-1	0-1
6	<b>Annual Forbs</b>			3-10	
	common sunflower	HEAN3	<i>Helianthus annuus</i>	3-10	1-2
12	<b>Fern</b>			3-10	
	Cochise scaly cloakfern	ASCO42	<i>Astrolepis cochisensis</i>	3-10	1-2
<b>Shrub/Vine</b>					
7	<b>Shrubs</b>			91-272	
	mariola	PAIN2	<i>Parthenium incanum</i>	13-54	1-7
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	0-54	1-5
	pungent oak	QUPU	<i>Quercus pungens</i>	0-40	0-4
	featherplume	DAFO	<i>Dalea formosa</i>	7-34	1-3
	whitethorn acacia	ACCO2	<i>Acacia constricta</i>	7-34	1-3
	catclaw acacia	ACGR	<i>Acacia greggii</i>	7-20	1-3
	catclaw mimosa	MIACB	<i>Mimosa aculeaticarpa var. biuncifera</i>	7-20	1-3
	resinbush	VIST	<i>Viguiera stenoloba</i>	7-20	1-3
	algerita	MATR3	<i>Mahonia trifoliolata</i>	3-10	1-2
	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	3-10	1-2
	javelina bush	COER5	<i>Condalia ericoides</i>	3-10	1-2
	longleaf jointfir	EPTR	<i>Ephedra trifurca</i>	0-1	0-1
	littleleaf sumac	RHMI3	<i>Rhus microphylla</i>	0-1	0-1
8	<b>Half-Shrubs</b>			10-30	
	dyssodia	DYSSO	<i>Dyssodia</i>	7-20	1-2
	rough menodora	MESC	<i>Menodora scabra</i>	3-10	1
	five-needle pricklyleaf	THPEP	<i>Thymophylla pentachaeta var. pentachaeta</i>	0-1	0-1
	hairy crinklemat	TIHI	<i>Tiquilia hispidissima</i>	0-1	0-1
9	<b>Cactus</b>			13-40	
	purple pricklypear	OPMAM	<i>Opuntia macrocentra var. macrocentra</i>	7-20	2-4



	ocotillo	FOSP2	<i>Fouquieria splendens</i>	3–10	0–4
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	3–10	1–3
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var. <i>imbricata</i>	3–10	1
	horse creeper	ECTE	<i>Echinocactus texensis</i>	0–1	0–1
	kingcup cactus	ECTR	<i>Echinocereus triglochidiatus</i>	0–1	0–1
	nylon hedgehog cactus	ECV12	<i>Echinocereus viridiflorus</i>	0–1	0–1
	cactus apple	OPEN3	<i>Opuntia engelmannii</i>	0–1	0–1
10	<b>Yucca</b>			3–10	
	Torrey's yucca	YUTO	<i>Yucca torreyi</i>	3–10	1
	soaptree yucca	YUEL	<i>Yucca elata</i>	0–1	0–1
11	<b>Yucca-like plants</b>			17–50	
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	7–34	1–3
	green sotol	DALE2	<i>Dasyliirion leiophyllum</i>	7–20	1–3
	Texas sacahuista	NOTE	<i>Nolina texana</i>	3–10	1–2

Table 30. Community 1.5 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Tallgrasses</b>			3–10	
	cane bluestem	BOBA3	<i>Bothriochloa barbinodis</i>	3–10	1–2
2	<b>Warm Season Midgrasses</b>			90–179	
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	34–61	2–4
	slim tridens	TRMU	<i>Tridens muticus</i>	27–40	1–2
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	7–34	1–2
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	13–27	1–2
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	0–13	1
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	3–10	1
3	<b>Warm Season Shortgrasses</b>			103–206	
	black grama	BOER4	<i>Bouteloua eriopoda</i>	13–81	1–5
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	7–47	1–2
	low woollygrass	DAPU7	<i>Dasyochloa pulchella</i>	7–20	1–2
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	7–20	1–2
	common wolfstail	LYPH	<i>Lycurus phleoides</i>	7–20	1–2
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	7–20	1–2
	streambed bristlegrass	SELE6	<i>Setaria leucopila</i>	7–20	1–2
	nineawn pappusgrass	ENDE	<i>Enneapogon desvauxii</i>	0–13	0–1
	blue grama	BOGR2	<i>Bouteloua gracilis</i>	3–10	1
	Carolina crabgrass	DIPU9	<i>Digitaria pubiflora</i>	0–1	0–1
4	<b>Cool-season Tallgrasses</b>			0–13	
	New Mexico feathergrass	HENE5	<i>Hesperostipa neomexicana</i>	0–13	1–2
<b>Forb</b>					
5	<b>Perennial Forbs</b>			18–36	
	croton	CROTO	<i>Croton</i>	3–10	1–2

	hawkweed buckwheat	ERHI3	<i>Eriogonum hieraciifolium</i>	3–10	1–2
	Davis Mountain mock vervain	GLBIC	<i>Glandularia bipinnatifida</i> var. <i>ciliata</i>	3–10	1–2
	threadleaf phlox	PHME2	<i>Phlox mesoleuca</i>	3–10	1–2
	polygala	POLYG	<i>Polygala</i>	1	1
	resurrection plant	SEPI	<i>Selaginella pilifera</i>	0–1	0–1
	James' nailwort	PAJA	<i>Paronychia jamesii</i>	1	1
	spreading fleabane	ERDI4	<i>Erigeron divergens</i>	0–1	0–1
	whitemargin sandmat	CHAL11	<i>Chamaesyce albomarginata</i>	0–1	0–1
6	<b>Annual Forbs</b>			3–10	
	common sunflower	HEAN3	<i>Helianthus annuus</i>	3–10	1–2
12	<b>Fern</b>			3–10	
	Cochise scaly cloakfern	ASCO42	<i>Astrolepis cochisensis</i>	3–10	1–2
	star cloak fern	NOST	<i>Notholaena standleyi</i>	0–1	0–1
<b>Shrub/Vine</b>					
7	<b>Shrubs</b>			121–242	
	mariola	PAIN2	<i>Parthenium incanum</i>	20–61	2–10
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	7–61	1–9
	pungent oak	QUPU	<i>Quercus pungens</i>	0–54	0–8
	featherplume	DAFO	<i>Dalea formosa</i>	13–27	1–3
	resinbush	VIST	<i>Viguiera stenoloba</i>	7–20	1–3
	algerita	MATR3	<i>Mahonia trifoliolata</i>	7–20	1–2
	javelina bush	COER5	<i>Condalia ericoides</i>	7–20	1–2
	littleleaf ratany	KRER	<i>Krameria erecta</i>	3–10	1–2
	Wright's beebrush	ALWR	<i>Aloysia wrightii</i>	3–10	1–2
	desert myrtlecroton	BEOB	<i>Bernardia obovata</i>	0–1	0–1
	longleaf jointfir	EPTR	<i>Ephedra trifurca</i>	0–1	0–1
	whitethorn acacia	ACCO2	<i>Acacia constricta</i>	0–1	0–1
	catclaw acacia	ACGR	<i>Acacia greggii</i>	0–1	0–1
	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	0–1	0–1
	catclaw mimosa	MIACB	<i>Mimosa aculeaticarpa</i> var. <i>biuncifera</i>	0–1	0–1
	littleleaf sumac	RHMI3	<i>Rhus microphylla</i>	0–1	0–1
8	<b>Half-Shrubs</b>			13–27	
	dyssodia	DYSSO	<i>Dyssodia</i>	7–20	1–2
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	3–10	1–2
	rough menodora	MESC	<i>Menodora scabra</i>	3–10	1
	fiveneedle pricklyleaf	THPEP	<i>Thymophylla pentachaeta</i> var. <i>pentachaeta</i>	0–1	0–1
	hairy crinklemat	TIHI	<i>Tiquilia hispidissima</i>	0–1	0–1
9	<b>Cactus</b>			36–72	
	purple pricklypear	OPMAM	<i>Opuntia macrocentra</i> var. <i>macrocentra</i>	7–20	1–3
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	7–20	1–3
	ocotillo	FOSP2	<i>Fouquieria splendens</i>	7–20	1–2
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var.	3–10	1

			<i>imbricata</i>		
	horse creeper	ECTE	<i>Echinocactus texensis</i>	0–1	0–1
	kingcup cactus	ECTR	<i>Echinocereus triglochidiatus</i>	0–1	0–1
	nylon hedgehog cactus	ECVI2	<i>Echinocereus viridiflorus</i>	0–1	0–1
	cactus apple	OPEN3	<i>Opuntia engelmannii</i>	0–1	0–1
10	<b>Yucca</b>			3–10	
	Torrey's yucca	YUTO	<i>Yucca torreyi</i>	3–10	1
	soaptree yucca	YUEL	<i>Yucca elata</i>	0–1	0–1
11	<b>Yucca-like plants</b>			40–81	
	green sotol	DALE2	<i>Dasyllirion leiophyllum</i>	7–47	1–11
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	7–34	1–3
	Texas sacahuista	NOTE	<i>Nolina texana</i>	7–20	1–2

Table 31. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Midgrasses</b>			25–76	
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	13–20	1–3
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	7–13	1–2
	slim tridens	TRMU	<i>Tridens muticus</i>	7–13	1–2
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	3–10	1
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	3–10	1
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	0–1	1
2	<b>Warm Season Shortgrasses</b>			41–127	
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	13–27	2–5
	black grama	BOER4	<i>Bouteloua eriopoda</i>	3–24	1–3
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	7–20	1–2
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	7–20	1–2
	low woollygrass	DAPU7	<i>Dasyochloa pulchella</i>	7–20	1
	Carolina crabgrass	DIPU9	<i>Digitaria pubiflora</i>	3–10	1
	red grama	BOTR2	<i>Bouteloua trifida</i>	2–6	1
<b>Forb</b>					
3	<b>Perennial Forbs</b>			7–20	
	scarlet beeblossom	GACO5	<i>Gaura coccinea</i>	2–6	1
	hawkweed buckwheat	ERHI3	<i>Eriogonum hieraciifolium</i>	0–1	0–1
4	<b>Annual Forbs</b>			3–9	
	common sunflower	HEAN3	<i>Helianthus annuus</i>	3–9	1
<b>Shrub/Vine</b>					
5	<b>Shrubs</b>			67–202	
	whitethorn acacia	ACCO2	<i>Acacia constricta</i>	17–84	4–16
	catclaw mimosa	MIACB	<i>Mimosa aculeaticarpa var. biuncifera</i>	10–57	1–6
	mariola	PAIN2	<i>Parthenium incanum</i>	7–20	1–3
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	7–13	1–3

	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	7–13	1–3
	resinbush	VIST	<i>Viguiera stenoloba</i>	3–10	1–2
	javelina bush	COER5	<i>Condalia ericoides</i>	2–6	1–2
	featherplume	DAFO	<i>Dalea formosa</i>	2–6	1–2
	algerita	MATR3	<i>Mahonia trifoliolata</i>	2–6	1
6	<b>Half-Shrubs</b>			0–1	
	dyssodia	DYSSO	<i>Dyssodia</i>	0–1	1
7	<b>Cactus</b>			17–50	
	purple pricklypear	OPMAM	<i>Opuntia macrocentra</i> var. <i>macrocentra</i>	7–13	1–2
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	7–13	1–2
	cactus apple	OPEN3	<i>Opuntia engelmannii</i>	3–10	1–2
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var. <i>imbricata</i>	3–10	1–2
	ocotillo	FOSP2	<i>Fouquieria splendens</i>	0–1	1
8	<b>Yucca-like plants</b>			8–22	
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	7–13	1–3
	green sotol	DALE2	<i>Dasyliirion leiophyllum</i>	3–10	1–2

Table 32. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
<b>Grass/Grasslike</b>					
1	<b>Warm Season Midgrasses</b>			34–101	
	sideoats grama	BOCU	<i>Bouteloua curtipendula</i>	13–31	1–3
	purple threeawn	ARPU9	<i>Aristida purpurea</i>	9–22	1–2
	slim tridens	TRMU	<i>Tridens muticus</i>	9–22	1–2
	curlyleaf muhly	MUSE	<i>Muhlenbergia setifolia</i>	4–18	1–2
	sand dropseed	SPCR	<i>Sporobolus cryptandrus</i>	4–13	1–2
	plains lovegrass	ERIN	<i>Eragrostis intermedia</i>	0–1	0–1
2	<b>Warm Season Shortgrasses</b>			56–168	
	hairy grama	BOHI2	<i>Bouteloua hirsuta</i>	9–45	1–3
	black grama	BOER4	<i>Bouteloua eriopoda</i>	4–31	1–2
	hairy woollygrass	ERPI5	<i>Erioneuron pilosum</i>	4–31	1–2
	Hall's panicgrass	PAHA	<i>Panicum hallii</i>	9–31	1–2
	low woollygrass	DAPU7	<i>Dasyochloa pulchella</i>	4–31	1
	red grama	BOTR2	<i>Bouteloua trifida</i>	0–18	0–1
	Carolina crabgrass	DIPU9	<i>Digitaria pubiflora</i>	4–13	1
<b>Forb</b>					
3	<b>Perennial Forbs</b>			9–27	
	scarlet beeblossom	GACO5	<i>Gaura coccinea</i>	2–7	1
	hawkweed buckwheat	ERHI3	<i>Eriogonum hieraciifolium</i>	0–1	0–1
4	<b>Annual Forbs</b>			2–7	
	common sunflower	HEAN3	<i>Helianthus annuus</i>	2–7	1

<b>Shrub/Vine</b>					
5	<b>Shrubs</b>			78–235	
	mariola	PAIN2	<i>Parthenium incanum</i>	22–76	3–13
	Pinchot's juniper	JUPI	<i>Juniperus pinchotii</i>	4–67	1–11
	pungent oak	QUPU	<i>Quercus pungens</i>	0–63	0–10
	featherplume	DAFO	<i>Dalea formosa</i>	4–22	1–3
	algerita	MATR3	<i>Mahonia trifoliolata</i>	2–16	1–3
	javelina bush	COER5	<i>Condalia ericoides</i>	2–16	1–3
	resinbush	VIST	<i>Viguiera stenoloba</i>	4–13	1–3
	Wright's beebrush	ALWR	<i>Aloysia wrightii</i>	2–7	1–2
	desert myrtlecroton	BEOB	<i>Bernardia obovata</i>	0–1	0–1
	longleaf jointfir	EPTR	<i>Ephedra trifurca</i>	0–1	0–1
	whitethorn acacia	ACCO2	<i>Acacia constricta</i>	0–1	0–1
	roundflower catclaw	ACRO	<i>Acacia roemeriana</i>	0–1	0–1
	littleleaf sumac	RHMI3	<i>Rhus microphylla</i>	0–1	0–1
6	<b>Half-Shrubs</b>			11–34	
	dyssodia	DYSSO	<i>Dyssodia</i>	4–13	1–2
	broom snakeweed	GUSA2	<i>Gutierrezia sarothrae</i>	4–13	1–2
	rough menodora	MESC	<i>Menodora scabra</i>	2–7	1
	five-needle pricklyleaf	THPEP	<i>Thymophylla pentachaeta</i> var. <i>pentachaeta</i>	0–1	0–1
	hairy crinklemat	TIHI	<i>Tiquilia hispidissima</i>	0–1	0–1
7	<b>Cactus</b>			13–40	
	purple pricklypear	OPMAM	<i>Opuntia macrocentra</i> var. <i>macrocentra</i>	4–13	1–3
	tulip pricklypear	OPPH	<i>Opuntia phaeacantha</i>	4–13	1–2
	ocotillo	FOSP2	<i>Fouquieria splendens</i>	2–7	1–2
	tree cholla	CYIMI	<i>Cylindropuntia imbricata</i> var. <i>imbricata</i>	2–7	1
	horse creeper	ECTE	<i>Echinocactus texensis</i>	0–1	0–1
	kingcup cactus	ECTR	<i>Echinocereus triglochidiatus</i>	0–1	0–1
	nylon hedgehog cactus	ECVI2	<i>Echinocereus viridiflorus</i>	0–1	0–1
	cactus apple	OPEN3	<i>Opuntia engelmannii</i>	0–1	0–1
8	<b>Yucca</b>			2–7	
	Torrey's yucca	YUTO	<i>Yucca torreyi</i>	2–7	1–2
	soaptree yucca	YUEL	<i>Yucca elata</i>	0–1	0–1
9	<b>Yucca-like plants</b>			16–58	
	green sotol	DALE2	<i>Dasyllirion leiophyllum</i>	4–31	1–6
	lechuguilla	AGLE	<i>Agave lechuguilla</i>	4–22	1–3
	Texas sacahuista	NOTE	<i>Nolina texana</i>	2–7	1–2

## Animal community

### Part 1: Wildlife

The Limestone Hills ecological site lies at the northern extent of the Chihuahuan Desert and provides habitat for many different wildlife species.

## Species of special interest:

These are species of special interest that have habitat needs associated with the Limestone Hills ecological site.

**Guadalupe Mountains Tiger Beetle:** This beetle is endemic to the Guadalupe Ridge and Mountains and is tightly associated with limestone outcroppings (SWCA Environmental Consultants, 2007). Adults feed on just about anything they can see and catch, including invertebrates that may be larger than themselves. Their vision seems acute, as any movement (even by a human at a distance) causes them to turn and face the source of the motion. Beetles, flies, caterpillars, ants, grasshopper nymphs, and spiders are just a few of the invertebrates reported as tiger beetle prey. Although most tiger beetles are wary and not easily approached, they are also preyed upon. Predators of tiger beetles include dragonflies, robber flies, other tiger beetles, birds, and small vertebrates. Mites are also known to parasitize tiger beetles (Spomer, Hoback, Golick, Higley, 2006).

**Rock Rattlesnake:** The rare mottled rock rattlesnake is found only in New Mexico, Texas, and Chihuahua, Mexico. In New Mexico, the rattlesnake is limited to the southern Guadalupe Mountains and exists within all canyons throughout the Guadalupe Ridge. It is the most frequently encountered rattlesnake in CCNP and is found around exposed bedrock where it feeds on lizards, snakes, and small mammals (SWCA Environmental Consultants, 2007).

**Texas Horned Lizard:** Horned lizards have habitat needs that require healthy harvester ant communities. Harvester ants are the preferred food of horned lizards and when this food resource declines due to shifts to a degraded plant community, or through infrastructure development, lizard numbers will also decline (Henke and Fair, 1998). Feeding may occur at nest entrances or on ant foraging trails and mature lizards are capable of eating 70 to 100 ants per day. Although ants comprise a majority of the diet, Texas horned lizards are opportunistic predators and will consume crickets, grasshoppers, beetles, centipedes, bees and caterpillars. The diagnostic plant community phase (1.1) is best for providing a wide range of plant and insect species needed for Texas horned lizard habitat.

**Gray Vireo:** The gray vireo is found in the desert Southwest. Over 80 percent of the Gray Vireo territories in New Mexico are found in 12 sites, with the largest site being found in the Guadalupe Mountains (Pierce, 2007). The Gray Vireo appears to not winter in New Mexico but move down to the Big Bend area where it is associated with various shrubs and cacti. Summer habitat in the Guadalupe's seems to be linked to juniper and oak plant communities at the upper end of the limestone hills ecological site (above 4300 feet). During breeding season, (April-July) the Gray Vireo are insectivorous, taking grasshoppers, stinkbugs, crickets, moths, and caterpillars for food. In New Mexico, nests are primarily in Juniper trees (Pierce, 2007). Plant communities within the historic range of variability are important for the Gray Vireo to find nesting, breeding, and brood-rearing cover. The birds will find nesting cover in plant communities 1.1 and 1.2, while moving to community phase 1.3 to find food.

**Peregrine Falcon:** The Peregrine Falcon is a species of concern that occurs throughout the west. According to experts at the "Living Desert Zoo and Gardens State park" in Carlsbad New Mexico, the peregrine falcon has only been spotted on a rare occasion in the fall or winter.

**Common hog-nosed skunk:** Hog-nosed skunks are distinguished from striped skunks primarily by the pelage, with a characteristic broad white marking beginning at the top of the head and extending down the back and tail. They make their dens in rocky areas within the Limestone Hills. They are omnivorous, and they eat differently according to the season. They mainly eat insects and grubs but also eat fruit, small mammals, snakes and carrion. Because rattlesnakes react to skunk musk with an alarm reaction, it is believed that skunks may feed extensively on rattlesnakes. In search of food, this skunk that roots can turn over large areas of earth with its bare nose and front claws as it searches for food (Buie, 2003).

**Mountain Lion:** The mountain lion is an excellent stalk-and-ambush predator, pursuing a wide variety prey. Deer make up its primary food source, but they will also hunt species as small as insects and rodents. The mountain lion stalks through shrubs and across ledges before delivering a powerful leap onto the back of its prey with a suffocating neck bite. The mountain lion is capable of breaking the neck of its prey with a strong bite and momentum bearing the animal to the ground. Kills are generally estimated at around one large ungulate every two weeks. This period shrinks for females raising young, and may be as short as one kill every three days when cubs are nearly mature at around 15 months.

Only females are involved in parenting. Females are fiercely protective of their cubs, and have been seen to successfully fight off animals as large as black bears in their defense. Caves and other alcoves that offer protection

are used as litter dens (Cougar, 2013).

The Very Shallow and Limestone Hills ecological sites provide excellent habitat for the mountain lion life cycle. The abundance of shrubs in plant community 1.2 is ideal for lions to hide and stalk prey. Mountain lions can work the edge of hill summits and position themselves above prey where they can pounce with a killing blow.

Eastern White-throated Wood Rat: This large rat is often called a packrat because of the large nest of sticks and other material that it incorporates into nests. The nocturnal rat feeds on a wide variety of plants and finds shelter around dense stands of cacti such as cholla and prickly pear. Plant communities 1.1 and 1.2 are ideal for nesting white-throated wood rats.

Other species associated with the limestone hills ecological site:

Birds:

Turkey Vulture  
Mississippi Kite  
Red-tailed Hawk  
American Kestrel  
Great Horned Owl  
Spotted Towhee  
Canyon Towhee  
Cassin's Sparrow  
Brewer's Sparrow  
Black-throated Sparrow  
White-crowned Sparrow  
Dark-eyed Junco  
Scaled Quail  
White-winged Dove  
Mourning Dove  
Eurasian Collared Dove (introduced)  
Lesser Nighthawk  
Common Nighthawk  
Black-chinned Hummingbird  
Ladder-backed Woodpecker  
Western Kingbird  
Cliff Swallow  
Barn Swallow  
Verdin  
Cactus Wren  
Rock Wren  
Northern Mockingbird  
Curved-billed Thrasher  
House Finch  
House Sparrow

Mammals:

Mexican Ground Squirrel  
Yellow-faced Pocket Gopher  
Merriam's Kangaroo Rat  
Merriam's Pocket Mouse  
Western Harvest Mouse  
Southern Plains Woodrat  
Cactus Mouse  
White-footed Mouse  
White-ankled Mouse  
Hispid Cotton Rat  
North American Porcupine  
Black-tailed Jackrabbit

Desert Cottontail  
American Badger  
Striped Skunk  
Grey Fox  
Coyote  
Bobcat  
Mule Deer  
Barbary Sheep (introduced)  
Ringtail

Reptiles:

Green Toad  
Red-spotted toad  
Rio-Grande Leopard Frog  
Eastern Collared Lizard  
Greater Earless Lizard  
Round Tailed Horned Lizard  
Crevice Spiny Lizard  
Prairie Lizard  
Common Side-blotched Lizard  
Texas Banded Gecko  
Chihuahuan Spotted Whiptail  
Common Checkered Whiptail  
Ring-necked Snake  
Striped Whip Snake  
Western Ground Snake

Note: This species list was composed with help from the Living Desert Zoo and Gardens State Park, Carlsbad, New Mexico.

Desert Bighorn and Barbary sheep: By 1946 the desert bighorn was extirpated from the Guadalupe Mountains. Illegal hunting and excessive competition from livestock are the major culprits. Disease from livestock played a role as well.

Currently, there is an estimated 400-770 Barbary sheep in the Guadalupe Mountains. This species fills the niche that desert bighorn once held. There has been consideration given to re-introducing the desert bighorn, but this will most likely not happen unless the population of Barbary sheep can be reduced.

Barbary sheep are native to North Africa, and were released in the Hondo Valley, Largo Canyon, and the Canadian River drainage between 1955 and 1970. Viable populations have become established in historic bighorn habitat in the Guadalupe and Sacramento Mountains. They compete with desert bighorn due to their higher rate of increase, ability to subsist on lower quality forage, and preference for habitat similar to that of bighorn. Barbary sheep are socially aggressive when they encounter bighorn and may disrupt the rut (Goldstein and Rominger, 2003).

Part II Livestock:

The Limestone Hills Ecological Site has traditionally been grazed by all kinds and classes of livestock, during all seasons of the year. In the early part of the 20th century, goats and sheep were used extensively along the Guadalupe Ridge, taking advantage of browse species. Currently, though, there are very few goat and sheep operations in the area due to many market factors. Cattle numbers are in decline due to drought and extensive wildfire from 2001-2011.

With a planned livestock grazing and browsing system, the limestone hills ecological site could be managed for sustained agriculture while maintaining the historic range of variability. Prescribed fire may be used as a management tool to hold the plant communities within the historic range of variability.

## Hydrological functions



The Lechuguilla soil component is in hydrologic group “D”; as are all soils that have a depth to impenetrable layer of less than 50 cm. Runoff from this site is common, especially during heavy rainstorms, because the soil is shallow and well drained. During heavy rain, once the soil is saturated, surface sheet flow is common. The severity of sheet flow depends on the plant community and the amount of gravel armoring. As the plant community changes from the historic range of variability to the “at risk” plant community, surface sheet flow increases due to a lack of vegetation and a decrease in soil aggregate stability.

Fire can temporarily change the soil surface chemistry, making it hydrophobic for a time and causing more sediment to move off site. It is important for vegetation to re-establish and provide structure for infiltration and organic matter for water storage.

Limestone has low permeability, but plant communities depend on deep cracks and fissures to hold soil, nutrients, and organic matter. In these deep cracks, organic matter acts like a sponge, storing water and keeping plants alive through dry periods. Deep cracks within bedding plains also act as conduits, moving water to plants rooted on a limestone terrace. Sometimes springs occur where bedding plains are exposed on hill sides.

## Recreational uses

The Limestone Hills Ecological Site provides limited recreational use due to its lack of drinking water. Hiking is limited to day trips and should not be attempted without adequate water and a large hat. Hunting is common on this site, especially for mule deer.

## Other information

## Inventory data references

Data was collected during the years of 2011 and 2012. For all tier one data points, ocular methods were used to collect estimates of production, ground cover, and canopy cover. The Doman-Krajina method was used for canopy cover estimates. Soil pits were dug for verification on many tier one plots. Tier two and three protocols always were verified and analyzed with soil pits. Other methods used were line-point-intercept (LPI), double-sampling (DS), canopy gap (CG), and soil stability (SS). This ecological site had a number of tier one and tier two plots, with one tier three at the diagnostic plant community. Historic data from BLM monitoring points were used as well.

## Type locality

Location 1: Eddy County, NM	
UTM zone	N
UTM northing	3560227
UTM easting	546367
General legal description	The tier 3 sample data was collected on BLM land along Dark Canyon Road.

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Scott Woodall

## **Rangeland health reference sheet**

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

Author(s)/participant(s)	
Contact for lead author	
Date	
Approved by	
Approval date	
Composition (Indicators 10 and 12) based on	Annual Production

## Indicators

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

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

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

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

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

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

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

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

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

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

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

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground annual-production or live foliar cover using symbols: >>, >, = to indicate much greater than, greater than, and equal to):**

Dominant:

Sub-dominant:

Other:

Additional:

---

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

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

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

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:**
- 

17. **Perennial plant reproductive capability:**
-