USDA Natural Resources Conservation Service

Ecological site R030XE196CA
Sandy Xeric-Intergrade Slopes

Accessed: 05/04/2024

General information

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

Figure 1. Mapped extent

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

MLRA notes

Major Land Resource Area (MLRA): 030X–Mojave Basin and Range

MLRA Description:

Major Land Resource Area (MLRA) 30, Mojave Desert, is found in southern California, southern Nevada, the extreme southwest corner of Utah and northwestern Arizona within the Basin and Range Province of the Intermontane Plateaus. The climate of the area is hot (primarily hyperthermic and thermic; however at higher elevations, generally above 5000 feet, mesic, cryic and frigid) and dry (aridic). Elevations range from below sea level to over 12,000 feet in the higher mountain areas found within the MLRA. Due to the extreme elevational range found within this MLRA, Land Resource Units (LRUs) were designated to group the MLRA into similar land units.

LRU Description:

This LRU (designated by 'XE') is found only in California at the transition zone between MLRA 20, the Southern California Mountains, and MLRA 30. Elevations range from 3500 to 5800 feet and precipitation ranges from 8 to 12 inches per year. The LRU is characterized primarily by cool thermic and mesic soil temperature regimes and aridic bordering on xeric soil moisture regimes. Precipitation is mostly winter, receiving approximately 85% between October and February, going from rain in the fall to snow into the winter. Snow can range from between 1 and 6 inches. Soils show indications of greater moisture storage with some mollic colors in the soil profile. Vegetation is highly productive and vigorous for the Mojave Desert and includes non-typical Mojave species such as, scrub oaks, manzanita, sumac, ziziphus, mountain mahogany, presence of singleleaf pinyon, and desert needlegrass.

Ecological Site Concept -

This site occurs on steep mountain slopes between 3400 to 5600 feet in elevation. Soils are typically shallow with an aridic bordering on xeric soil moisture regime and a cool thermic soil temperature regime. Surface boulders and outcrops are typical. Large rock fragments make a significant contribution to the soil surface (RV > 5%). Boulders and large rock fragments contribute to soil stability and provide additional surface run-on, increasing moisture availability on the site, which supports a relatively high cover and high diversity of shrub and tree species.

Single-leaf pinyon pine (Pinus monophylla) and Muller oak (Quercus cornelius-mulleri) dominate. Important secondary species include California juniper (*Juniperus californica*), bigberry manzanita (Arctostaphylos glauca), blackbrush (*Coleogyne ramosissima*), and desert needlegrass (*Achnatherum speciosum*). Production reference value (RV) for is 590 pounds per acre and ranges from 230 to 950 pounds per acre depending on annual precipitation and annual species production.

Data ranges in the physiographic data, climate data and soil data are based on major components only (15 percent or greater). Information for associated minor components may be included in the narrative section.

Associated sites

R030XB164CA	**Steep South Slopes** This site occurs on steep south-facing slopes at elevations of 2300 to 3950 feet. Soils are shallow sands. The southerly aspect, hot temperatures and shallow rocky soils favor brittlebush (Encelia farinosa). Warm thermic soil temperature and aridic soil moisture regimes distinguish this site from R030XE196CA.
R030XB170CA	**Bouldery Very Shallow To Shallow Gravelly Slopes** This site is found cool hills and mountains with very shallow to shallow soils over bedrock. Blackbrush (Coleogyne ramosissima), singleleaf pinyon (Pinus monophylla) and Muller oak (Quercus cornelius-mulleri) are the dominant species at this site. A typic-aridic soil moisture regime which is not borderline xeric distinguishes R030XB170CA from R030XE196CA.
R030XB172CA	**Warm Gravelly Shallow Hills** This site is found on steep stony mountain and hill slopes with shallow to moderately deep soils. Slopes are generally greater than 40% with more than 10% surface stone cover. Creosote bush (Larrea tridentata) and Parish's goldeneye (Viguiera parishii) dominate the site. A warm thermic temperature regime and a typic-aridic soil moisture distinguish this site from R030XE196CA.
R030XB189CA	**Shallow Cool Hills** This site also occurs on steep mountain slopes on shallow soils with a cool thermic soil temperature regime. Blackbrush (Coleogyne ramosissima) and California juniper (Juniperus californica) are dominants at this site. R030XB189CA is distinguished from R030XE196CA by a typic-aridic soil moisture regime.
R030XB193CA	**Very Shallow To Moderately Deep Gravelly Slopes** This site occurs on warm thermic steep hill and mountain slopes with very shallow to moderately deep soils which typically have an argillic horizon within 2 to 7 cm of the soil surface. The site is characterized by a diverse shrub assemblage, comprised of Jojoba (Simmondsia chinensis), burrobush (Ambrosia dumosa), Parish's goldeneye (Viguiera parishii), Nevada jointfir (Ephedra nevadensis), and water jacket (Lycium andersonii), and is not strongly dominated by any one species. A warm thermic soil temperature regime and typic-aridic moisture regime distinguishes this site from R030XE196CA.
R030XB213CA	**Moderately Deep Gravelly Mountain Slopes** This site is found on very steep, very shallow to moderately deep, warm thermic hill and mountain slopes. California juniper (Juniperus californica) and Eastern Mojave buckwheat (Eriogonum fasciculatum) are the dominant species. A warm thermic soil temperature regime and typic-aridic moisture regime distinguishes this site from R030XE196CA.
R030XD040CA	**Hyperthermic Steep North Slopes** Hyperthermic steep north slopes with burrobush (Ambrosia dumosa) and brittlebush (Encelia farinosa) distinguish this site from R030XE196CA.
R030XE191CA	**Dry Sandy Mountain Slopes** This site is found on steep hill and mountain slopes (30-60%). Soils are shallow to weathered bedrock. Muller oak (Quercus cornelius-mulleri) and singleleaf pinyon (Pinus monophylla) are the dominant species on R030XE191CA. A lower large fragment cover distinguishes this site from R030XE196CA.

R030XE200CA	**Xeric Very Deep Sandy Fan Aprons On Pediments** This site occurs on hills with 4-8% slopes. Lower slopes distinguish this site from R030XE196CA. Soils are very deep to weathered bedrock, having a cool thermic temperature regime, a xeric-aridic soil moisture regime and have a sand texture.
R030XY202CA	**Very Rarely To Rarely Flooded Thermic Ephemeral Stream** This is a very rarely to rarely flooded ephemeral stream with Nevada jointfir (Ephedra nevadensis), water jacket (Lycium andersonii) and desert almond (Prunus fasciculata).

Similar sites

R030XE200CA	**Xeric Very Deep Sandy Fan Aprons On Pediments** This site occurs on hills with 4-8% slopes. Lower slopes distinguish this site from R030XE196CA. Soils are very deep to weathered bedrock, having a cool thermic temperature regime, a xeric-aridic soil moisture regime and have a sand texture.
R030XB170CA	**Bouldery Very Shallow To Shallow Gravelly Slopes** This site is found cool hills and mountains with very shallow to shallow soils over bedrock. Blackbrush (Coleogyne ramosissima), singleleaf pinyon (Pinus monophylla) and Muller oak (Quercus cornelius-mulleri) are the dominant species at this site. A typic-aridic soil moisture regime which is not borderline xeric distinguishes R030XB170CA from R030XE196CA.
R030XB172CA	**Warm Gravelly Shallow Hills** This site is found on steep stony mountain and hill slopes with shallow to moderately deep soils. Slopes are generally greater than 40% with more than 10% surface stone cover. Creosote bush (Larrea tridentata) and Parish's goldeneye (Viguiera parishii) dominate the site. A warm thermic temperature regime and a typic-aridic soil moisture distinguish this site from R030XE196CA.
R030XE191CA	**Dry Sandy Mountain Slopes** This site is found on steep hill and mountain slopes (30-60%). Soils are shallow to weathered bedrock. Muller oak (Quercus cornelius-mulleri) and singleleaf pinyon (Pinus monophylla) are the dominant species on R030XE191CA. A lower large fragment cover distinguishes this site from R030XE196CA.
R030XB164CA	**Steep South Slopes** This site occurs on steep south-facing slopes at elevations of 2300 to 3950 feet. Soils are shallow sands. The southerly aspect, hot temperatures and shallow rocky soils favor brittlebush (Encelia farinosa). Warm thermic soil temperature and aridic soil moisture regimes distinguish this site from R030XE196CA.

Table 1. Dominant plant species

Tree	(1) *Pinus monophylla* (2) *Juniperus californica*
Shrub	(1) *Quercus cornelius-mulleri* (2) *Arctostaphylos glauca*
Herbaceous	Not specified

Physiographic features

This ecological site is found on hill and mountain slopes. It occurs at elevations of 3440 to 5580 feet. Slopes may range from 8 to 75 percent, but 15 to 50 percent slopes are typical. This site occurs on all aspects in the middle of its elevation range. At the lower end of its elevation range, it is found on north slopes. At the upper end, it tends to be found on south slopes. This site experiences no flooding or ponding, and runoff class is medium to high.

Table 2. Representative physiographic features

Landforms	(1) Hill (2) Mountain
Flooding frequency	None
Elevation	1,049–1,701 m
Slope	8–75%
Water table depth	0 cm

Aspect	Aspect is not a significant factor

Climatic features

The climate at this site is arid, and characterized by cool, somewhat moist winters and hot, dry summers. The average annual precipitation ranges from 7 to 10 inches with most falling as rain from November to March. Mean annual air temperature ranges from 55 to 63 degrees Fahrenheit. June, July, and August can experience average maximum temperatures of 100 degrees Fahrenheit while December and January can have average minimum temperatures near 20 degrees Fahrenheit. The frost free period is 210 to 270 days.

Maximum and minimum monthly climate data for this ESD were generated by the Climate Summarizer (http://www.nm.nrcs.usda.gov/technical/handbooks/nrph/Climate_Summarizer.xls) using data from the following climate stations (results are weighted averages; numbers in square brackets represent relative weights):

LTHC1 Lost Horse, Joshua Tree National Park (Period of record = 1991 to 2011) [1]

44467 Kee Ranch, CA (Period of record = 1948 to 1979) [1]

45112 Yucca Valley, CA (Period of record = 1990 to 2011) [2]

45863 Morongo Valley, CA (Period of record = 1948 to 1972) [2]

The Lost Horse weather station is closest to this ecological site but is limited by the number of years data was collected. The Joshua Tree weather station is also nearby this ecological site but is located at approximately 2750 feet in elevation while the ecological site has an elevational range of 3400 to 5600 feet. This weather station is lacking precipitation data for the years between 1975 and 2008 and there is very little temperature data. Kee Ranch weather station contains precipitation data for all years of the period of record but has no temperature data. The Yucca Valley weather station contains temperature and precipitation data for the 20 year period of record.

Frost Free Period and Mean Annual Precipitation were determined using a variety of climate data and models. Freeze Free Period is a best guess based on available temperature data and the Frost Free Period. Due to sparse temperature data, the Frost Free Period determined using the Climate Summarizer does not agree with the models used to populate the National Soil Information System.

Table 3. Representative climatic features

Frost-free period (average)	270 days
Freeze-free period (average)	300 days
Precipitation total (average)	254 mm

Influencing water features

Soil features

This ecological site is typically found on very shallow and shallow soils over fractured, extremely weakly cemented, granitoid bedrock, but may also be found on deep soils. These soils have an aridic bordering on xeric soil moisture regime and a cool thermic soil temperature regime. The surface textures are gravelly loamy fine sand, gravelly sand, gravelly loamy sand, loamy sand or coarse sand. Subsurface textures are sand, loamy sand, and sandy loam with gravelly and cobbly texture modifiers. Rock fragments less than 3 inches in diameter compose 20 to 55 percent of the surface cover. Rock fragments greater than 3 inches in diameter compose 2 to 20 percent of the surface cover. In subsurface horizons, rock fragments less than 3 inches in diameter compose 5 to 65 percent of the horizon volume (for a depth of 0 to 59 inches). Rock fragments greater than 3 inches are typically not present in the subsurface horizons but may be as high as 10 percent of the subsurface volume.

The soil series that are associated with this site that are more than 15 percent of a mapunit include: Smithcanyon (mixed, thermic, shallow Xeric Torripsamments); Stubbespring (Loamy, mixed, superactive, thermic, shallow Xeric Haplargids); and a higher order Xeric Torriorthents. This ecological site is also associated with a minor component of Pinecity (mixed, thermic, shallow Typic Torripsamments).

The Smithcanyon soils are most frequently associated with this ecological site. These soils are very shallow to shallow, and formed in colluvium over residuum formed from granitoid and/or gneiss. Stubbesprings soils are also shallow to very shallow, but have an argillic horizon beginning 4 to 10 inches below the soil surface. The Xeric Torriorthents soils are moderately deep or deep or sandy or sandy-skeletal over a weathered bedrock contact. Pinecity soils are very shallow to shallow and have a typic aridic soil moisture regime. These soils are not typical for this ecological site, and only steep, high elevational slopes are associated with this site.

This ecological site is mapped in the following areas of the Joshua Tree National Park Soil Survey (CA794) listed by map unit ID; map unit; component; and component percent:

3291; Smithcanyon-Stubbespring-Rock outcrop complex, 15 to 50 percent slopes; Smithcanyon; 40%; Smithcanyon; moderately sloping; 8%; Stubbespring; 25%
3292; Smithcanyon-Pinecity-Rock outcrop association, 15 to 50 percent slopes; Smithcanyon; 35%; Smithcanyon; very steep; 2%; Smithcanyon; strongly sloping, 2%
3293; Smithcanyon-Pinecity association, 15 to 50 percent slopes; Smithcanyon; 50%
3296; Desertqueen-Pinecity complex, 15 to 50 percent slopes; Smithcanyon; 6%
3325; Ironped-Rock outcrop-Hexie complex, 30 to 60 percent slopes; Smithcanyon; 1%
3335; Xeric Torriorthents-Rock outcrop association, 15 to 75 percent slopes; Xeric Torriorthents; 30%
3336; Xeric Torriorthents-Bigbernie association, 30 to 75 percent slopes; Xeric Torriorthents; 45%
4630; Thunderclap-Smithcanyon complex, 4 to 15 percent slopes; Smithcanyon; 30%

Table 4. Representative soil features

Parent material	(1) Colluvium–granite (2) Residuum–gneiss
Surface texture	(1) Gravelly loamy sand (2) Gravelly sand (3) Loamy sand
Family particle size	(1) Sandy
Drainage class	Somewhat excessively drained to well drained
Permeability class	Moderately rapid to rapid
Soil depth	5–381 cm
Surface fragment cover <=3"	20–55%
Surface fragment cover >3"	2–20%
Available water capacity (0-101.6cm)	0.51–6.86 cm
Calcium carbonate equivalent (0-101.6cm)	0–1%
Electrical conductivity (0-101.6cm)	0–2 mmhos/cm
Sodium adsorption ratio (0-101.6cm)	0–5
Soil reaction (1:1 water) (0-101.6cm)	6.1–8.4
Subsurface fragment volume <=3" (Depth not specified)	5–65%
Subsurface fragment volume >3" (Depth not specified)	0–10%

Ecological dynamics

Abiotic factors

The major factors affecting this site are steep slopes, dominantly north-facing slopes, that have an aridic bordering on xeric soil moisture regime, with very shallow to shallow soils above weathered bedrock. This ecological site occurs on steep slopes with an aridic bordering on xeric soil moisture regime, typically with very shallow to shallow soils, at elevations of approximately 3400 to 5800 feet. Surface boulders and outcrops are typical. Large rock fragments make a significant contribution to the soil surface (RV > 5%). Boulders and large rock fragments contribute to soil stability and provide additional surface run-on, increasing moisture availability on the site, which supports a relatively high cover and high diversity of shrub and tree species relative to nearby slopes with less large rock fragment cover. While elevation, aspect and slope do not make significant differences in plant species composition they make minor contributions to the variation within this ecological siteMuller oak and singleleaf pinyon pine dominate, and a relatively high cover and diversity of secondary shrubs is present, including California juniper, bigberry manzanita and blackbrush..

Single-leaf pinyon pine is a long-lived, slow-growing tree that is a widespread dominant of Mojave Desert woodlands on shallow soils with xeric soil moisture regimes (Minnich 2007). At 7 to 10 inches, the mean annual precipitation of this ecological site is at the low end of the mean annual precipitation range for single-leaf pinyon, which is 8 to 18 inches (Zouhar 2001). Low precipitation, with dry landscape positions, means that an open cover of relatively low density pinyon pine is found on this site. Muller's oak is a long-lived, deep-rooted evergreen shrub that occurs in areas of higher rainfall such as the western margins of Mojave and Colorado Desert mountains and into the eastern slopes of the Peninsular Ranges in the California Floristic Province (Baldwin 2002). The deep roots of both single-leaf pinyon and Muller's oak can penetrate deeply into cracks in weathered bedrock, accessing water stored below the soil horizons (Jones et al. 1993).

Disturbance Dynamics

Drought, and interactions with insect attack and disease are the most important drivers of dynamics within desert pinyon woodlands (Minnich 2007, Romme et al. 2009). Pinyon woodlands are highly susceptible to drought, with widespread mortality and increased susceptibility to insect attack during drought (Shaw 2006, Minnich 2007, Romme et al. 2009). Trees in southern California close to urban centers may be especially at risk because increased nitrogen deposition from air pollution further increases susceptibility of pinyon pine to pathogens (Jones et al. 2004, Allen et al. 2010). Pinyon-juniper woodlands in the southwest experienced unprecedented drought and insect-induced mortality in the early 2000's, with higher mortality in lower elevation stands, and a significant increase in standing dead pinyon pines (Shaw 2006). Cone-bearing trees (> 35 years of age) are more likely to die during drought, so older stands may be more severely drought-affected (Romme et al. 2009). This ecological site receives relatively heavy nitrogen deposition due to its proximity to the greater Los Angeles area (Allen et al. 2009), and is characterized by taller, old trees; thus, this ecological site may be especially vulnerable to the effects of drought.

Wildfire has historically been infrequent in the desert due to widely spaced shrubs and discontinuous fuels, but the establishment of invasive species increases wildfire risk by making a more continuous, easily ignitable fuel bed (D'Antonio and Vitousek. 1992; Knapp 1995). This ecological site is likely to have experienced infrequent, stand-replacement fires, occurring every 35 and 200 years (Vasek and Clovis 1976; Minnich and Howard 1984; Wangler and Minnich 1996; Minnich 1999; Brown and Smith 2000). Muller oak is well adapted to fire and may begin to sprout as early as 10 days following a fire (James 1984; Keeley 1981).

Singleleaf pinyon recolonizes a site very slowly following stand-replacement fires because pinyon post-fire survival is dependent on seed survival and animal seed dispersal (Knapp 1995). Pinyon seedling establishment may be delayed for 20 to 30 years until a nurse plant shrub layer has developed (Stager and Klebenow 1987; Minnich 1999).

California juniper (*Juniperus californica*) does not sprout from live root tissue following fire (Hanes 1971). Juniper reestablishment is dependent on seed survival and animal seed dispersal. Juniper may be able to repopulate an area as early as fifteen years, especially when islands of juniper have survived a burn, but may take as long as 50 years to repopulate an area where it has been completely removed (Wright 1972; Schmidt and Larson 1989).

In areas with higher precipitation, bigberry manzanita can return to its original population size within 20 years following fire (Hanes 1971). At the desert edge, where this ecological site occurs, bigberry seedling establishment is sparse and subject to drought mortality (Tratz 1978). At this ecological site, bigberry manzanita may not reach its original population size until well beyond 20 years with post-fire survival being dependent on precipitation and fire return intervals (Wirtz 1982; Horton and Kraebel 1955).

The ability of blackbrush (*Coleogyne ramosissima*) to recolonize a post-fire site is severely limited by infrequent seedling establishment (Callison and Brotherson 1985; Webb et al. 1987). Blackbrush does not resprout following fire (Bowns and West 1976; Hansen et al. 1999). Blackbrush is highly competitive for resources and reduced competition from late seral species for light, water, and nutrients facilitates growth of other species (Pendleton and Meyer 2004).

An altered fire frequency regime due to the presence of exotic annual grasses has the potential to permanently alter the plant community. In this altered state Muller oak, red brome (*Bromus madritensis*), cheatgrass (*Bromus tectorum*), desert needlegrass (*Achnatherum speciosum*), narrowleaf goldenbush (*Ericameria linearifolia*) and Eastern Mojave buckwheat (*Eriogonum fasciculatum*) are likely to persist.

State and transition model

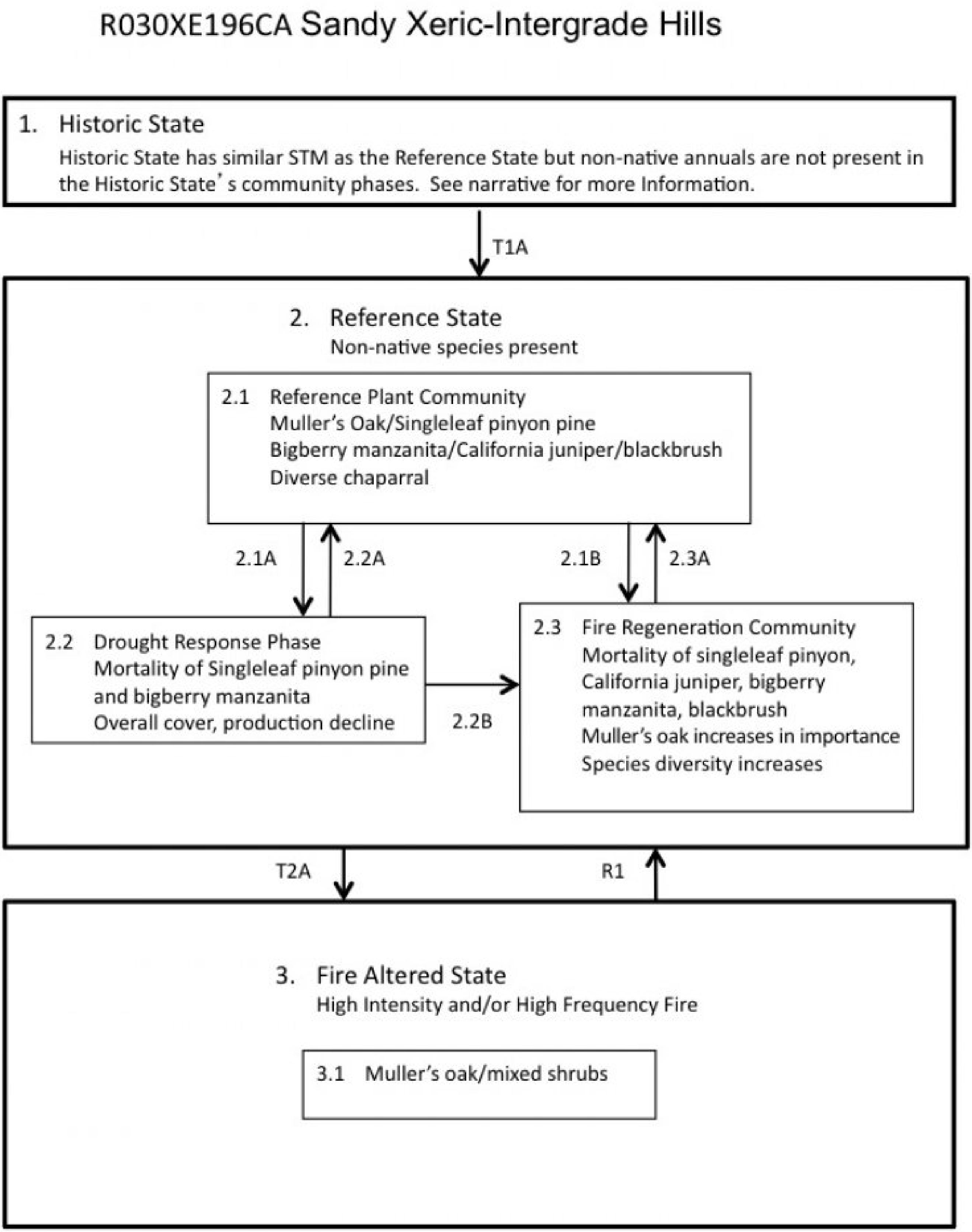

Figure 4. R030XE196CA

State 1
Historic State

This state is similar to State 2.0, but Historic State 1.0 contains only native species. If dynamics were included in this state, they would be similar to those displayed in State 2.0. The presence of exotic species in State 2.0 may increase fire frequency and intensity from that experienced in Historic State 1.0

Community 1.1
Historic Reference Community

This community phase is similar to Community Phase 2.1 but exotic plant species are not present in Community Phase 1.1.

State 2
Reference State

There are three community phases maintained by the current natural conditions for this ecological site.

Community 2.1
Reference Plant Community

Figure 5. Community Phase 2.1

The reference plant community is dominated by Muller oak and singleleaf pinyon. Some sites may also be co-dominated by bigberry manzanita. California juniper is typically present as a secondary small tree. Secondary shrubs include blackbrush, beargrass (*Nolina parryi*), eastern Mojave buckwheat (*Eriogonum fasciculatum*), narrowleaf goldenbush (*Ericameria linearifolia*), green rabbitbrush (*Ericameria teretifolia*), Mojave yucca (*Yucca schidigera*), and threadleaf snakeweed (*Gutierrezia microcephala*). The invasive annual grasses, red brome (*Bromus rubens*) and cheatgrass (bromus tectorum), are naturalized in this community, and may be abundant.

Table 5. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Tree	168	280	560
Shrub/Vine	78	336	420
Forb	–	22	45
Grass/Grasslike	11	22	39
Total	**257**	**660**	**1064**

Table 6. Ground cover

Tree foliar cover	2-15%
Shrub/vine/liana foliar cover	10-30%
Grass/grasslike foliar cover	1-15%
Forb foliar cover	0-3%
Non-vascular plants	0%
Biological crusts	0%

Litter	12-19%
Surface fragments >0.25" and <=3"	20-55%
Surface fragments >3"	2-20%
Bedrock	0-17%
Water	0%
Bare ground	1-23%

Community 2.2
Drought Response

Figure 7. Community Phase 2.2

Severe drought can lead to water stress and cause mortality in pinyon pine. Drought weakens the trees and makes them more susceptible to bark beetle infestations, which increases mortality rates (Waring and Cobb 1992; Allen and Breshears 1998). Severe drought may also kill other species such as California juniper and bigberrry manzanita. Standing snags of pinyon and manzanita are common in this community phase. Tree and shrub mortality allows annuals access to more light and precipitation (Minnich 2003). Although annual production and cover will be suppressed during the drought, annuals will be able to quickly utilize moisture of the following precipitation events. Years with heavy winter precipitation will likely lead to a heavy growth of exotic grasses (Humphrey 1974; Brown and Minnich 1986). Allen and Breshears (1998) observed an upward shift in the pinyon-juniper/ponderosa ecotone after drought mortality of ponderosa pine in New Mexico. Prolonged severe and reoccurring drought is likely to cause an upward shift in the California juniper-blackbrush and Muller oak-singleleaf pinyon ecotone; however, increased fire frequency and intensity due to the presence of exotic grasses may prevent this ecotonal shift and will likely push both of these plant communities into a permanently altered state. Because this ecological site is sensitive to climate changes, these areas may act as an indicator of change in other ecosystems (Brown et al. 2001). This community phase is also at risk of high intensity fire following years with a heavy growth of exotic grasses and the abundance of dead woody fuels. This community phase is also at risk due to projected global climate change, which is expected to increase the frequency and intensity of drought occurring with warmer temperature (Easterling et al. 2000; Watson et al. 2001; Hoerling and Kumar 2003). Mueller et al. (2005) found a reduction in tree density within Northern Arizona pinyon-juniper woodland (*Pinus edulis* and *Juniperus monosperma*) did not buffer sites against additional mortality during the next drought. Mueller et al. went on to hypothesize that vegetational shifts due to pinyon mortality maybe long-term because pinions are slow growing, long-lived species, are dependent on mutalistic ectomycorrhizae, and are better able to establish with nurse plants. Breshears et al. (2005) also noted overstory pinyon mortality changes ecosystem type, properties and land surface conditions for decades. Another factor in post-drought pinyon establishment is the mutualistic relationship between pinyon and vertebrate species. Pinyon seeds are wingless as a result of co-evolution with animal seed dispersers, mostly avian and rodent species (VanderWall and Balda 1977). Successful pinyon seed germination and establishment most often occurs in animal seed caches (Evans 1988; Tomback and Linhart 1990; Lanner 1996; Chambers 2001). The loss of mutualistic animal habitat due to pinyon mortality poses additional challenges to pinyon recruitment following severe drought (Mueller et al. 2005).

Table 7. Ground cover

Tree foliar cover	10-15%
Shrub/vine/liana foliar cover	18-35%
Grass/grasslike foliar cover	10-17%
Forb foliar cover	0-5%
Non-vascular plants	0%
Biological crusts	0%
Litter	10-15%
Surface fragments >0.25" and <=3"	16-21%
Surface fragments >3"	2%
Bedrock	6-16%
Water	0%
Bare ground	1-6%

Community 2.3
Fire regeneration community

This community phase develops with fire. Fire is more likely when climatic conditions have produced an accumulation of fine fuels, or when there has been a long-term accumulation of woody fuels due to the absence of fire. . The community is at risk when residual dry matter, shrubs and trees create a continuous fuel ladder. Anthropogenic disturbances such as trails, firebreaks and openings may enhance the development of this community phase by expanding the area of invasion by red brome and other annuals (Horton and Kraebel 1955). This community phase is characterized by the loss of pinyon pine, dominance by Muller's oak, and an increase in perennial grass and subshrub cover. Pinyon pine is generally killed by even moderate fire intensity {Romme, 2009}. Muller's oak is a vigorous resprouter, and will begin recovery in the first year after fire. The perennial grasses found in this site can also quickly resprout, and these species will increase in response to fire {Sawyer, 2009}. Subshrubs can rapidly recolonize from seed, as can the short-lived shrubs narrow-leaved goldenbush, eastern Mojave buckwheat, and green rabbitbrush. As tall shrub cover increases, shade-dependent seedlings of pinyon pine will begin to establish. After fifty years with no disturbance, pine cover will begin to shade out shorter-lived shrubs, and mature woodlands will re-establish at 100 to 150 years post-fire {Wangler, 1996}.

Pathway 2.1A
Community 2.1 to 2.2

Reference Plant Community

Drought Response

This pathway occurs with prolonged or severe drought.

Pathway 2.1B
Community 2.1 to 2.3

This pathway occurs with fire.

Pathway 2.2A
Community 2.2 to 2.1

Drought Response

Reference Plant Community

This pathway occurs with time and a return to average or above average precipitation. The presence of mutualistic animal species, live mature pinyon, and nurse plants will enhance singleleaf pinyon recovery. Singleleaf pinyon reaches reproductive maturity in approximately 35 years (Evans 1988; Meeuwig et al. 1990).

Pathway 2.2B
Community 2.2 to 2.3

This pathway occurs with fire.

Pathway 2.3A
Community 2.3 to 2.1

This pathway occurs with a long period of time without disturbance (100 – 150 years).

State 3
Fire Altered

This state develops with recurrent fire (fire return interval < 10 years). It is characterized by the loss of single leaf pinyon pine, California juniper, bigberry manzanita and blackbrush, and dominance by Mullers' oak. There is one known community phase for this state maintained by frequent high intensity fires.

Community 3.1
Grasses/Muller oak

Figure 8. Community Phase 3.1

Fire return intervals shorter than ten years favor obligate resprouters such as Muller oak, and tend to eliminate obligate seeders such as bigberry manzanita (Arnold et al. 1951; Zelder et al. 1983; Keeley 1986). Other species at this site likely to persist with shorter fire return intervals are red brome, cheatgrass, desert needlegrass, narrowleaf goldenbush and Eastern Mojave buckwheat, Parry's beargreass (*Nolina parryi*), and Mojave yucca (*Yucca schidigera*) (Thatcher and Hart 1974; Keeley and Keeley 1984; Koniak 1985; West et al. 1998; Minnich 2003).

Table 8. Annual production by plant type

Plant Type	Low (Kg/Hectare)	Representative Value (Kg/Hectare)	High (Kg/Hectare)
Grass/Grasslike	34	112	123
Forb	1	62	106
Shrub/Vine	17	84	101
Tree	–	–	28
Total	**52**	**258**	**358**

Transition 1A
State 1 to 2

Exotic forbs and grasses are introduced to the Historic State. Some areas of this ecological site may only contain trace amounts of exotic plant species. Exotic species are well adapted to the desert climate. Attempts to eradicate this species may be in vain as seed sources are widespread throughout the state of California and the Southwest.

Transition T2A
State 2 to 3

This transition may occur with recurrent fire.

Restoration pathway 1
State 3 to 2

Restoration of communities severely altered by repeat fire at the landscape scale is extremely difficult, and especially so on the steep, rugged and remote slopes of this ecological site. Methods may include aerial seeding of early native colonizers such as sandberg bluegrass, desert needlegrass, desert globemallow, and deervetch. Increased native cover may help to reduce non-native plant invasion, helps to stabilize soils, provides a source of food and cover for wildlife, and provides microsites that facilitate California juniper establishment. However, the amount of seed required for success is often prohibitive. Stabilization of soils using mulch or straw is sometimes used on severe burns on steep slopes to prevent soil erosion, but the effectiveness of this is not clear, and in National Park lands, the benefits of introducing foreign material into wilderness have to be carefully weighed with the potential benefits. Large-scale planting of both early colonizers and community dominants tends to be more successful than seeding, especially if outplants receive supplemental watering during the first two years. Bigberry manzanita, an obligate fire-seeder with a limited seedbank in desert communities, would need to be outplanted, or seeds heat-treated prior to introduction. Pre-emergent herbicides (Plateau) have been used in the year immediately post-fire to attempt to inhibit or reduce brome invasion. How successful this is on a landscape scale, and the non-target effects have not yet been determined.

Additional community tables

Table 9. Community 1.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)

Table 10. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Tree					
1	**Trees**			168–560	
	singleleaf pinyon	PIMO	*Pinus monophylla*	168–560	2–10
	California juniper	JUCA7	*Juniperus californica*	0–17	0–3
Shrub/Vine					
2	**Native Shrubs**			78–420	
	bigberry manzanita	ARGL4	*Arctostaphylos glauca*	0–191	0–7
	Muller oak	QUCO7	*Quercus cornelius-mulleri*	78–157	10–20
	Eastern Mojave buckwheat	ERFA2	*Eriogonum fasciculatum*	2–45	0–3
	narrowleaf goldenbush	ERLI6	*Ericameria linearifolia*	2–22	0–6
Grass/Grasslike					
3	**Native Grasses**			1–28	
	desert needlegrass	ACSP12	*Achnatherum speciosum*	1–28	1–5
4	**Non-native Grasses**			0–22	
	red brome	BRRU2	*Bromus rubens*	0–22	0–5
	cheatgrass	BRTE	*Bromus tectorum*	0–1	0–1
Forb					
5	**Native Forbs**			0–34	
	Forb, annual	2FA	*Forb, annual*	0–11	0–1
	calthaleaf phacelia	PHCA2	*Phacelia calthifolia*	0–11	0–1
	chia	SACO6	*Salvia columbariae*	0–11	0–1
6	**Non-native Forbs**			0–11	
	redstem stork's bill	ERCI6	*Erodium cicutarium*	0–11	0–1

Table 11. Community 2.2 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)

Table 12. Community 2.3 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)

Table 13. Community 3.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Kg/Hectare)	Foliar Cover (%)
Tree					
1	**Trees**			0–28	
	singleleaf pinyon	PIMO	*Pinus monophylla*	0–28	0–2
Shrub/Vine					
2	**Native Shrubs**			17–101	
	Muller oak	QUCO7	*Quercus cornelius-mulleri*	0–34	3–5
	bigberry manzanita	ARGL4	*Arctostaphylos glauca*	0–22	0–3
	goldenbush	ERICA2	*Ericameria*	0–22	0–1
	narrowleaf goldenbush	ERLI6	*Ericameria linearifolia*	2–17	1–3
	Parry's beargrass	NOPA	*Nolina parryi*	0–11	0–1
	Acton's brittlebush	ENAC	*Encelia actonii*	0–6	0–1
	Eastern Mojave buckwheat	ERFA2	*Eriogonum fasciculatum*	0–6	0–1
	threadleaf snakeweed	GUMI	*Gutierrezia microcephala*	0–3	0–2
	skunkbush sumac	RHTR	*Rhus trilobata*	0–1	0–2
	Mojave yucca	YUSC2	*Yucca schidigera*	0–1	0–2
Grass/Grasslike					
3	**Native Grasses**			6–22	
	desert needlegrass	ACSP12	*Achnatherum speciosum*	6–22	2–10
4	**Non-native Grasses**			34–112	
	cheatgrass	BRTE	*Bromus tectorum*	34–90	1–25
	red brome	BRRU2	*Bromus rubens*	0–22	2–6
Forb					
5	**Native Forbs**			0–22	
	chia	SACO6	*Salvia columbariae*	0–22	0–5
	desert globemallow	SPAM2	*Sphaeralcea ambigua*	0–2	0–2
	Forb, annual	2FA	*Forb, annual*	0–1	0–1
	shrubby deervetch	LORI3	*Lotus rigidus*	0–1	0–1
	wishbone-bush	MILAV	*Mirabilis laevis var. villosa*	0–1	0–1
6	**Non-native Forbs**			0–101	
	redstem stork's bill	ERCI6	*Erodium cicutarium*	0–101	0–10

Animal community

Bighorn sheep and mule deer may tend to use this site in the winter to feed on blackbrush, juniper, desert needlegrass and big galleta (Sampson and Jespersen 1963; Bradley 1965; Stark 1966; Bowns and West 1976; Loope et. al 1988; Urness and Austin 1989; Seegmiller et. al 1990; Krausman et. al 1997). Small mammals, such as kangaroo rats, and birds will cache and eat blackbrush achenes and juniper berries (Barrett 1983; West 1983; Blake 1984; Mozingo 1987). A list of the many animals which may use the area is presented below.

MAMMALS:

Badgers, Skunks, Weasels
Long-tailed Weasel (Mustela frenata latirosta)

Bats
Desert Long-legged Bat (Myotis volans interior)

Northern Fringed Bat (Myotis thysanodes thysanodes)
Western Pipistrelle (Pipistrellus hesperus hesperus)
Desert Big Brown Bat (Eptesicus fuscus pallidus)
Hoary Bat (Lasiurus cinereus cinereus)
Pallid Bat (Antrozous pallidus minor)

Bears
California Black Bear (Ursus Americanus californianus)

Canids
Desert Coyote (Canis latrans mearnsi)
Common Gray Fox (Urocyon cinereoargenteus scottii)

Cats
California Mountain Lion (Felis concolor californica)
Desert Bobcat (Lynx rufus baileyi)

Ringtails
California Ringtail (Bassariscus astutus ocatvus)

Deer & Sheep
Southern Mule Deer (Blacktail) (Odocoileus hemionus fuliginatus)
Desert Bighorn Sheep (Ovis canadensis nelsoni)

Rabbits & Hares
Southern Desert Cottontail (Sylvilagus audubonii arizonae)

Rodents
Dusky Chipmunk (Tamias obscurus davisi)
Whitetail Antelope Squirrel (Ammospermophilus leucurus leucurus)
Western Mojave Ground Squirrel (Spermophilus beecheyi parvulus)
Long-tailed Pocket Mouse (Chaetodipus formosus mojavensis)
Western Chisel-toothed Kangaroo Rat (Dipodomys microps occidentalis)
Merriam’s Kangaroo Rat (Dipodomys merriami merriami)
Desert Wood Rat (Neotoma lepida lepida)
Eastern Dusky-footed Wood Rat (Neotoma fuscipes simplex)
White-throated Wood Rat (Neotoma albigula venusta)
Sonoran Deer Mouse (Peromyscus maniculatus sonoriensis)
Southern California Pinyon Mouse (Peromyscus truei chlorus)
Desert Grasshopper Mouse (Onychomys torridus pulcher)

Shrews
Desert Shrew (Gray) (Notiosorex crawfordi crawfordi)

REPTILES:

Lizards
Desert Banded Gecko (Coleonyx variegatus variegatus)
Mojave Collared Lizard (Crotaphytus bicinctores)
Western Chuckwalla (Sauromalus ater obesus)
Great Basin Fence Lizard (Sceloporus biseriatus longipes)
Western Brush Lizard (Urosaurus graciosus graciosus)
Great Basin Whiptai (Aspidoscelis tigris tigris)
Western Red-tailed Skink (Eumeces gilberti rubricaudatus)
San Diego Alligator Lizard (Elgaria multicarinata webbii)
Silvery Legless Lizard (Anniella pulchra pulchra)

Snakes

Southwestern Blind Snake (Leptotyphlops humilis humilis)
Desert Rosy Boa (Lichanura trivirgata gracia)
Mojave Glossy Snake (Arizona occidentalis candida)
Desert Night Snake (Hypsiglena torquata deserticola)
California Kingsnake (Lampropeltis getula californiae)
California Striped Racer (Masticophis lateralis lateralis)
Great Basin Gopher Snake (Pituophis catenifer deserticola)
Western Long-nosed Snake (Rhinocheilus lecontei lecontei)
Smith’s Black-headed Snake (Tantilla hobartsmithi)
California Lyre Snake (Trimorphodon biscutatus vandenburghi)
Southwestern Speckled Rattlesnake (Crotalus mitchelli pyrrhus)
Red Diamond Rattlesnake (Crotalus ruber ruber)
Southern Pacifi c Rattlesnake (Crotalus helleri)

This list is not intended to be an exhaustive list of animals found in this ecological site. Many birds are likely to use this ecological site. No wildlife inventory was used to create the above list; this list was made based on species' habitat preferences (National Park Service 2012).

Recreational uses

This ecological site occurs in remote, steep terrain with limited access. As such, it has important wilderness values. It may be used for cross-country hiking, solitude, botanizing, and aesthetic enjoyment.

Wood products

Wood of single-leaf pinyon may be used for fuel wood and fence posts, particle and cement board (Zouhar 2001). It is not suitable for lumber because of its small size and irregular growth pattern (Zouhar 2001).

California juniper is a poor source of lumber because of low volume and multi-stemmed growth form. However, early ranchers used juniper for fenceposts, and it is used for fuel and as Christmas trees (Cope 1992).

Other products

Single-leaf pinyon pine is very important for many Native American tribes. The melted gum is used to bind and heal cuts, prevent sunburn, to stop menstruation, for muscle soreness, diarhea, rheumatism, colds, and nausea, among others. Pinyon nuts are an important food source, and were the staple food source in the past for many tribes. The pinyon seeds were one of the few foods given to babies as an alternative food source by the Cahuilla. Needles are used to make baskets, and were used as a spice to flavor meats. Wood and bark were used in house construction, and the pitch was used for water-proofing. http://herb.umd.umich.edu/herb/search.pl?searchstring=Pinus%20monophylla).

Inventory data references

Cover data for this ecological site was described using 2 line-point intercept transects. The complete protocol for this sampling method is found in Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems, Volume 1: Quick Start.

Production data for this ecological site was described using 1 modified double-sampling transect. The protocol was modified by California State Rangeland Ecologist Kendra Moseley to use fewer plots and less destructive sampling. The complete protocol for this sampling method is found in Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems, Volume 2: Design, supplementary methods and interpretation.

Below are the Pedon User ID locations used to describe each community phase.

Community Phase 2.1
1249806912
1249810208 (Type location)

Community Phase 2.2
12498-006-E (Type location)
1249806702

Community Phase 3.1
1249800601
1249800613
1249800622
1249800630 (Type location)

Type locality

Location 1: San Bernardino County, CA	
Township/Range/Section	T1S R6E S30
UTM zone	N
UTM northing	3767637
UTM easting	555738
General legal description	This site is approximately 0.58 miles south of Black Rock Spring

Other references

Allen, C. D. and D.D. Breshears. 1998. Proc. Natl. Acad. Sci. USA 95, 14839–14842.

Arnold, K.; L.T. Burcham; R.L. Fenner and R.F. Grah. 1951. Use of fire in land clearing. Calif Agric 5(3):9-11; 5(4):4-5, 13

Barrett, R.H. 1983. Food habits of coyotes, Canis latrans, in eastern Tehama County, California. California Fish and Game. 69(3): 184-186.

Blake, J.G. 1984. A seasonal analysis of bird communities in southern Nevada. Southwestern Naturalist. 29(4): 463-474.

Bowns, J.E. 1973. An autecological study of blackbrush (*Coleogyne ramosissima* Torr.) in southeastern Utah. Logan, UT: Utah State University. 115 p. Dissertation.

Bowns, J.E. and N.E. West. 1976. Blackbrush (*Coleogyne ramosissima* Torr.) on southwestern Utah rangelands. Research Report 27. Logan, UT: Utah State University, Utah Agricultural Experiment Station. 27 p.

Bradley, W.G. 1965. A study of the blackbrush plant community of the Desert Game Range. Transactions, Desert Bighorn Council. 11: 56-61.

Breshears, D., et al. 2005. Regional vegetation die-off in response to global-change-type drought. Proceedings of the National Academy of Sciences (USA) 102:15144–15148.

Brown, D.E. and R.A. Minnich. 1986. Fire and changes in creosote bush scrub of the western Sonoran Desert, California. American Midland Naturalist 116:411–422.

Brown, J.K. and J.K. Smith, eds. 2000. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech Rep. RMRS-GRT-42-vol. 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 257 p.

Brown, J.H., T.G. Whitham; S.K. Morgan Ernest and C.A. Gehring. 2001. Complex species interactions and the dynamics of ecological systems: long-term experiments. Science, 293, 643–650.

Callison, J. and J.D. Brotherson. 1985. Habitat relationships of the blackbrush community (*Coleogyne ramosissima*) of southwestern Utah. The Great Basin Naturalist. 45(2): 321-326.

Chambers, J.C. 2001. Pinus monophylla establishment in an expanding pinon–juniper woodland: environmental conditions, facilitation and interacting factors. Journal of Vegetation Science, 12, 27–40.

D'Antonio, C.M. and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 3:63–87.

Easterling, D.R., G.A. Meehl; C. Parmesan; S.A. Changnon; T.R. Karl and L.O. Mearns. 2000. Science 289, 2068–2074.

Evans, R.A. 1988. Management of pinyon-juniper woodlands. Gen. Tech. Rep. INT-249. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 34 p.

Hanes, T.L. 1971. Succession after fire in the chaparral of southern California. Ecological Monographs. 41(1): 27-52.

Hansen, D.J., W.K. Ostler and D.B. Hall. 1999. The transition from Mojave Desert to Great Basin Desert on the Nevada Test Site. In: McArthur, E.D.; W.K. Ostler and C.L. Wambolt; compilers. Proceedings: shrub ecotones; 1998 August 12-14; Ephraim, UT. Proceedings RMRS-P-11. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 148-158.

Hoerling, M.P. and A. Kumar, 2003: The perfect ocean for drought. Science, 299, 691-694.

Horn, K.J.; B.R. McMillan and S.B. St. Clair. 2012. Expansive fire in Mojave Desert shrubland reduces abundance and species diversity of small mammals. Journal of Arid Environments 77: 54-58.

Horton, J.S. and C.J. Kraebel. 1955. Development of vegetation after fire in the chamise chaparral of southern California. Ecology. 36(2): 244-262.

Humphrey, R.R. 1974. Fire in the deserts and desert grassland of North America. In: Kozlowski, T.T. and C.E. Ahlgren, eds. Fire and ecosystems. New York: Academic Press: 365-400.

James, S. 1984. Lignotubers and burls--their structure, function and ecological significance in Mediterranean ecosystems. Botanical Review. 50(3): 225-266.

Keeley, J.E. 1981. Reproductive cycles and fire regimes. In: Mooney, H.A.; T.M. Bonnicksen; N.L. Christensen; [and others], technical coordinators. Fire regimes and ecosystem properties: Proceedings of the conference; 1978 December 11-15; Honolulu, HI. Gen. Tech. Rep. WO-26. Washington, DC: U.S. Department of Agriculture, Forest Service: 231-277.

Keeley, J.E. 1986. Resilience of mediterranean shrub communities to fires. In Dell, B.; A.J.M. Hopkins and B.B. Lamont, eds. Resilience in Mediterranean-type ecosystems, W. Junk, Dordrecht, pp. 95–112.

Keeley, J.E. and S.C. Keeley. 1984. Postfire recovery of California coastal sage scrub. The American Midland Naturalist. 111(1): 105-117.

Keeley, J.E. and P.H. Zedler. 1978. Reproduction of chaparral shrubs after fire: a comparison of sprouting and seeding strategies. American Midland Naturalist. 99(1): 142-161.

Koniak, S. 1985. Succession in pinyon-juniper woodlands following wildfire in the Great Basin. The Great Basin Naturalist. 45(3): 556-566.

Knapp, P.A. 1995. Intermountain West lightning-caused fires: climatic predictors of area burned. Journal of Range Management. 48(1): 85-91.

Krausman, P.R., A.J. Kuenzi, R.C. Etchberger, [and others]. 1997. Diets of mule deer. Journal of Range Management. 50(5): 513-522.

Lanner, R.M. 1996. Made for each other: a symbiosis of birds and pines. New York: Oxford University Press. 160 p.

Loope, L.L., P.G. Sanchez, P.W. Tarr, [and others]. 1988. Biological invasions of arid land nature reserves. Biological Conservation. 44: 95-118.

Meeuwig, R.O., J.D. Budy and R.L. Everett. 1990. Pinus monophylla Torr. & Frem. singleleaf pinyon. In: Burns, Russell M. and B.H. Honkala, technical coordinators. Silvics of North America. Volume 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 380-384.

Minnich, R.A. 1999. Vegetation, fire regimes, and forest dynamics. In: Miller, P. R. and J.R. McBride, eds. Oxidant air pollution impacts in the montane forests of southern California: a case study of the San Bernadino Mountains. Ecological Studies: Analysis and Synthesis. Vol. 134. New York: Springer-Verlag: 44-80.

Minnich, R.A. 2003. Fire and dynamics of temperate desert woodlands in Joshua Tree National Park. Report submitted to the National Park Service, Joshua Tree National Park. Contract number P8337000034/0001. 32 p.

Minnich, R. and L. Howard. 1984. Biogeography and prehistory of shrublands. In: DeVries, J.J., ed. Shrublands in California: literature review and research needed for management. Contribution No. 191. Davis, CA: University of California, Water Resources Center: 8-24.

Mozingo, H.N. 1987. Shrubs of the Great Basin: A natural history. Reno, NV: University of Nevada Press. 342 p.

Muller, C.H.; R.B. Hanawalt and J.K. McPherson. 1968. Allelopathic control of herb growth in the fire cycle of California chaparral. Bulletin of the Torrey Botanical Club. 95(3): 225-231.

Mueller R.C.; C.M. Scudder; M.E. Porter; R.T. Trotter III; C.A. Gehring and T.G. Whitham. 2005. Differential tree mortality in response to severe drought: evidence for long-term vegetation shifts. Journal of Ecology 93: 1085–1093.

National Park Service. 2012. Joshua Tree National Park: Animals. http://www.nps.gov/jotr/naturescience/animals.htm. Accessed 2012 Feb. 22.

Pendleton, B.K. and S.E. Meyer. 2004. Habitat-correlated variation in blackbrush (*Coleogyne ramosissima*: Rosaceae) seed germination response. Journal of Arid Environments 59:229-243.

Sampson, A.W. and B.S. Jespersen. 1963. California range brushlands and browse plants. Berkeley, CA: University of California, Division of Agricultural Sciences, California Agricultural Experiment Station, Extension Service. 162 p.

Schmidt, W.C. and M. Larson. 1989. Silviculture of western inland conifers. In: Burns, R.M., compiler. The scientific basis for silvicultural and management decisions in the National Forest System. Gen. Tech. Rep. WO-55. Washington, DC: U.S. Department of Agriculture, Forest Service: 40-58.

Seegmiller, R.F.; P.R. Krausman; W.H. Brown and F.M. Whiting. 1990. Nutritional composition of desert bighorn sheep forage in the Harquahala Mountains, Arizona. Desert Plants. 10(2): 87-90.

Stager, D.W. and D.A. Klebenow. 1987. Mule deer response to wildfire in Great Basin pinyon-juniper woodland. In: Everett, R.L., compiler. Proceedings--pinyon-juniper conference; 1986 January 13-16; Reno, NV. Gen. Tech. Rep. INT-215. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 572-579.

Stark, N. 1966. Review of highway planting information appropriate to Nevada. Bull. No. B-7. Reno, NV: University of Nevada, College of Agriculture, Desert Research Institute. 209 p. In cooperation with: Nevada State Highway Department.

Thatcher, A.P. and V.L. Hart. 1974. Spy mesa yields better understanding of pinyon-juniper in range ecosystem. Journal of Range Management. 357:354–357.

Tomback, D.F. and Y.B. Linhart. 1990. The evolution of bird-dispersed pines. Evolutionary Ecology. 4: 185-219.

Tratz, W.M. 1978. Postfire vegetational recovery, productivity, and herbivore utilization of a chaparral-desert ecotone. Los Angeles, CA: California State University. 133 p. Thesis.

Urness, P.J. and D.D. Austin. 1989. The effects of grazing and browsing animals on wildlife habitats. Utah Science. 50(2): 104-107.

Vander Wall, S.B. and R.P. Balda. 1977. Coadaptations of the Clark's nutcracker and the piñon pine for efficient seed harvest and dispersal. Ecol. Monogr., 47, pp. 89–111

Vasek, F.C. and J.F. Clovis. 1976. Growth forms in Arctostaphylos glauca. American Journal of Botany. 63(2): 189-195.

Wangler, M.J. and R.A. Minnich. 1996. Fire and succession in pinyon-juniper woodlands of the San Bernadino Mountains, California. Madrono. 43(4): 493-514.

Waring G.L. and N.S. Cobb. 1992. The impact of plant stress on herbivore population dynamics. In: E. Bernays, ed. Insect-plant interactions, vol 4. CRC, Boca Raton, Fla. pp 167–226

Watson, R.T. & Core Writing Team, eds. 2001. Intergovernmental Panel on Climate Change Climate Change 2001: Synthesis Report, A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. (Cambridge Univ. Press, New York).

Webb, R.H.; J.W. Steiger and R.M. Turner. 1987. Dynamics of Mojave Desert shrub assemblages in the Panamint Mountains, California. Ecology. 68(3): 478-490; 1987.

West, N.E. 1983. Colorado plateau-Mohavian blackbrush semi-desert. In: West, N.E., ed. Temperate deserts and semi-deserts. New York: Elsevier Scientific Publishing Company: 399-411. (Goodall, David W., ed. in chief; Ecosystems of the world; vol. 5).

West, N.E.; R.J. Tausch and P.T. Tueller. 1998. A management-oriented classification of pinyon-juniper woodlands of the Great Basin. Gen. Tech. Rep. RMRS-GTR-12. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 42 p.

Wirtz, W.O., II. 1982. Postfire community structure of birds and rodents in southern California chaparral. In: Conrad, C.E. and W.C. Oechel, technical coordinators. Proceedings of the symposium on dynamics and management of Mediterranean-type ecosystems; 1981 June 22-26; San Diego, CA. Gen. Tech. Rep. PSW-58. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station: 241-246.

Wright, H.A. 1972. Shrub response to fire. In: McKell, C.M.; J.P. Blaisdell and J.R. Goodin, eds. Wildland shrubs--their biology and utilization: Proceedings of a symposium; 1971 July; Logan, UT. Gen. Tech. Rep. INT-1. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 204-217.

Zedler, P.H.; C.R. Gautier and G.S. McMaster. 1983. Vegetation change in response to extreme events: The effect of a short interval between fires in California chaparral and coastal scrub. Ecology 64: 809-818.

Contributors

Allison Tokunaga
Dustin Detweiler

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:**