Ecological site R042CY002NM
Limestone Mountains

Accessed: 05/18/2024

General information

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

Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 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 Mountains Ecological Site predominantly occurs in LRU 42.9, which is a subunit of MLRA 42 (Southern Desertic Basins, Plains, and Mountains)

It is possible, though very rare, that the Limestone Mountains Ecological Site may occur outside of this proposed 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 Mountains Ecological Site < LRU 42.9 Northeastern Chihuahuan Desert Mountains< 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 Mountains Ecological Site < Guadalupe Mountains Woodland Subsection < Sacramento-Monzano Mountains Section < Arizona-New Mexico Mountains Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow Province (Cleland, et al., 2007).

EPA: Limestone Mountains Ecological Site<23b Madrean Lower Montane Woodlands<23 Arizona/New Mexico Mountains. (Griffith, et al., 2006)

Ecological site concept

The Limestone Mountains Ecological Site is positioned on slopes within the LRU 42.9. Elevation ranges from 5000 to 7000 feet. Soil depth can range from very shallow to shallow (5-50 cm) above limestone dolomite, or calcareous sandstone bedrock. Slopes are greater than 25 percent but are common around 35-60 percent. Aspect is very important to ecological site dynamics.

Associated sites

R042CY902NM	**Limestone Hills** The limestone mountains site transitions into the limestone hills below 5500 feet where a “thermic” soil temperature regime becomes evident.
R042CY001NM	**Shallow Limestone** This site has slopes < than 25% and make up mountain summits.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

The Limestone Mountains Ecological Site is positioned on slopes within the LRU 42.9. Elevation ranges from 5000 to 7000 feet. Soil depth can range from very shallow to shallow (5-50 cm) above limestone dolomite, or calcareous sandstone bedrock. Slopes are greater than 25 percent but are common around 35-60 percent. Aspect is very important to ecological site dynamics.

The Limestone Mountains Ecological Site occurs on slopes of mountains, ridges, and mesas and is most closely associated with the Shallow Limestone Ecological Site, which occurs on summit positions. The Limestone Mountains site includes, on average, about 15 percent rock outcrop.

Geology: The primary geologic formations that make up the parent material for the Limestone Mountains Ecological Site include those of the Artesia Group: the Queen, Grayburg, Seven Rivers, Tansil, Yates, and to a lesser extent the Capitan Limestone Formations. During Guadalupian time of the Permian Period, dynamic sedimentation of carbonate and evaproite 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 & Vincent, 1971).

On the landward side of the reef (the backreef) the Artesia Group formed. The oldest of these formations, the Queen and Grayburg, make up the majority of the Guadalupe Mountains. Much of this geology consists of limestone, dolomite and calcareous sandstone.

Younger than the Queen and Grayburg, 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.

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, 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 Tansill is characterized by clastic sediments such as siltstone and sandstone as well as layers of dolomite. Unlike the Yates, however, the Tansill 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 began to rise, creating the

Guadalupe Ridge and Mountains and exposing the Artesia Group. Over the years, much of the more clastic, layers have eroded away, leaving very shallow soils mixed with exposed dolomitic limestone and calcareous sandstone rock outcrop which is the makeup of the Limestone Mountains Ecological Site.

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

1. Site is within MLRA 42.8, which is the ustic-aridic soil moisture regime, and the thermic soil temperature regime. (Often contains red berry juniper)
2. Soils are loamy and not skeletal, and reside in low areas on stream terraces and fan remnants. - Loamy Terrace ESD
2. Soils are skeletal (Greater than 35% rock fragments greater than 2 mm by volume)
3. Soils are deep to very deep. (Greater than 100cm to root restrictive layer)
4. Site exists in an active floodplain.-Draw ESD
4. Site exists on a stream terrace or fan remnant-Gravelly ESD
4. Site exists on steep slopes in limestone colluvium over gypsum residuum.-Limy Gyp Escarpment
3. Soils are very shallow to moderately deep (5-100cm).
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

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. Mountain escarpments of the Limestone Mountains Ec

Table 2. Representative physiographic features

Landforms	(1) Mountain slope (2) Escarpment
Flooding frequency	None
Elevation	1,524–2,134 m
Slope	25–100%
Aspect	Aspect is not a significant factor

Climatic features

The mean annual precipitation is 13.2 inches to 20.1 inches, occurring mostly as high intensity, short-duration afternoon thunderstorms from July through September. Mean annual air temperature is 46 to 72 degrees F. The frost-free season is 212 to 243 days.

Annual weather patterns, influenced by global climate events, such as El Niño and La Nina, affect and alter production and composition across the Limestone Mountains 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, species composition, and richness 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 climatic 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 or 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, in1947-1957, 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)	245 days
Freeze-free period (average)	262 days
Precipitation total (average)	508 mm

Influencing water features

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

Soil features

The Limestone Mountains Ecological Site is tied to the Queen and Biduya component of map units CC5, CC9, QR2, and RB1 within LRU 42.9. The CC5 and QR2 map units are very similar, each consisting of a complex of soil components which is dominated by about 70 percent Queen and similar soils and 15 percent rock outcrop. The CC9 and RB1 map units are associated with about 40 percent rock outcrop; 30 percent Biduya and 20 percent Queen and similar soils. Queen and Biduya soils are formed from residuum and colluvium from limestone, dolomite and calcareous sandstones, along with additions of eolian dust.

The Queen component has developed an argillic horizon, which is evidence that this position on the landform is somewhat stable and resists erosion long enough for soil processes to advance and develop. This stability is both due to a high density of grass and shrub roots, holding the soil material in place even on steeper slopes, as well as gravel mulch covering the soil surface, protecting it from erosive forces.

Many of these sloped landforms have stair-stepped surfaces resulting from the stratified character of the limestone. These steps can act as terraces providing micro-topographic benches of near-level ground where soil materials can accumulate. Thicker profiles are found at the inside of the step, near the base of the riser, and taper to thinner profiles with little or no soil near the drop off-edge of the tread. The rock outcrop component mostly appears as small benches and slick rock along the mountain slopes. Sometimes this rock appears as small cliff bands which range from 3 to 30 feet (1 to 10 m) in relief.

In normal years this soil is driest during May and June and moist in some part for more than 90 consecutive days during the growing season. The soil moisture regime is ustic bordering on aridic. The mean annual soil temperature: is 55 to 59 degrees F, which is classified as the mesic temperature regime.

The Queen taxonomic class is: Loamy-skeletal, mixed, superactive, mesic Aridic Lithic Argiustolls. Due to its dark mollic horizon, it is believed that this soil developed under a grassland plant community.

TYPICAL PEDON: Queen very stony silty clay loam - savanna. (Colors are for dry soil unless otherwise noted.)

A--0 to 3 inches (0 to 8 cm); dark grayish brown (10YR 4/2) very gravelly loam, very dark brown (10YR 2/2), moist; 25 percent clay; weak thin platy parts to moderate medium granular structure; soft, very friable, slightly sticky, slightly plastic; common very fine roots and common fine roots; common very fine tubular and common fine interstitial pores; 25 percent gravel and 10 percent cobble and 5 percent stone; noneffervescent, 1 percent calcium carbonate equivalent; neutral, pH 6.7; clear smooth boundary.

Bt1--3 to 8.5 inches (8 to 21 cm); very dark grayish brown (10YR 3/2) gravelly clay loam, very dark brown (10YR 2/2), moist; 32 percent clay; moderate medium subangular blocky structure; slightly hard, friable, moderately sticky, moderately plastic; common medium roots and common coarse roots and common very fine roots and common fine roots; common very fine interstitial and common fine tubular pores; common distinct clay films on all faces of peds; 20 percent gravel and 5 percent cobble and 5 percent stone; noneffervescent, 1 percent calcium carbonate equivalent; neutral, pH 7.3; clear wavy boundary.

Bt2--8.5 to 14.5 inches (21 to 37 cm); dark grayish brown (10YR 4/2) very channery clay loam, very dark brown (10YR 2/2), moist; 29 percent clay; moderate fine subangular blocky structure; slightly hard, friable, moderately sticky, moderately plastic; few coarse roots and common very fine roots and common fine roots; common very fine interstitial and common fine vesicular pores; common distinct clay films on all faces of peds; 5 percent cobble and 5 percent stone and 50 percent channer; noneffervescent, 2 percent calcium carbonate equivalent; slightly alkaline, pH 7.4; abrupt smooth boundary.

R--14.5 to 78.5 inches (37 to 200 cm); indurated limestone or dolomite bedrock.

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

Typical Surface Fragments > 3" (% Cover): 15-25%

Typical Subsurface Fragments <=3" (% Volume): 15-30%

Typical Subsurface Fragments > 3" (%% Volume): 15-25%

Typical Soil Depth: 20-40 cm

Calcium Carbonate Equivalent (percent):
A horizons-0 to 2
Bt horizon-1 to 6
Btk- 5 to 25

Total average available water capacity: 3.85 cm H2O/cm soil.

Figure 5. Queen Component

Table 4. Representative soil features

Parent material	(1) Eolian deposits–dolomite (2) Residuum–limestone and sandstone
Surface texture	(1) Extremely gravelly loam (2) Extremely flaggy clay loam
Family particle size	(1) Loamy
Drainage class	Moderately well drained to well drained
Permeability class	Slow to moderate
Soil depth	3–51 cm
Surface fragment cover <=3"	20–30%
Surface fragment cover >3"	18–33%
Available water capacity (0-101.6cm)	2.54–5.08 cm
Calcium carbonate equivalent (0-101.6cm)	0–25%
Electrical conductivity (0-101.6cm)	0 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0

Soil reaction (1:1 water) (0-101.6cm)	6.9–8.2
Subsurface fragment volume <=3" (Depth not specified)	15–30%
Subsurface fragment volume >3" (Depth not specified)	13–30%

Ecological dynamics

The Limestone Mountains Ecological Site contains a mix of grass, shrubs, trees, forbs, and succulents. It is often dry due to its very shallow depth and exposure to many dry, windy days. Overall, this site is dominated by grasses, shrubs and succulents with a few trees scattered. 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 5000 Feet on north facing slopes), temperatures are warmest and driest and tend to promote more succulents and Chihuahuan desert species, such as black grama, sotol, and redberry juniper. As elevation increases toward the upper extreme, (at about 7000 ft. on south facing slopes, and 6500 on north facing slopes), warm season species tend to shift toward cool season species and trees become a larger part of the composition. Above 7000 feet on this landform, this site transitions into a cooler, moister ponderosa pine forest.

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 50 cm in a few places. As soil depth increases, plants have greater access to water and nutrients. Species such as blue grama prefer a deeper soil, while curly leaf muhly and desert ceanothus 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 and oak brush increase where higher fracturing is evident as their roots can extend down into cracks and fissures.

Percent slope affects water runoff and retention. Generally, the steeper the slope is, the higher the runoff. In formations of the Artesia group, 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. When percolating water is stopped by impermeable bedrock layers, it is forced to flow laterally. This causes springs to surface on steep slopes, producing highly productive plant communities, even woodland coves.

Fire is a consistent disturbance regime that suppresses 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. Since 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.

State and transition model

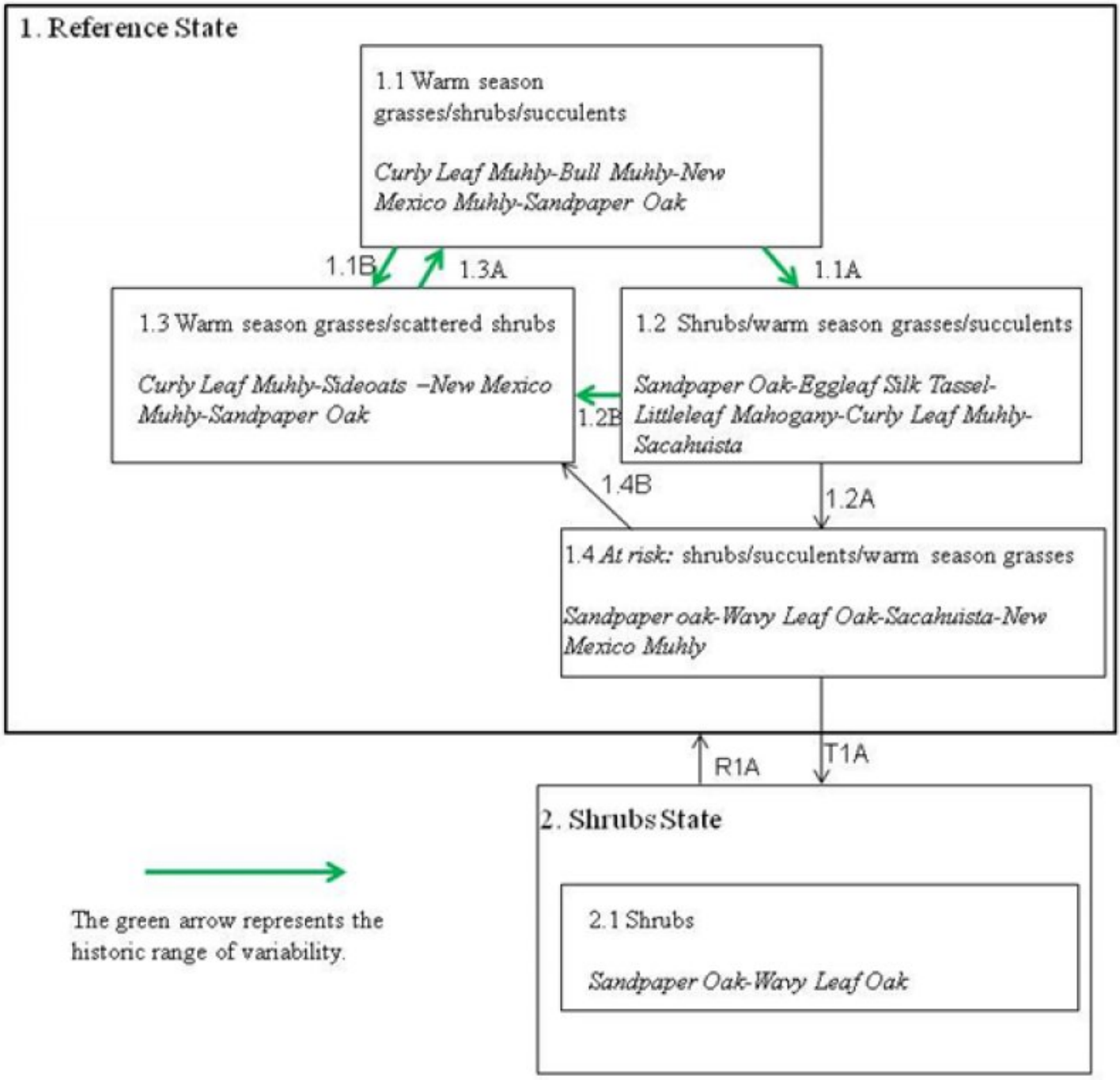

Figure 6. Limestone Mountains State and Transition Model

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 > 70%, depending on the amount of rock outcrop. 1.1A Community Pathway: This pathway represents intervals between fires, during which natural processes increase shrub and succulent vigor and decrease the vigor of grasses. 1.1B Community Pathway: This pathway represents fire. Fire suppresses succulents and many shrubs, giving grasses a competitive advantage. 1.2 Shrubs/warm season grasses/succulents: Over time, foliar cover of shrubs and succulents increases and that of warm season grasses decreases. 1.2A Community Pathway: This pathway represents an interval between fires, which is 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. 1.3 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, the plant community shifts from 1.3 to 1.1. 1.4 At risk: shrubs/succulents/warm season grasses: Due to gradual changes in hydrologic function and soil chemistry, shrubs and succulents increase over time. This community is no longer within the historic range of variability due to fire suppression. 1.4B Community Pathway: This pathway represents a decrease in shrubs and an increase in grasses, through either anthropogenic or natural processes. T1A Transition one: Slow variables: Continued increase of shrubs due to fire suppression, coupled with the decrease in soil organic matter due to a reduction in fine-root turnover, leading to a decrease in plant available water. Trigger events: A severe hot wildfire causing a loss of organic carbon. Threshold: A hydrologic function threshold is crossed. 2.0 Shrub State 2.1 Shrubs: Very few grasses exist as the bulk of the foliar cover is made of shrubs. R1A Restoration Process: An increase in the competitive advantage of grass species through physical, chemical, and biological management practices.

Community 1.1
Warm season grasses/shrubs/succulents (diagnostic plant community)

Figure 7. Community 1.1; Yucca Trail; 5800 ft; CCNP; 4/9/11

This community phase consists of a mix of warm season grasses, shrubs and succulents. Foliar cover is between 75 and 85 percent; basal cover is between 15 and 20 percent; and bare ground is around 3 percent. Warm season grasses make up about 45 percent foliar cover; shrubs, 25 percent; and succulents, 10 percent. The average surface soil stability rating (Herrick, et al., 2001) is 5 under canopy and 4.0 in the interspaces. Annual production averages around 1200 lbs/ac, but can span between 800 and 1600 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 5-7 years after low intensity fire. Curly leaf muhly is the dominant grass while New Mexico muhly, sideoats grama, and bull muhly are present at all elevations. At the uppermost elevations of this site, cool season grasses such as muttongrass and Arizona fescue begin to appear. Oaks are the dominant shrub through all elevations and aspects. On the warmer slopes, sandpaper oak, desert scrub oak, and Mohr shin oak dominate the site. On the cooler slopes, Gambel oak, gray oak and wavy leaf oak often dominate. A few scattered trees dot the landscape, especially alligator juniper, pinon pine, ponderosa pine, and Texas Madrone. Eggleaf silktassle is a unique shrub that, in this LRU, tends to only be found on the Limestone Mountains Ecological Site. This plant community phase optimizes energy flow, hydrologic function, and nutrient cycling. The diversity of root systems takes 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	493	740	986
Shrub/Vine	359	538	717
Forb	45	67	90
Total	**897**	**1345**	**1793**

Table 6. Ground cover

Tree foliar cover	2-5%
Shrub/vine/liana foliar cover	30-40%
Grass/grasslike foliar cover	40-50%
Forb foliar cover	2-5%
Non-vascular plants	1%
Biological crusts	1-3%
Litter	60-70%
Surface fragments >0.25" and <=3"	30-40%
Surface fragments >3"	15-25%
Bedrock	10-20%
Water	0%
Bare ground	1-3%

Table 7. 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	–	2-5%	10-20%	1-2%
>0.3 <= 0.6	–	6-10%	10-20%	–
>0.6 <= 1.4	–	14-20%	3-7%	–
>1.4 <= 4	–	3-8%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

Figure 9. Plant community growth curve (percent production by month). NM4272, Limestone Mountains.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	5	7	10	15	25	25	8	5	0	0

Community 1.2
Shrubs/warm season grasses/succulents

Figure 10. Community 1.2; Wild Cow Mesa; USFS; 4-24-12

This community phase consists of a mix of shrubs, warm season grasses, and succulents. Foliar cover is between 70 and 90 percent, basal cover is between 5 and 15 percent, and bare ground is around 1 to 4 percent. Warm season grasses make up about 25 percent foliar cover; shrubs, 35 percent; succulents, 15 percent; and trees, 3 percent. The average surface soil stability rating is 5.0 under canopy and 3.8 in the interspaces. Annual production averages around 1100 lbs/ac, but can span between 700 and 1500 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 at all elevations. New Mexico muhly, bull muhly, and sideoats grama are also quite prevalent. Various oaks including: sandpaper oak, mohr shin oak, gambel oak, wavy leaf oak, desert scrub oak, and grey oak can grow thick in this community. Other abundant shrubs include: desert ceanothus, shaggy mountain mahogany, and egg leaf silk tassle. Abundant succulents include: sacahuista, sotol, and banana yucca. Texas Madrone and alligator juniper are also scattered across the community. This plant community has developed due to an increase in shrub vigor and a decrease in grass vigor. As shrubs increase they gain a competitive advantage, primarily by out-competing the grasses for water and nutrients. As shrubs increase, energy flow begins to lessen, fine-root turnover decreases, causing a decrease in labile carbon and soil organic matter. Fire is the natural event that keeps shrub species from gaining a competitive advantage and stimulates colonization by grasses.

Community 1.3
Warm season grasses/scattered shrubs

Figure 11. Community 1.3; Yucca Mesa; CCNP; 6000 feet; 5-10-1

This community consists of a mix of warm season grasses, shrubs, and succulents. This plant phase exists after fire has recently burned the site reducing 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 and if precipitation has followed which is adequate for growth to resume. Basal cover is between 15 and 30 percent, and bare ground is around 3 to 6 percent. Warm season grasses make up about 45 percent foliar cover; shrubs, 20 percent; and succulents, 5 percent. The average surface soil stability rating is 5 under canopy and 3.5 in the interspaces. Annual production averages around 1100 lbs/ac, but can span between 600 and 1600 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 one to six years after fire. It is a grass dominated site, with basal sprouting shrubs scattered across its extent. Curly leaf muhly is the dominant grass across all elevations, followed by New Mexico muhly, sideoats grama, bull muhly, and plains lovegrass, Oak species re-sprout quickly after fire and make up large portions of the plant community. Forbs, such as desert verbena, may flourish after fire. This plant community is the ecological site's response to fire within the reference state. Fire is a natural event that keeps shrub species from gaining a competitive advantage and stimulates colonization by grasses. Following fire, labile carbon increases, creating more soil organic matter which improves aggregate stability and eventually increases plant available water.

Community 1.4
At risk: shrubs/succulents/warm season grasses

Figure 12. Community 1.4; Guadalupe Ridge; USFS; 6067 feet; 8

This community consists of a mix of shrubs, succulents and warm season grasses. 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 60 and 80 percent; basal cover is between 10 and 20 percent; and bare ground is around 2 to 10 percent. Warm season grasses make up about 10 percent foliar cover; shrubs, 50 percent; and succulents, 10 percent. The average surface soil stability rating is 5 under canopy and 3.8 in the interspaces. Annual production averages around 900 lbs/ac, but can span between 500 and 1300 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. Oak brush dominates the site, especially sandpaper oak and wavy leaf oak. The underground system of an oak consists of a lignotuber with deep-feeding roots. Lignotubers possess many scattered adventitious buds. Clones are interconnected with rhizomes that intertwine with lignotubers. Root grafting is common (Simonin, 2000). This unique underground system allows oaks to generate rapidly after fire. This plant community has developed over time due to a number of slow ecological variables. One management practice that influences ecology is fire suppression which gives shrubs gain a competitive advantage. Through deeper root systems, shrubs can access 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 begins to break down creating a decrease in infiltration and an increase in runoff. The dominance of oak brush is the major concern with this community. Oak may have the ability to affect other plants through allelopathy and hydrology. The extensive root system can take advantage of water at the soil surface as well as moisture deep in the rock strata. This site is "at risk" of crossing a threshold into state two.

Pathway 1.1A
Community 1.1 to 1.2

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

Shrubs/warm season grasses/succulents

This pathway is the slow movement, from Community 1.1 to Community 1.2. This pathway represents intervals between fires within the historic range of variability. It will take 10 to 14 years after fire for shrubs and succulents to achieve foliar cover > 30%. The vigor of shrubs and succulents increases as grass vigor decreases due to various ecological processes. One such process is the direct competition for resources. In the absence of fire, shrubs are at a competitive advantage due to their greater access to moisture deep in cracks and fissures within the bedrock strata. Another process is the slow decrease in labile carbon which decreases soil organic matter. This leads to reduced plant available water and, in turn, reduction 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 (with the exception of oaks) 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 either re-grow from root systems or else come back from seed. Grasses can colonize quickly via 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, and 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. wolftail does not occur at 7000 feet)

Pathway 1.2B
Community 1.2 to 1.3

Shrubs/warm season grasses/succulents

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 (with the exception of oaks) and succulents are suppressed. This pathway occurs within the historic range of variability. Many shrubs and succulents take a while to respond after a fire event. They must either re-grow from root systems or else come back from seed. Grasses colonize quickly after a fire event via tillering, especially when precipitation follows closely after fire.

Pathway 1.2A
Community 1.2 to 1.4

Shrubs/warm season grasses/succulents

At risk: shrubs/succulents/warm season grasses

This pathway is the slow movement, from Community 1.2 to 1.4. This pathway represents an interval between fires which has exceeded the historic range of variability. The vigor of shrubs and succulents increases as grass vigor decreases due to various ecological processes. One such process is the direct competition for resources. In the absence of fire, shrubs are at a competitive advantage due to their greater access to moisture deep in cracks and fissures within the bedrock strata. Also, grass vigor diminishes because of a slow decrease in labile carbon, which reduces soil organic matter and leads to a decrease in plant available water.

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 1.1. It represents intervals between fires, during which natural processes increase shrub and succulent vigor and decrease grass production and composition. The vigor of shrubs and succulents increases as grass vigor decreases due to various ecological processes. One such process is the direct competition for resources. Shrubs have greater access to moisture deep in cracks and fissures within the bedrock strata. Another is a slow decrease in organic matter resulting from a diminishing bank of labile carbon which eventually leads to a decrease in plant available water and ultimately grass vigor.

Pathway 1.4B
Community 1.4 to 1.3

At risk: shrubs/succulents/warm season grasses

Warm season grasses/scattered shrubs

This pathway represents suppression of oak species through fire and/or browsing, driving plant Community 1.4 to 1.3. Grasses respond fairly quickly after fire, while shrubs (with the exception of oaks) and succulents are reduced.

State 2
Shrub State

Very few grasses exist as the bulk of the foliar cover is made of shrubs.

Community 2.1
Shrubs

Figure 13. Community 2.1; Guadalupe Ridge; 6010 feet; USFS 5-

This community consists of a mix of shrubs, succulents, and 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 40 and 60 percent, basal cover is between 3 and 12 percent, and bare ground is around 5 to 20 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 3.5 under canopy and 3 in the interspaces. Annual production averages around 500 lbs/ac, but can span between 300 and 700 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. After many years of slow retrogression a trigger event such as a severe wildfire causes this site to cross a threshold where ecological processes and soil properties keep it in a degraded state. This site has become an oak brush plant community. Fire usually stimulates sprouting of oak after top-kill, increasing density of previously open stands, and merging scattered stands into continuous thickets. Oak regeneration after fire is usually vigorous; sprouts may be observed within 10 days (Simonin, 2000). After the trigger event, oak brush has the competitive advantage due to deeper root systems, allowing it to take advantage of moisture stored in cracks and fissures in the bedrock. Meanwhile grasses struggle with reduced plant available water, which results from the destruction of soil organic matter, along with the soil's hydrophobicity. Furthermore, oaks may exude allelopathic chemicals which suppress other plant species, causing foliar cover to remain low for long periods of time. Soil erosion is increased on this site, causing possible problems down-slope.

Transition T1A
State 1 to 2

Slow variables: Continued increase of shrubs due to fire suppression, coupled with the loss of grasses due to a decrease in soil organic matter, leading to diminished plant available water. Trigger events: A severe "hot" wildfire causing a loss of grasses and organic carbon. . Fire usually stimulates sprouting of oak after top-kill, increasing density of previously open stands, and merging scattered stands into continuous thickets. Oak regeneration after fire is usually vigorous causing sprouts to be observed within 10 days (Simonin, 2000). Threshold: A hydrologic function threshold is crossed.

Restoration pathway R1A
State 2 to 1

An increase in the competitive advantage of grass 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 reduce shrubs. Also, range seeding, winter feeding, and high intensity-short duration livestock grazing can help bring grass and organic matter back into the system while restoring soil carbon and microbial levels. Once fuel levels are adequate, and species diversity has improved, prescribed burning will help reduce shrub competition and improve grass vigor. Monitoring foliar cover by species will help inform the land manager if plant composition is responding to management.

Additional community tables

Table 8. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Grass/Grasslike					
1	**Warm Season Tallgrasses**			45–90	
	little bluestem	SCSC	*Schizachyrium scoparium*	13–67	1–5
	silver beardgrass	BOLA2	*Bothriochloa laguroides*	13–40	1–3
2	**Warm Season Midgrasses**			314–628	
	curlyleaf muhly	MUSE	*Muhlenbergia setifolia*	67–175	4–10
	sideoats grama	BOCU	*Bouteloua curtipendula*	81–135	4–8
	New Mexico muhly	MUPA2	*Muhlenbergia pauciflora*	54–135	3–7
	bullgrass	MUEM	*Muhlenbergia emersleyi*	27–81	2–8
	purple threeawn	ARPU9	*Aristida purpurea*	27–81	2–6
	plains lovegrass	ERIN	*Eragrostis intermedia*	13–67	1–3
	pine muhly	MUDU	*Muhlenbergia dubia*	0–1	0–1
3	**Warm Season Shortgrasses**			90–179	
	hairy grama	BOHI2	*Bouteloua hirsuta*	13–94	1–5
	blue grama	BOGR2	*Bouteloua gracilis*	27–81	1–5
	common wolfstail	LYPH	*Lycurus phleoides*	0–54	0–4
	black grama	BOER4	*Bouteloua eriopoda*	0–1	0–1
4	**Cool-season Tallgrasses**			36–72	
	New Mexico feathergrass	HENE5	*Hesperostipa neomexicana*	13–67	1–3
	littleawn needlegrass	ACLO7	*Achnatherum lobatum*	0–27	0–2
	needle and thread	HECO26	*Hesperostipa comata*	0–1	0–1
5	**Cool-season Midgrasses**			0–27	
	pinyon ricegrass	PIFI	*Piptochaetium fimbriatum*	0–27	0–2
Forb					
6	**Perennial Forbs**			27–54	
	Davis Mountain mock vervain	GLBIC	*Glandularia bipinnatifida var. ciliata*	0–27	0–3
	hawkweed buckwheat	ERHI3	*Eriogonum hieraciifolium*	0–13	0–2
	white sagebrush	ARLU	*Artemisia ludoviciana*	0–13	0–1
	whitemargin sandmat	CHAL11	*Chamaesyce albomarginata*	0–1	0–1
	croton	CROTO	*Croton*	0–1	0–1
	nodding onion	ALCE2	*Allium cernuum*	0–1	0–1
	woodsorrel	OXALI	*Oxalis*	0–1	0–1
	woolly paperflower	PSTA	*Psilostrophe tagetina*	0–1	0–1
7	**Annual Forbs**			0–1	
	common sunflower	HEAN3	*Helianthus annuus*	0–1	0–1
14	**Fern**			0–1	
	Cochise scaly cloakfern	ASCO42	*Astrolepis cochisensis*	0–1	0–1
Shrub/Vine					
8	**Shrubs**			224–448	
	pungent oak	QUPU	*Quercus pungens*	13–121	3–9

	hairy mountain mahogany	CEMOP	*Cercocarpus montanus var. paucidentatus*	27–81	2–6
	eggleaf silktassel	GAOV	*Garrya ovata*	13–67	1–5
	desert ceanothus	CEGR	*Ceanothus greggii*	13–67	1–5
		QUPA4	*Quercus ×pauciloba*	0–54	0–2
	skunkbush sumac	RHTRT	*Rhus trilobata var. trilobata*	13–40	1–3
	resinbush	VIST	*Viguiera stenoloba*	0–27	0–1
	lotebush	ZIOB	*Ziziphus obtusifolia*	0–27	0–1
	Gambel oak	QUGA	*Quercus gambelii*	0–27	0–1
	gray oak	QUGR3	*Quercus grisea*	0–27	0–1
	Mohr oak	QUMO	*Quercus mohriana*	0–27	0–1
	Sonoran scrub oak	QUTU2	*Quercus turbinella*	0–27	0–1
	catclaw mimosa	MIACB	*Mimosa aculeaticarpa var. biuncifera*	0–1	0–1
9	**Half-Shrubs**			54–108	
	Mexican orange	CHDU	*Choisya dumosa*	13–67	1–5
	damianita	CHME3	*Chrysactinia mexicana*	13–40	1–3
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	0–27	0–2
	Guadalupe rabbitbrush	CHSP3	*Chrysothamnus spathulatus*	0–1	0–1
	dyssodia	DYSSO	*Dyssodia*	0–1	0–1
10	**Cactus**			18–36	
	purple pricklypear	OPMAM	*Opuntia macrocentra var. macrocentra*	0–54	0–3
	tulip pricklypear	OPPH	*Opuntia phaeacantha*	0–1	0–1
	pinkflower hedgehog cactus	ECFA	*Echinocereus fasciculatus*	0–1	0–1
	rainbow cactus	ECPE	*Echinocereus pectinatus*	0–1	0–1
11	**Yucca**			7–20	
	banana yucca	YUBA	*Yucca baccata*	7–20	1–2
12	**Yucca-like plants**			63–126	
	sacahuista	NOMI	*Nolina microcarpa*	13–67	1–5
	Texas sacahuista	NOTE	*Nolina texana*	0–27	0–4
	green sotol	DALE2	*Dasylirion leiophyllum*	0–27	0–4
	slimfoot century plant	AGGR4	*Agave gracilipes*	0–27	0–2
	Parry's agave	AGPAN6	*Agave parryi ssp. neomexicana*	7–20	1–2
Tree					
13	**Trees**			9–28	
	alligator juniper	JUDE2	*Juniperus deppeana*	7–20	1–3
	oneseed juniper	JUMO	*Juniperus monosperma*	0–13	0–2
	twoneedle pinyon	PIED	*Pinus edulis*	0–13	0–2
	Texas madrone	ARXA80	*Arbutus xalapensis*	0–13	0–1
	ponderosa pine	PIPO	*Pinus ponderosa*	0–1	0–1

Animal community

Part I: Wildlife

The Limestone Mountains Ecological Site lies at the northern extent of the Chihuahuan Desert and provides habitat for many different wildlife species.

Species of interest:

These are species of interest that have habitat needs associated with the Limestone Mountains 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, March, 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, et al., 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 feed on lizards, snakes, and small mammals (SWCA Environmental Consultants, March, 2007).

Texas Horned Lizard: Texas 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 & 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 habit.

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 Guadalupes seems to be linked to juniper and oak plant communities, which are abundant on the Limestone Mountains Ecological Site. 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 rare occasions 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, but probably utilize the very shallow ecological site for hunting. 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 alarm, it is believed that skunks may feed extensively on rattlesnakes. In search of food, this skunk 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 Shallow Limestone and Limestone Mountains 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 bundles 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 very shallow 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)
Elk
Ringtail
Black Bear

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 eliminated 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 thought about re-introducing the desert bighorn, but this will never 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 & Rominger, 2003).

Part II Livestock

The Limestone Mountains 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 down as well due to drought and extensive wildfire from 2001-2011.

With a planned livestock grazing system, the Limestone Mountains ecological site could be managed for sustained agriculture while maintaining the historic range of variability

Hydrological functions

The Queen 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 restricted to heavy rainstorms because the soil is highly permeable and well drained. Once the soil is saturated during heavy rain, surface sheet flow can occur. The severity of sheet flow depends on percent slope, canopy cover, 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. This hydrophobicity increases runoff, 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, pockets of soil store water which helps keep deep rooted plants alive through dry periods.

Recreational uses

The shallow limestone 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 can be profitable on this site as it provides habitat for deer and elk.

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 production, ground cover, and canopy cover estimates. 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	3550248
UTM easting	533735
General legal description	110 feet south of the Yucca trail, near the top.

Other references

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Contributors

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Rangeland health reference sheet

Interpreting Indicators of Rangeland Health is a qualitative assessment protocol used to determine ecosystem

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

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

Indicators

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

   _____

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

   _____

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

   _____

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

   _____

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

   _____

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

   _____

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

   _____

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

   _____

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

   _____

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

    _____

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:

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

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

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

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16. **Potential invasive (including noxious) species (native and non-native). List species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicators, we are describing what is NOT expected in the reference state for the ecological site:**

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17. **Perennial plant reproductive capability:**
