USDA Natural Resources Conservation Service

Ecological site R042CY006NM
Limy Gyp Escarpment

Accessed: 11/21/2024

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.

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 Limy Gyp Escarpment Ecological Site predominantly occurs in LRU 42.8, which is a subunit of MLRA 42 (Southern Desertic Basins, Plains, and Mountains)

It is possible, though very rare, that the Limy Gyp Escarpment 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: Limy Gyp Escarpment 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: Limy Gyp Escarpment 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: Limy Gyp Escarpment Ecological Site<24b Chihuahuan Desert Grasslands<24 Chihuahuan Deserts (Griffith, et al., 2006).

Ecological site concept

The soils are skeletal (grater than 35% by volume rock fragments greater than 2 mm). Soil depth is deep to very deep (> 100 cm).This site is positioned on gypsiferous shale badlands around Seven Rivers Hills and Azotea Mesa west of Carlsbad, New Mexico.

Associated sites

R042CY902NM	**Limestone Hills** This site has slopes > 25% and occurs on hillsides above the Limy Gyp Escarpment ecological site.

Table 1. Dominant plant species

Tree	Not specified
Shrub	Not specified
Herbaceous	Not specified

Physiographic features

The Limy Gyp Escarpment Ecological Site is found on scarp slopes of mesas and plateaus from the Seven Rivers Formation within LRU 42.8. Elevation ranges from 3200 to 4500 feet. The soil depth to gypsiferous shale parent material is between 85 and 160 cm. Slopes vary from 15 to 65 percent but are generally between 30 and 50 percent. Aspect plays an important role on this site.

The Limy Gyp Escarpment Ecological Site can most easily be seen on the side slopes of the Seven Rivers Hills, near Carlsbad. It is interspersed with pink gypsum badlands that are highly erodible, often with large gullies. The Limy Gyp Escarpment Ecological site is closely associated with the Limestone Hills and Very Shallow Ecological Sites. The Limestone Hills occurs on bedrock controlled limestone with a slope greater than 25 percent. The Very Shallow Ecological Site occurs over limestone at summit positions.

Geology: The primary geologic formations that make up the parent material for the Limy Gyp Escarpment 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 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, 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.

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 of rock began to rise, creating the Guadalupe Ridge and Mountains while exposing the Seven Rivers, Tansill, and Yates Formations. When the Seven Rivers is exposed on hill slopes there is a mixture of gypsum, shale, and mudstone which forms the parent material of the Limy Gyp Escarpment Ecological Site. Furthermore, across the surface there is often limestone colluvium that has covered the site from upper areas of limestone bedrock.

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

1. Site is within LRU 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 that are stream terraces and fan remnants.-Loamy Terrace ESD
2. Soils are skeletal (Greater than 35% by volume rock fragments greater than 2mm)
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 alluvial fan-Gravelly ESD
4. Site exists on steep slopes on limestone colluvium over gypsiferous shale badlands.-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 1. Seven Rivers Hills by Gas Plant Road; 3-21-12

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Mesa (3) Plateau
Flooding frequency	None
Elevation	975–1,372 m
Slope	15–65%
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 Limy Gyp Escarpment 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

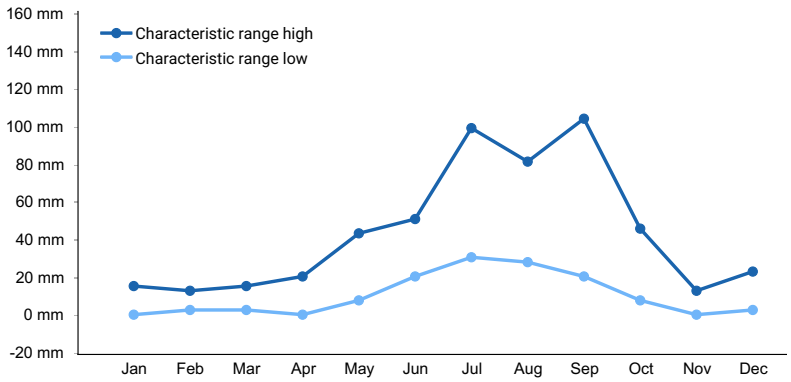


Figure 2. Monthly precipitation range

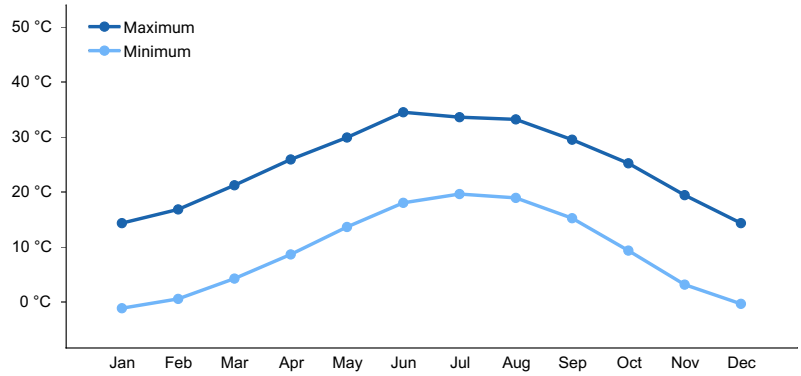


Figure 3. Monthly average minimum and maximum temperature

Influencing water features

The Limy Gyp Escarpment 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. To learn about the dynamic processes of the soil component, refer to the "plant communities" section of the ESD.

The Limy Gyp Escarpment Ecological Site is tied to the Bogle component of map unit BL1 within LRU 42.8 Northeastern Chihuahuan Desert Hills. This map unit consists of a complex of soil components which is dominated by about 55% Bogle, 25% Lechuguilla, and 10% badlands.

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 soil temperature: is 59 to 66 degrees F, which is classified as the thermic temperature regime.

TYPICAL PEDON: Bogle very cobbly loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 3 inches (0 to 8 centimeters); brown (10YR 5/3) very cobbly loam, dark brown (10YR 3/3), moist; 40 percent sand; 19 percent clay; weak fine subangular blocky structure parts to moderate medium granular structure; very friable, slightly hard, slightly sticky, slightly plastic; common fine and very fine roots; common fine interstitial pores; 10 percent limestone channers, 30 percent limestone gravel and 15 percent limestone cobbles; violent effervescence; 8 percent calcium carbonate equivalent; slightly alkaline, pH 7.4; clear smooth boundary.

Bk--3 to 13 inches(8 to 33 centimeters); pale brown (10YR 6/3) extremely cobbly loam, brown (10YR 4/3), moist; 35 percent sand; 18 percent clay; moderate medium subangular blocky structure; very friable, slightly hard, slightly sticky and slightly plastic; common fine and very fine and few medium roots ; common fine tubular and common very fine interstitial pores; 2 percent fine irregular carbonate masses throughout and 20 percent very fine irregular carbonate masses throughout; 1 percent gypsum; 5 percent limestone channers and 25 percent limestone gravel and 25 percent limestone cobbles and 5 percent limestone stones; violent effervescence; 35 percent calcium carbonate equivalent; slightly alkaline, pH 7.5; clear wavy boundary.
2Bky--13 to 57 inches(33 to 145 centimeters); pink (7.5YR 8/3) very stony gypsiferous loam, light brown (7.5YR 6/3), moist; 40 percent sand; 18 percent clay; friable, hard, slightly sticky, slightly plastic; few fine and very fine roots; common very fine tubular pores; 10 percent fine irregular moderately cemented carbonate nodules on bottom of rock fragments and 30 percent medium irregular gypsum masses throughout; 36 percent gypsum; 20 percent limestone gravel and 25 percent limestone cobbles and 15 percent limestone stones; violent effervescence; 8 percent calcium carbonate equivalent; slightly alkaline, pH 7.7; gradual wavy boundary.
Cr—57 to 81+ inches (145 to 200+ centimeters); moderately cemented gypsiferous shale bedrock; vertical cracks, less than 1 centimeter wide, with a spacing of 25cm or more apart.

TYPE LOCATION: Eddy County, New Mexico; from the intersection of State Highway 137 (Queens Hwy) and County Road 401 (Marathon Rd); 4.8 mi (3 km) west on County Road 401 to turnoff north on drilling pad. From upper pad, hike due north uphill to Bogle soils. (Martha Creek USGS 7.5 minute topographic quadrangle; Latitude: 32 degrees, 27 minutes, 54.80 seconds North; Longitude: 104 degrees, 31 minutes, 31.63 seconds West, NAD 83; UTM 544596 E, 3592103 N, UTM Zone 13.

Typical Surface Fragments <=3" (% Cover): 25-35%

Typical Surface Fragments > 3" (% Cover): 10-20%

Typical Subsurface Fragments <=3" (% Volume): 25-35%

Typical Subsurface Fragments > 3" (%% Volume): 10-25%

Calcium Carbonate Equivalent (percent):
A horizon-15 to 50
Bk horizon-15 to 45
2Bky horizon-5 to 50

Total Average Available Water Capacity (cm H2O/cm soil): 5.0 cm

Figure 4. Limy Gyp Escarpment

Table 4. Representative soil features

Parent material	(1) Colluvium–rock gypsum (2) Residuum–shale
Surface texture	(1) Very gravelly silt (2) Extremely gravelly loam (3) Very cobbly
Family particle size	(1) Loamy
Drainage class	Well drained
Permeability class	Moderate to rapid
Soil depth	203–254 cm
Surface fragment cover <=3"	30–60%
Surface fragment cover >3"	5–20%
Available water capacity (0-101.6cm)	3.81–6.35 cm
Calcium carbonate equivalent (0-101.6cm)	5–50%

Electrical conductivity (0-101.6cm)	0–6 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–1
Soil reaction (1:1 water) (0-101.6cm)	7.2–7.9
Subsurface fragment volume <=3" (Depth not specified)	15–45%
Subsurface fragment volume >3" (Depth not specified)	5–30%

Ecological dynamics

Aspect is probably the single largest driver of plant diversity on the Limy Gyp Escarpment Ecological Site. On southern aspects, temperatures are warmest and driest and tend to promote more Chihuahuan Desert grassland communities. On north facing aspects, the cooler temperatures tend to promote more shrub dominance. Sideoats grama is a dominant grass on all aspects.

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, 2001, “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 is beneficial for many habitat requirements.

Gypsum in the soil also affects plant composition and growth. Nutrient and water dynamics are affected by the percentage of gypsum in the soil. As one approaches eroded areas with exposed gypsum, a shift in plant composition toward more gypsiferous plants, such as hairy crinklemat (*Tiquilia hispidissima*,), is evident.

Livestock grazing is the dominant agricultural use on this site. Preferred grass species such as sideoats and black grama dominate the site and provide excellent forage for cattle, while shrub species provide browse for sheep, goats, and wildlife species, especially mule deer.

State and transition model

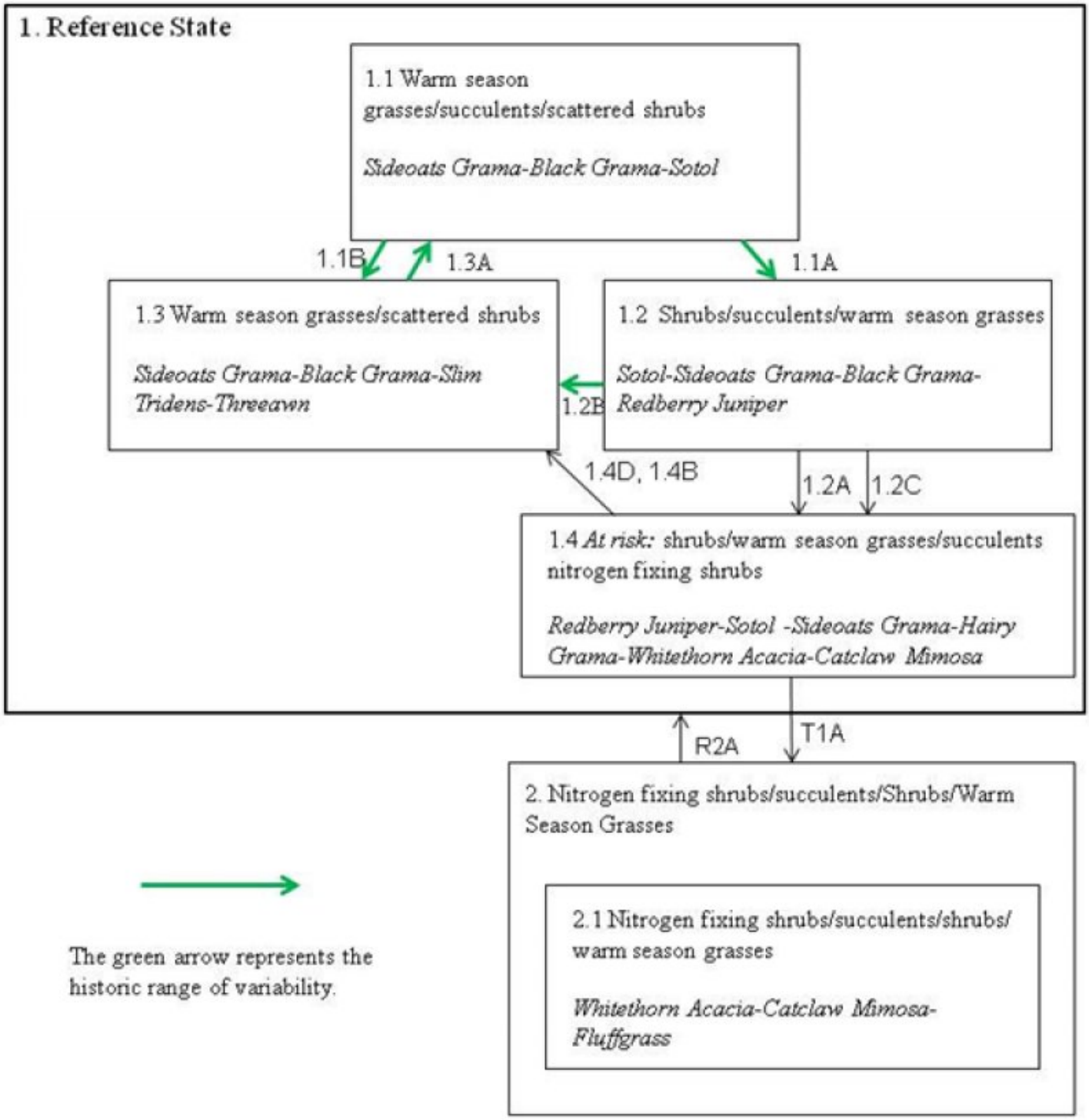


Figure 5. Limy Gyp Escarpment State and Transition Model

State 1
Reference State

1.1 Warm season grasses/succulents/scattered shrubs (diagnostic plant community) A mix of grasses, shrubs and succulents is present. Total foliar cover is > 60%. 1.1A Community Pathway: This pathway represents intervals between fire, during which natural processes increase shrub and succulent vigor and decrease grass species 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 species production and 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 community exists after fire. Grasses respond well to fire, while many shrubs and succulents decrease. 1.3A Community Pathway: This pathway represents intervals between fire, 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 nitrogen fixing shrubs, coupled with the loss of the grass plant community due to a decrease in plant available water resulting from a decrease in soil organic matter. Trigger event: A severe drought, causing a loss of organic carbon. Threshold: A hydrologic function/soil chemistry threshold was crossed. 2.0 Nitrogen fixing shrubs/succulents/shrubs/warm season grasses State 2.1 Nitrogen fixing shrubs/succulents/shrubs/warm season grasses: Nitrogen fixing shrubs have 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 and various leguminous shrubs. 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.

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

Figure 6. Seven Rivers Hills; 4-5-12

This community phase consists of a mix of warm season grasses, succulents, a few forbs and a few scattered shrubs. Foliar cover is between 60 and 80 percent, basal cover is between 10 and 20 percent, and bare ground is minimal due to over 65 percent surface rock fragments. Warm season grasses make up about 40 percent foliar cover; succulents 15 percent; shrubs 12 percent; and forbs 3 percent. The average surface soil stability rating is 5 under the canopy and 4.5 in the interspaces. Annual production averages around 500 lbs/ac, but can span between 300 and 700 lbs/ac, depending on soil annual weather patterns. This community exists approximately 5-7 years after low intensity fire. Sideoats is a common grass throughout all aspects. Thermic species, such as black grama, slim tridens and hairy tridens, are more dominant on southern aspects, while shrubs such as sotol and redberry juniper are common on northern aspects. This plant community phase 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 profile. 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	168	280	392
Shrub/Vine	151	252	353
Forb	17	28	39
Total	**336**	**560**	**784**

Table 6. Ground cover

Tree foliar cover	0%
Shrub/vine/liana foliar cover	25-29%
Grass/grasslike foliar cover	35-45%
Forb foliar cover	2-4%
Non-vascular plants	1%
Biological crusts	1-3%
Litter	30-40%
Surface fragments >0.25" and <=3"	55-65%
Surface fragments >3"	3-7%
Bedrock	1-2%
Water	0%
Bare ground	2-6%

Table 7. Canopy structure (% cover)

Height Above Ground (M)	Tree	Shrub/Vine	Grass/ Grasslike	Forb
<0.15	0%	2-4%	3-7%	1-3%
>0.15 <= 0.3	–	3-7%	24-28%	1-2%
>0.3 <= 0.6	–	4-8%	8-12%	–
>0.6 <= 1.4	–	6-10%	–	–
>1.4 <= 4	–	3-7%	–	–
>4 <= 12	–	–	–	–
>12 <= 24	–	–	–	–
>24 <= 37	–	–	–	–
>37	–	–	–	–

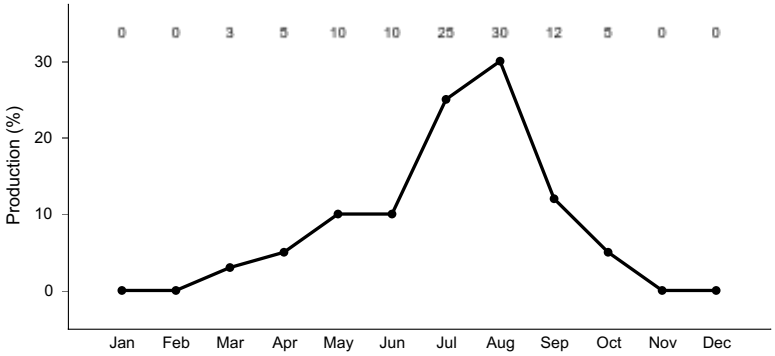


Figure 8. Plant community growth curve (percent production by month). NM4286, Limy Gyp Escarpment Reference State.

Community 1.2
Shrubs/succulents/warm season grasses

Figure 9. Community 1.2; Seven Rivers Hills; 2-23-12

This community phase combines a mix of shrubs, succulents, and warm season grasses. Foliar cover is between 60 and 80 percent; basal cover is between 5 and 15 percent; and bare ground is around 2 to 6 percent. Warm season grasses make up about 30 percent foliar cover; shrubs, 15 percent; and succulents, 25 percent. The average surface soil stability rating is 5 under canopy and 4.5 in the interspaces. Annual production averages around 450 lbs/ac, but can span between 300 and 600 lbs/ac, depending on annual weather patterns. This community exists approximately 14-18 years after fire. Sideoats grama is the dominant grass with black grama, slim tridens and hairy tridens playing an important role across the landscape. Sotol is the dominant plant within this community. Redberry juniper is abundant on northern aspects. This plant community developed from an increase in shrub vigor and a decrease in grass vigor. As shrubs increase they gain a competitive advantage, primarily by out-competing grasses for water and nutrients. As shrubs increase, energy flow begins to lessen, and fine-root turnover decreases, causing a decrease in decomposition, labile carbon and soil organic matter. Fire is the natural event that keeps shrub species from gaining a competitive advantage and facilitates colonization by grasses.

Community 1.3
Warm season grasses/scattered shrubs

Figure 10. Community 1.3; Seven Rivers Hills; 3-16-12

This community phase consists of a mix of warm season grasses, shrubs, and succulents. It exists shortly after fire; succulents and shrubs have been suppressed, while grasses exhibit renewed vigor. Foliar cover is between 50 and 70 percent, depending on fire and weather variability. Basal cover is between 5 and 15 percent, and bare ground is around 2 to 6 percent. Warm season grasses make up about 45 percent foliar cover; shrubs, 10 percent; and succulents, 5 percent. The average surface soil stability rating is 5 under canopy and 4.5 in the interspaces. Annual production averages around 400 lbs/ac, but can span between 200 and 600 lbs/ac, depending on the 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 the site. Sideoats grama is the dominant grass with black grama, slim

tridens, threeawn and hairy tridens being common. Redberry juniper seems to be the first shrub species sprouting back, along with creosote along the toe slopes. 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, leading to greater soil organic matter, infiltration, and plant available water. Over time shrubs and succulents move back onto the site.

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

Figure 11. Community 1.4; Seven Rivers Hills; 2-23-12

This community phase consists of a mix of shrubs, succulents and warm season grasses 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. Thus, 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 35 and 65 percent, basal cover is between 5 and 15 percent, and bare ground is around 5 to 15 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 below canopy and 4 in the interspaces. Annual production averages around 400 lbs/ac, but can span between 200 and 600 lbs/ac, depending on annual weather patterns. This community exists due to past management and disturbance, primarily fire suppression coupled with loosely managed livestock grazing over many years. Greater densities of short, warm season grasses tend to occur in this community along with a greater percentage of nitrogen fixing shrubs such as whitethorn acacia and catclaw mimosa. 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 deep in the profile and parent material, 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. Another factor in creating this community is the loose management of livestock over many years. Livestock contribute to the distribution of seed and can lessen plant vigor and soil organic matter through continuous grazing and over-utilization. As grass and some shrub vigor 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.

Pathway 1.1A
Community 1.1 to 1.2

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

Shrubs/succulents/warm season grasses

This pathway is the slow movement from Community 1.1 to Community 1.2. This pathway represents intervals 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 > 30%. Shrub and succulent vigor increases as grass vigor decreases due to various ecological processes. The first is through direct competition for resources. Shrubs have greater access to moisture and nutrients deep within the soil profile. The second is a slow decrease in labile carbon, thus decreasing soil organic matter. This in turn, 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/succulents/scattered shrubs (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, 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.

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.

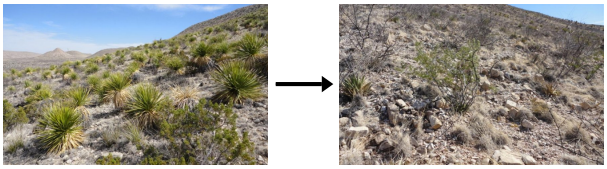
Pathway 1.2C
Community 1.2 to 1.4

Shrubs/succulents/warm season grasses

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

This pathway represents a growing competitive advantage to 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 from Community 1.2 to Community 1.4. This pathway represents intervals between fires, which have exceeded the historic range of variability. 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 within the soil profile and parent material. Another process is a slow decrease in labile carbon, thus decreasing soil organic matter. This, in turn leads to a decrease in water-holding capacity and a consequential decrease in grass vigor.

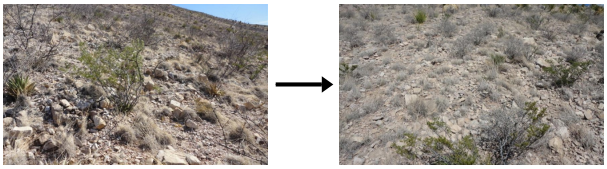
Pathway 1.3A
Community 1.3 to 1.1

Warm season grasses/scattered shrubs

Warm season grasses/succulents/scattered shrubs (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 increases shrub and succulent vigor and decreases grass species production and 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 deep in the soil profile and parent material. 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

This 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.

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

Nitrogen fixing shrubs have 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 and various leguminous shrubs. This community has a mix of shrubs, succulents, and warm season grasses.

Community 2.1
Nitrogen fixing shrubs/succulents/shrubs/warm season grasses

Figure 12. Community 2.1; Seven Rivers Hills; 2-23-12

This community 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 20 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 250 lbs/ac, but can span between 100 and 400 lbs/ac, depending on 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 deep in the soil profile. Conversely, grasses struggle with the slow decline of soil organic matter and the resulting decrease in 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. Livestock contribute to the distribution of seed and can lessen plant 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 changes in the chemistry and hydrology of the system occur. 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 to a state in which only whitethorn and, a few scattered shrubs and grasses exist.

Transition T1A
State 1 to 2

This transition moves the site across a threshold to state two. Slow variables: Continued encroachment by nitrogen fixing shrubs, coupled with the loss of the herbaceous plant community. Both chemical and hydrological shift occurs as the C:N decreases, creating an increase in the nitrogen turnover rate and 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.

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 shrugs in the plant community. Also, range seeding, winter feeding, 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, once fuel loads are adequate, prescribed burning will help suppress 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 Midgrasses**			104–243	
	sideoats grama	BOCU	*Bouteloua curtipendula*	67–112	10–18
	slim tridens	TRMU	*Tridens muticus*	22–45	3–7
	purple threeawn	ARPU9	*Aristida purpurea*	17–28	2–4
	mesa dropseed	SPFL2	*Sporobolus flexuosus*	11–22	1–3
	curlyleaf muhly	MUSE	*Muhlenbergia setifolia*	6–17	1–2
2	**Warm Season Shortgrasses**			57–133	
	black grama	BOER4	*Bouteloua eriopoda*	17–50	3–9
	hairy grama	BOHI2	*Bouteloua hirsuta*	11–34	2–4
	Hall's panicgrass	PAHA	*Panicum hallii*	17–28	2–4
	hairy woollygrass	ERPI5	*Erioneuron pilosum*	11–22	1–3
3	**Cool Season Tallgrasses**			7–16	
	New Mexico feathergrass	HENE5	*Hesperostipa neomexicana*	6–17	1–2
Forb					
4	**Perennial Forbs**			17–39	
	hawkweed buckwheat	ERHI3	*Eriogonum hieraciifolium*	3–9	1–2
	showy menodora	MELO2	*Menodora longiflora*	3–9	1–2
	early shaggytuft	STBA	*Stenandrium barbatum*	3–9	1–2
	whitemargin sandmat	CHAL11	*Chamaesyce albomarginata*	3–9	1
	gypsum phacelia	PHIN	*Phacelia integrifolia*	1	1
5	**Annual Forbs**			1	
11	**Fern**			3–8	

	Cochise scaly cloakfern	ASCO42	*Astrolepis cochisensis*	3–9	1–2
Shrub/Vine					
6	**Shrubs**			57–133	
	Pinchot's juniper	JUPI	*Juniperus pinchotii*	6–39	1–5
	creosote bush	LATR2	*Larrea tridentata*	6–39	1–3
	mariola	PAIN2	*Parthenium incanum*	11–22	1–2
	featherplume	DAFO	*Dalea formosa*	6–17	1–2
	longleaf jointfir	EPTR	*Ephedra trifurca*	6–17	1–2
	resinbush	VIST	*Viguiera stenoloba*	3–9	1
	javelina bush	COER5	*Condalia ericoides*	3–9	1
	catclaw acacia	ACGR	*Acacia greggii*	0–1	0–1
	algerita	MATR3	*Mahonia trifoliolata*	0–1	0–1
7	**Half-Shrubs**			20–47	
	hairy crinklemat	TIHI	*Tiquilia hispidissima*	11–22	1–3
	desert zinnia	ZIAC	*Zinnia acerosa*	6–17	1–2
	broom snakeweed	GUSA2	*Gutierrezia sarothrae*	3–9	1
8	**Cactus**			13–31	
	purple pricklypear	OPMAM	*Opuntia macrocentra var. macrocentra*	11–22	1–2
	ocotillo	FOSP2	*Fouquieria splendens*	3–9	1
	rainbow cactus	ECPE	*Echinocereus pectinatus*	1	1
	horse crippler	ECTE	*Echinocactus texensis*	1	1
9	**Yucca**			10–24	
	Torrey's yucca	YUTO	*Yucca torreyi*	6–17	1–2
	soaptree yucca	YUEL	*Yucca elata*	0–11	0–1
10	**Yucca-like plants**			50–118	
	green sotol	DALE2	*Dasylirion leiophyllum*	22–112	2–18
	lechuguilla	AGLE	*Agave lechuguilla*	11–22	1–2
	Texas sacahuista	NOTE	*Nolina texana*	6–17	1–2

Animal community

Part I: Wildlife

The Limy Gyp Escarpment 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 Limy Gyp Escarpment Ecological Site.

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 (SWCA Environmental Consultants, 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 Guadalupe's seems to be linked to juniper and oak plant communities. 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. 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)

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.

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, Limestone Hills, and Limy Gyp Escarpment ecological sites provide the best habitat for the mountain lion life cycle. The abundance of shrubs in plant community two 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.

Other species associated with the Limy Gyp Escarpment 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
Mountain Lion
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.

Part II Livestock:

The Limy Gyp Escarpment 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 Limy Gyp Escarpment Ecological Site could be managed for sustained agriculture while maintaining the historic range of variability. Also, prescribed fire may also be a part of the management mix to move the system to community phase 1.3, which is primarily a grassland plant community.

Hydrological functions

The Bogle soil component is in hydrologic group B. The soils have a moderate infiltration rate when thoroughly wet and are well drained. The Limy Gyp Escarpment Ecological Site receives runoff moisture from the Limestone Hills and Very Shallow sites above.

Recreational uses

The Limy Gyp Escarpment 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 good on this site as deer can be hunted where permitted.

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 foliar 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.

Type locality

Location 1: Eddy County, NM	
UTM zone	N
UTM northing	3592103
UTM easting	544596
General legal description	The tier three sample data was collected on BLM land in the Seven Rivers Hills.

Other references

Coauthors:

Aaron Miller-MLRA 70 Project Leader, NRCS
Logan Peterson-MLRA 70 Soil Scientist, NRCS

Special Contributors:

Steve Daly-Soil/Range Conservationist, Carlsbad Field Office, BLM
Herman Garcia-Ecological Site Inventory Specialist, Southwest Region 8, NRCS
Tracy Hughes-Range Conservation Technician, Carlsbad Field Office, NRCS
Darren James-Researcher, USDA, Jornada ARS

Reviewers:

Steve Daly-Soil Conservationist, Carlsbad Field Office, BLM
Herman Garcia-Ecological Site Inventory Specialist, Southwest Region 8, NRCS
Mark Moseley-Ecological Site Inventory Specialist, Texas Region 9, NRCS
Richard Strait-State Soil Scientist, New Mexico NRCS
John Tunberg-State Rangeland Management Specialist, New Mexico NRCS
Renee West-Biologist, Carlsbad Caverns National Park

ESD Workgroup:

Lu Burger-Natural Resource Specialist, State Office, BLM
Steve Daly-Soil Conservationist, Carlsbad Field Office, BLM
Samuel Denman-Cultural Resource Specialist, Carlsbad Caverns National Park
Garth Grizzle, District Conservationist, Area Range Conservationist, NRCS, retired
Charles Hibner-MLRA 70 SS Leader, NRCS, retired
Tracy Hughes-Range Conservation Technician, Carlsbad, NRCS
Laurie Kincaid-Rancher, Carlsbad
Michael McGee- Hydrologist, Roswell Field Office, BLM
Aaron Miller-MLRA 70 Project Leader, NRCS
Susan Norman-GIS Specialist, Carlsbad Caverns National Park
Logan Peterson-MLRA 70 Soil Scientist, NRCS
Mark Sando-Rangeland Management Specialist, Guadalupe District, USFS
Kent Schwartzkopf-Chief, Stewardship and Science Div., Carlsbad Caverns National Park
Renee West-Biologist, Carlsbad Caverns National Park
Pete Biggam-Soils Program Manager, National Park Service, Lakewood Colorado

References:

Ahlstrand, G., 1981. Ecology of fire in the Guadalupe Mountains and adjacent Chihuahuan Desert. Carlsbad(New Mexico): Carlsbad Caverns and Guadalupe Mountains National Park.

Bestelmeyer, et al., 2010. Practical Guidance for Developing State-and-Transition Models. Rangelands, p. 26.

Buie, L., 2003. Hog-nosed skunk. [Online]
Available at: http://itech.pensacolastate.edu/sctag/hn_skunk/index.htm
[Accessed 26 10 2012].

Burger, P., 2007. Walking Guide to the Geology of Carlsbad Cavern. Carlsbad, NM: Carlsbad Caverns and Guadalupe Mountains Association.

Burkett, B., Version 1.1. A Field Guide to Pedoderm and Pattern Classes, Las Cruces, New Mexico: USDA-ARS Jornada Experimental Range.

Cleland, D. T. et al., 2007. Ecological Subregions: Sections and Subsections of the Conterminiuos United States.. s.l.:United States Forest Service.

Cougar. (2013, September 8). In Wikipedia, The Free Encyclopedia. Retrieved 21:37, September 19, 2013, from http://http://en.wikipedia.org/w/index.php?title=Cougar&oldid=571991990

Duniway, Bestelmeyer, Tugel, 2010. Soil Processes and Properties That Distinguish Ecological Sites and States. Rangelands, pp. 9-15.

Gebow, B. S., 2001. Search, Compile, and Analyze Fire Literature and Research Associated with Chihuahuan Desert Uplands, Tuscon: The University of Arizona.

Goldstein and Rominger, 2003. Plan for the Recovery of Desert Bighorn Sheep in New Mexico, Santa Fe: New MExico Department of Game and Fish.

Griffith, et al., 2006. Ecoregions of New Mixico. Reston(Virginia): U.S. Geological Survey.

Henke & Fair, 1998. Management of Texas Horned Lizards, Kingsville, Tx.: Caesar Kleberg WIldlife Research Institute.

Herrick, Whiteford, De Soyza, Van Zee, Havstad, Seybokd, Walton, 2001. Soil aggregate stability kit for field-based soil quality and rangeland health evalutations.. s.l.:s.n.

Herrick, et al., 2001. Soil aggregate stability kit for field-based soil quality and rangeland health evalutations.. s.l.:s.n.

Kayser, D. W., 2010. Prehistory: SHort and Seet. "Different peoples over a long period of time vistied, used the abundant resoruces or lived here at CASVE.", s.l.: s.n.
Kelley, V., 1971. Geology of the Pecos Country, Southeastern New Mexico. s.l.:New Mexico bureau of Mines and Mineral Resources.

Keys to Soil Taxonomy; United States Department of Agriculture, Natural Resources Conservation District; Eleventh Edition; 2010

New Mexico Game and Fish, n.d. Wildlife Notes-Ringtail, s.l.: New Mexico Game and Fish.

Pellant, Pyke, Shaver, Herrick, 2005. Interpreting Indicators of Rangeland Health. Version 4 ed. Denver(CO.): United States Department of the Interior, Bureau of Land Managment, National science and Technology Center, Division of Science Integration.

Peterson, F. F., 1981. Landforms of the Basin and Range Province, Reno: Nevada Agricultural Experiment Station.

Pierce, L. J., 2007. Gray Vireo (Vireo vicinior) Recovery Plan, Santa Fe, NM: New Mexico Department of Game and Fish.

Schoeneberger, P.J., and Wysocki, D.A. 2012. Geomorphic Description System, Version 4.2. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Spomer, Hoback, Golick, Higley, 2006. Biology, Lifecycle, and Behavior. [Online]
Available at: http://drshigley.com/lgh/netigers/index.htm
[Accessed 26 10 2012].

SWCA Environmental Consultants, 2007. Carlsbad Caverns National Park, Environmental Assessment, s.l.: U.S. Department of Interior.

United States Department of Agriculture, Natural Resources Conservation Service, 2006. Land Resource Regions and Major Land Resource Areas of the United States, the caribbean, and the Pacific Basin. s.l.:s.n.

Contributors

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:**

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):**

---

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:**
