USDA Natural Resources Conservation Service

Ecological site R040XD200CA
Rarely Flooded Fans

Accessed: 04/25/2024

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): 040X–Sonoran Basin and Range

MLRA Statement:
Major land resource area (MLRA) 31 is the Lower Colorado Desert. This area is in the extreme southeastern part of California, in areas along the Colorado River, and in Western Arizona. The area is comprised of rough, barren, steep, and strongly dissected mountain ranges, generally northwest to southwest trending that are separated by intermontane basins. Elevation ranges from approximately 275 feet below sea level at the lowest point in the Salton Trough to 2700 feet along low northwest to southeast trending mountain ranges. The average annual precipitation is 2 to 6 inches with high temporal and spatial variability. Winter temperatures are mild, summer temperatures are hot, and seasonal and diurnal temperature fluctuations are large. Monthly minimum temperature averages range from 40 to 80 degrees F (4 to 27 degrees C). Monthly maximum temperature averages range from 65 to 110 degrees F (18 to 43 degrees C) (WRCC 2002). Temperatures are rarely below 28 degrees F, and extremely rarely fall below 24 degrees F. Precipitation is bimodal, with approximately 20 to 40 percent of annual precipitation falling between July and September. This summer rainfall, in combination with very hot temperatures and very few to no days of hard freeze are what characterize this MLRA and distinguish it from the Mojave Desert (MLRA 30).

Site Concept:
This ecological site occurs on very rarely flooded to rarely flooded fan aprons and alluvial fans at elevations of 540 to 2730 feet. Soils are very deep and sandy. Production reference value (RV) is 218 pounds per acre and ranges from 100 to 396 pounds per acre depending on annual precipitation and annual forb production. Brittlebush and creosote bush are dominant.

Data ranges in the physiographic data, climate data, water features, and soil data sections of this Ecological Site Description are based on major components only (15 percent of map unit or greater).

Associated sites

R040XD030CA	**Extremely Stony Fan Remnants** This ecological site is on extremely stony fan remnants, near the mountain base. Teddybear cholla and a diversity of cacti and shrubs, including creosote bush and brittlebush.
R040XD034CA	**Gravelly, Braided, Ephemeral Stream** This ephemeral stream is on frequently to occasionally flooded braided drainageways and channels. Burrobrush and desert lavender are dominant with a diversity of other species.
R040XD201CA	**Cobbly Fan Remnants** This ecological site is on fan remnants with stony surfaces. Creosote bush and brittlebush are dominant, with several cacti species.

R040XD202CA	**Stony, Occasionally Flooded Ephemeral Stream** This ephemeral stream occurs on occasionally flooded, stony, inset fans, with blue paloverde, brittlebush, creosote bush, and Schott's dalea present.

Similar sites

R040XD201CA	**Cobbly Fan Remnants** This ecological site is also dominated by creosote bush and brittlebush, bit is it on more stable fan remnants with stony surfaces, and more cacti diversity.

Table 1. Dominant plant species

Tree	Not specified
Shrub	(1) *Larrea tridentata* (2) *Encelia farinosa*
Herbaceous	Not specified

Physiographic features

This ecological site occurs on fan aprons, alluvial fans, and rarely on bars in drainageways. Elevations range from 540 feet to 2730 feet, with slopes ranging from 2 to 8 percent.

Table 2. Representative physiographic features

Landforms	(1) Fan apron (2) Alluvial fan
Flooding duration	Extremely brief (0.1 to 4 hours) to very brief (4 to 48 hours)
Flooding frequency	None to rare
Ponding frequency	None
Elevation	540–2,730 ft
Slope	2–8%
Aspect	Aspect is not a significant factor

Climatic features

The climate of this ecological site is characterized by hot temperatures, aridity, and a bimodal precipitation pattern. Precipitation falls as rain, with 30 percent falling in summer between July and October, and 60 percent falling in winter between November and March. The mean annual precipitation is 2 to 4 inches, and mean annual air temperature is 73 to 79 degrees F. The frost free period is 360 to 365 days, and freeze free period is 363 to 365 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):

42598, Eagle Mountain, CA (Period of record = 1933 to 2011) [2]

43855, Hayfield Reservoir, CA (Period of record = 1933 to 2011) [1]

The data from multiple weather were combined to most accurately reflect the climatic conditions of this ecological site.

Table 3. Representative climatic features

Frost-free period (average)	365 days
Freeze-free period (average)	365 days
Precipitation total (average)	4 in

Influencing water features

Soil features

The soils associated with this ecological site are very deep, somewhat excessively to excessively drained, and formed in alluvium from igneous or metamorphic parent material. The surface textures are gravelly loamy sand, gravelly sand, gravelly loamy fine sand, and loamy fine sand. Subsurface horizons are composed of sand, loamy sand and coarse sand with non-gravelly to extremely gravelly (Rizzo) modifiers. Surface rock fragments less than 3 inches in diameter range from 55 to 80 percent cover, and fragments greater than 3 inches range from 0 to 15 percent cover (up to 30 percent on outlier soil). Subsurface percent by volume of rock fragments less than 3 inches (at depths of 1 to 59 inches) ranges from 20 to 46, and greater that 3 inch fragments range from 0 to 14.

This ecological site is associated with the following major soil components (greater that 15 percent of mapunit) : Carsitas, Goldrose and Rizzo. The Carsitas soils are mixed, hyperthermic Typic Torripsamments. The Goldrose soils are sandy, mixed, hyperthermic Typic Torriorthents. The Rizzo soils are sandy-skeletal, mixed, hyperthermic Typic Torriorthents. The Carsitas soils have two C horizons composed of gravelly sand from 0 to 10 inches and gravelly coarse sand below 10 inches. The Goldrose soils have only one thick layer with greater than 35 percent rock fragments, and have stronger structure in a Bw horizon than is found in adjacent soils. The Rizzo soils have greater than 35 percent rock fragments in the particle control section.

Minor soil components associated with this site are the Rockhound series and a higher order of Typic Haplargids. The Rockhounds soils are loamy-skeletal, mixed, superactive, hyperthermic Typic Haplargids, and the Typic Haplargids are coarse-loamy, mixed, superactive, hyperthermic Typic Haplargids. These are older soils on fan remnants, which have argillic soil horizons with finer textures. These soils are well drained with slow to moderately rapid permeability. Available water capacity (AWC) is higher at 2.3 to 3.9 inches per upper 40 inches of soil, while more typical AWC is less than 2.5 inches.

This ecological site has been correlated to the following map units and soil components in the Joshua Tree National Park Soil Survey Area (CA794):

Map unit ID; Map unit name; Component; Percent
1555; Goldrose-Carsitas-Chemwash complex, 4 to 8 percent slopes; Goldrose ; ; 35 and Carsitas; very rarely flooded; 30
2120; Rizzo-Deprave complex, 2 to 8 percent slopes; Rizzo; rarely flooded; 35
2409; Rizzo-Chemwash-Carsitas complex, 4 to 8 percent slopes; Goldrose; ; 4
2421; Carsitas complex, 4 to 8 percent slopes; Carsitas; very rarely flooded; 55 and Rizzo; very rarely flooded; 5 and Typic Haplargids; very rarely flooded; 2
2140; Rockhound silt loam, 4 to 15 percent slopes; Rockhound; rarely flooded; 10

Table 4. Representative soil features

Surface texture	(1) Gravelly sand (2) Gravelly loamy sand (3) Gravelly loamy fine sand
Family particle size	(1) Sandy
Drainage class	Somewhat excessively drained to excessively drained
Soil depth	60 in
Surface fragment cover <=3"	55–80%
Surface fragment cover >3"	0–30%

Available water capacity (0-40in)	1–2.5 in
Calcium carbonate equivalent (0-40in)	0%
Electrical conductivity (0-40in)	0 mmhos/cm
Sodium adsorption ratio (0-40in)	0
Soil reaction (1:1 water) (0-40in)	6–8.4
Subsurface fragment volume <=3" (Depth not specified)	20–46%
Subsurface fragment volume >3" (Depth not specified)	0–14%

Ecological dynamics

This ecological site occurs on very rarely to rarely flooded fan aprons, alluvial fans, and seldomly on bars in drainageways. The soils are very deep and sandy, with non-gravelly to extremely gravelly texture modifiers. Brittlebush and creosote bush dominate, and burrobush (*Ambrosia dumosa*) and Schotts dalea (*Psorothamnus schottii*) are important secondary shrubs. Very rare to rare sheet floods from hillslope and fan runoff favor the establishment of brittlebrush, burrobrush, and Schott's dalea. Deep sandy soils allow for rapid and deep infiltration of water, which supports deep-rooted species such creosote bush.
Creosote bush is a long-lived, deep-rooted evergreen shrub dominant across vast areas of the North American warm deserts. Creosote bush maintains its evergreen status by using water held in deep soil layers. Creosote bush is typically the dominant shrub on deep coarse soils with little development (Hamerlynk et al. 2002, Hamerlynk and McAuliffe 2008), such as on this ecological site.

Brittlebush is common on steep south-facing slopes (McAuliffe and Devender 1998, Hamerlynk et al.). When dominant on lower landscape positions, such as this site, it is generally present due to disturbance (Sawyer et al. 2009) such as flooding. Brittlebush is an extremely drought-tolerant, drought-deciduous shrub. Adaptations in degree of leaf pubescence and leaf size allow brittlebush to occupy sites ranging from relatively mesic coastal environments to extremely arid deserts (Ehleringer and Cook 1990, Sandquist and Ehleringer 1997, Housman et al. 2002, Sandquist and Ehleringer 2003). Desert plants have smaller, more pubescent leaves, and a more compact growth form. Smaller more pubescent leaves reduce leaf temperatures and increases water use efficiency. The tradeoff is that plant productivity declines because smaller leaves have less surface area available for photosynthesis, and because pubescence reduces the absorption of solar radiation (Housman et al. 2002, Sandquist and Ehleringer 2003).

While leaf and shoot-adaptations allow brittlebush to withstand hot temperatures and extreme aridity, freezing temperatures restrict brittlebush. Frosts cause branch die-back and mortality in adult brittlebush (Sandquist and Ehleringer 1996), and reduce seedling establishment (Bowers 1994). Brittlebush seedlings emerge over multiple pulses in response to cool season rains, with emergence triggered by a minimum of 19 mm of precipitation, and seedlings are killed if freezing temperatures occur within nine days of the trigger event (Bowers 1994). The low incidence of frost in MLRA31 allows brittlebush to be a dominant species.

The disturbances impacting this ecological site include drought, invasion by non-native species and fire.

Non-native annual species such as Mediterranean grass (*Schismus barbatus*), redstem stork's bill (*Erodium cicutarium*) and Asian mustard (*Brassica tournefortii*) have become naturalized in the Colorado Desert over the past century (Brown and Minnich 1986, D'Antonio and Vitousek 1992, Brooks and Berry 2006). At lower elevations, where soil temperature regimes are hyperthermic and soil moisture is more limiting, Mediterranean grass is the dominant non-native grass (Brooks and Berry 2006). Like native annuals, nonnative annual cover and production is directly related to winter precipitation (Beatley , Brooks and Berry 2006, Barrows et al. 2009).

This site has the potential for relatively high biomass of native and non-native annual species during years of higher precipitation, and has fairly high shrub cover, so has a relatively high risk of fire (Brown and Minnich, 1986). Creosote bush is poorly adapted to fire (Webb et al. 2010), while a brittlebush dominated community recovers rapidly (Brown and Minnich 1986, Steers and Allen 2011). Repeat burning could trigger a transition to an altered state dominated by brittlebush.

Desert regions are characterized by low mean annual precipitation and extreme variability in the amount of precipitation received in any year or decade (Hereford et al. 2006). Thus, episodic mortality in response to periods of drought is important in shaping desert community dynamics (Hereford et al. 2006, Miriti et al. 2007).

State and transition model

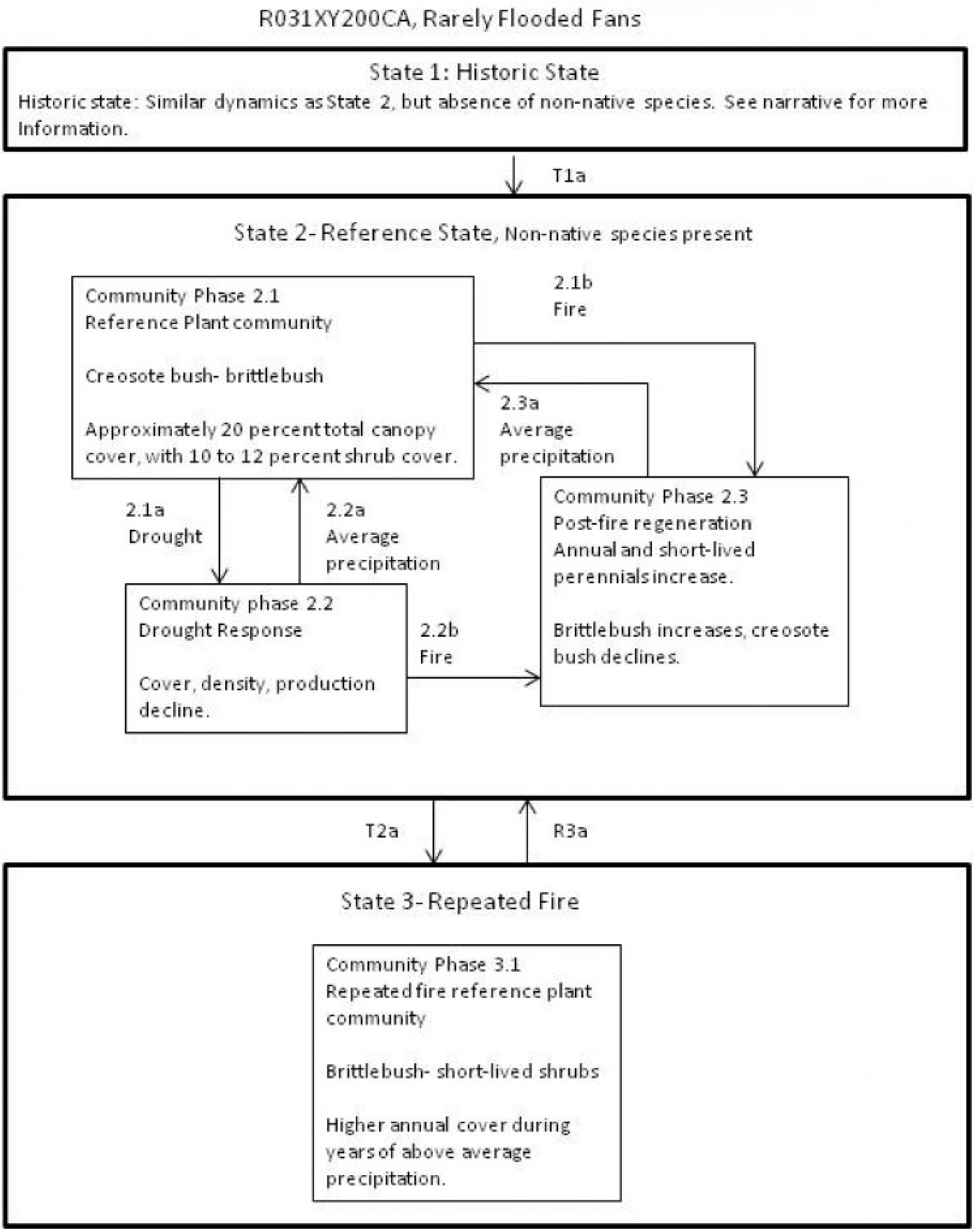

Figure 4. R031XY200CA Model

State 1
Historic State

State 1 represents the historic range of variability for this ecological site. This state no longer exists due to the ubiquitous naturalization of non-native species in the Colorado Desert. Periodic drought was the natural disturbance influencing this ecological site. Data for this State does not exist, but dynamics and composition would have been similar to State 2, except with only native species present. See State 2 narrative for more detailed information.

State 2
Reference State

State 2 represents the current range of variability for this site. Non-native annuals, including Mediterranean grass is naturalized in this plant community, but have not altered the ecological dynamics of this site.

Community 2.1
Reference community

Figure 5. Reference Community

This community phase is dominated by creosote bush and brittlebush. Secondary shrubs are present at low levels, and include burrobush, burrobrush (*Hymenoclea salsola*), Schott's dahlia, branched pencil cholla (*Cylindropuntia ramosissima*), and ocotillo (*Fouquieria splendens*). Desert ironwood (*Olneya tesota*) and blue paloverde (*Parkinsonia florida*) are generally trace species. Forbs are present in most years, with higher production and diversity during years of higher precipitation. Common species include pincushion flower (*Chaenactis fremontii*), cryptantha (Cryptantha spp.), buckwheat (Eriogonum spp.), smooth desertdandelion (*Malacothrix glabrata*), desert poppy (*Eschscholzia glyptosperma*),pygmy poppy (*Eschscholzia minutiflora*), lupine (Lupinus sp.), birdcage evening primrose (Oenothera deltoids), desert Indianwheat (*Plantago ovata*), and chia (*Salvia columbariae*). The non-native annual forb red-stem stork's bill (*Erodium cicutarium*) is present with up to 6 percent cover, and Asian mustard (*Brassica tournefortii*) is occasionally present with less than 1 percent cover. The non-native Mediterranean grass (Schismus sp) is often present with low cover.

Table 5. Annual production by plant type

Plant Type	Low (Lb/Acre)	Representative Value (Lb/Acre)	High (Lb/Acre)
Shrub/Vine	50	132	200
Forb	50	75	165
Tree	0	10	30
Grass/Grasslike	0	1	1
Total	**100**	**218**	**396**

Table 6. Ground cover

Tree foliar cover	0-1%
Shrub/vine/liana foliar cover	7-19%
Grass/grasslike foliar cover	1-3%
Forb foliar cover	6-16%
Non-vascular plants	0%

Biological crusts	0%
Litter	16-40%
Surface fragments >0.25" and <=3"	20-50%
Surface fragments >3"	0-1%
Bedrock	0%
Water	0%
Bare ground	14-20%

Community 2.2
Drought Response

This community phase is characterized by declines in cover and production due to branch-pruning and lack of recruitment of long-lived species such as creosote bush, mortality of short-lived species (burrobush and burrobrush) and lack of emergence of annual species. Bowers (2005) measured no effect of drought on mortality rates of brittlebush during modest drought in the 1950s. Brittlebush is buffered from severe drought-induced impacts by the physiological adaptations of its leaves. It can vary the degree of leaf pubescence in response to periods of drought, where each successive leaf cohort produces more pubescence over the course of a drought (Sandquist and Ehleringer 2003). Individuals are able to continue photosynthesizing during drought, although at reduced rates of production. Creosote bush exhibits branch-pruning, but low mortality in response to drought in the Mojave Desert (Webb et al. 2003, Hereford et al. 2006, Miriti et al. 2007). In the Sonoran desert, mortality of creosote bush due to severe drought may be more pronounced, but still less than 5% (Bowers 2005).

Community 2.3
Post-fire Regeneration

This community phase is characterized by the loss of creosote bush from the plant community. Brittlebush rapidly colonizes burned areas, and reaches dominance before associated shrub species (Brown and Minnich 1986, Steers and Allen 2011). In burned creosote bush scrub in the Colorado Desert, brittlebush seedlings overwhelmingly dominated shrub succession within the first year after burning, and within 3 to 5 year dominated total cover (Brown and Minnich, 1986). By twelve years after fire, pre-burn cover and density is reached, and is dominated by brittlebush (Steers and Allen 2011). By twenty years, there is sparse cover of creosote bush and other secondary shrubs with brittlebush (Steers and Allen 2011).

Pathway 2.1a
Community 2.1 to 2.2

This pathway occurs with prolonged or severe drought.

Pathway 2.1b
Community 2.1 to 2.3

This community pathway occurs with moderate to severe fire.

Pathway 2.2a
Community 2.2 to 2.1

This pathway occurs with average to above average precipitation and the recovery of vegetation.

Pathway 2.2b
Community 2.2 to 2.3

This pathway occurs with moderate to severe fire. This pathway is unlikely unless it occurs within one year of a heavy precipitation year, when standing annual biomass is still present.

Pathway 2.3a
Community 2.3 to 2.1

This community pathway occurs with time, and a lack of additional disturbance.

State 3
Repeated Fire

This state develops when the fire return interval is less than 50 years. The reference plant community has been significantly altered. It is characterized by the loss of creosote bush, and dominance by brittlebush. Data is not available for this state, and the description is based on research from nearby burned areas.

Community 3.1
Repeated Fire

This community is dominated by brittlebush. Native forbs and native and non-native annual grasses become more abundant.

Transition 2A
State 2 to 3

This transition occurs when the fire return interval in the reference state is less than 50 years.

Restoration pathway R3a
State 3 to 2

Restoration of communities severely altered by repeat fire at the landscape scale is difficult. Methods may include aerial seeding of early native colonizers such desert globemallow, burrobrush, and brittlebush. Increased native cover may help to reduce non-native plant invasion, helps to stabilize soils, provides a source of food and cover for wildlife, including desert tortoise (Gopherus agassizii), and provides microsites that facilitate creosote bush establishment. However, the amount of seed required for success is often prohibitive. Large-scale planting of both early colonizers and community dominants tends to be more successful in terms of plant survival, especially if outplants receive supplemental watering during the first two years. Creosote bush and burrobush can be successfully propagated and outplanted. 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 7. Community 2.1 plant community composition

Group	Common Name	Symbol	Scientific Name	Annual Production (Lb/Acre)	Foliar Cover (%)
Shrub/Vine					
1	**Shrubs**			50–200	
	creosote bush	LATR2	*Larrea tridentata*	30–130	4–15
	burrobush	AMDU2	*Ambrosia dumosa*	0–40	0–3
	brittlebush	ENFA	*Encelia farinosa*	14–30	1–3
	burrobrush	HYSA	*Hymenoclea salsola*	0–8	0–2
	Schott's dalea	PSSC5	*Psorothamnus schottii*	0–5	0–1
	ocotillo	FOSP2	*Fouquieria splendens*	0–5	0–1
	branched pencil cholla	CYRA9	*Cylindropuntia ramosissima*	0–5	0–1
Forb					
2	**Forbs**			50–135	
	chia	SACO6	*Salvia columbariae*	5–100	1–4
	cryptantha	CRYPT	*Cryptantha*	1–50	1–13
	sowthistle desertdandelion	MASO	*Malacothrix sonchoides*	3–40	1–6
	desert Indianwheat	PLOV	*Plantago ovata*	0–30	0–9
	lupine	LUPIN	*Lupinus*	0–20	0–3
	pincushion flower	CHFR	*Chaenactis fremontii*	0–5	0–2
	buckwheat	ERIOG	*Eriogonum*	0–1	1–2
	desert poppy	ESGL	*Eschscholzia glyptosperma*	0–1	0–1
	pygmy poppy	ESMI	*Eschscholzia minutiflora*	0–1	0–1
	birdcage evening primrose	OEDE2	*Oenothera deltoides*	0–1	0–1
5	**Non-native forbs**			0–30	
	redstem stork's bill	ERCI6	*Erodium cicutarium*	0–30	0–6
	Asian mustard	BRTO	*Brassica tournefortii*	0–5	0–1
Grass/Grasslike					
3	**Annual grass**			0–1	
	Mediterranean grass	SCHIS	*Schismus*	0–1	0–1
Tree					
4	**Trees**			0–30	
	desert ironwood	OLTE	*Olneya tesota*	0–40	0–1
	blue paloverde	PAFL6	*Parkinsonia florida*	0–10	0–1

Animal community

Creosote bush shrublands provides a home for an abundance of specialist insect species, for example, creosote bush flowers provide nutrition for over twenty species of bees, and the creosote bush grasshopper (Bootettix argentatus) feeds solely on creosote leaves (Pavlik 2008). Brittlebush is used as forage by desert bighorn sheep and mule deer.

Hydrological functions

This ecological site allows for rapid infiltration of run-off from the nearby mountain slopes.

Recreational uses

This ecological site may be used for cross-country hiking and aesthetic enjoyment. When brittlebush is in flower, is lights up the area with its yellow blooms.

Other products

Creosote bush is an important medicinal plant for Native Americans. It has a very wide range of uses from treatment for consumption, bowl complaints, and menstrual cramps, to induce vomiting, relief for arthritis, rheumatism, aching bones and sprains, congestion and cold, as an antiseptic and disinfectant, dandruff, antispasmodic, to induce urination, gonorrhea, and to cancer treatment. (This list is not exhaustive). http://herb.umd.umich.edu/herb/search.pl?searchstring=Larrea+tridentata.

Creosote bush stems are used to make weapons, digging tools, and basket handles, and creosote gum is used for knife and awl handles. Creosote bush branches are used as thatch in dwelling construction. http://herb.umd.umich.edu/herb/search.pl?searchstring=Larrea+tridentata.

Brittlebush has medicinal uses for Native Americans, including as a poultice for pain and for toothaches. Brittlebush resin is used as chewing gum, to fasten arrow points to twigs, to waterproof water bottles, and is melted to make a varnish. Brittlebush twigs were used as kindling for quick fires. http://herb.umd.umich.edu/herb/search.pl?searchstring=Encelia+farinosa.

Brittlebush resin is burned as incense in churches in Mexico (Tesky 1993).

Inventory data references

The following NRCS vegetation plots were used to describe this ecological site:

8181001
1250014906
HASP04- Type location
HASP06
J5-D

Type locality

Location 1: Riverside County, CA	
UTM zone	N
UTM northing	3730877
UTM easting	632932
General legal description	The type location is approximately half way between Chirioco Summit and Desert Center, north of HW 10, on BIM property, just outside the boundary of Joshua Tree National Park.

Other references

Barrows, C. W., E. B. Allen, M. L. Brooks, and M. F. Allen. 2009. Effects of an invasive plant on a desert sand dune landscape. Biological Invasions 11:673-686.

Beatley, J. C. 1969. Dependence of desert rodents on winter annuals and precipitation. Ecology 50:721-724.

Bowers, J. E. 1994. Natural conditions for seedling emergence of three woody species in the northern Sonoran Desert. Madroño 41:73-84.

Bowers, J. E. 2005. Effects of drought on shrub survival and longevity in the northern Sonoran Desert. Journal of the Torrey Botanical Society 132:421-431.

Brooks, M. L. and K. H. Berry. 2006. Dominance and environmental correlates of alien annual plants in the Mojave Desert, USA. Journal of Arid Environments 67:100-124.

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.

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 23:63-87.

Ehleringer, J. R. and C. S. Cook. 1990. Characteristics of Encelia species differing in leaf reflectance and transpiration rate under common garden conditions. Oecologia 82:484-489.

Hamerlynk, E. P. and J. R. McAuliffe. 2008. Soil-dependent canopy die-back and plant mortality in two Mojave Desert shrubs. Journal of Arid Environments 72:1793-1802.

Hamerlynk, E. P., J. R. McAuliffe, E. V. McDonald, and S. D. Smith. 2002. Ecological responses of two Mojave desert shrubs to soil horizon development and soil water dynamics. Ecology 83:768-779.

Hereford, R., R. H. Webb, and C. I. Longpre. 2006. Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave Desert region, 1893-2001. Journal of Arid Environments 67:13-34.

Housman, D. C., M. V. Price, and R. A. Redak. 2002. Architecture of coastal and desert Encelia farinosa (Asteraceae): consequences of plastic and heritable variation in leaf characteristics. American Journal of Botany 89:1303-1310.

McAuliffe, J. R. and T. R. V. Devender. 1998. A 22,000-year record of vegetation change in the north-central Sonoran Desert. Paleography, Palaeoclimatalogy, Paleoecology 141:253-275.

Miriti, M. N., S. Rodriguez-Buritica, S. J. Wright, and H. F. Howe. 2007. Episodic death across species of desert shrubs. Ecology 88:32-36.

Pavlik, B. M. 2008. The California Deserts: an ecological rediscovery. University of California Press, Ltd., Berkeley and Los Angeles, California.

Sandquist, D. R. and J. R. Ehleringer. 1997. Intraspecific variation in leaf pubescene and drought response in Encelia farinosa associated with contrasting desert environments. New Phytologist 135:635-644.

Sandquist, D. R. and J. R. Ehleringer. 2003. Population- and family-level variation of brittlebush (Encelia farinosa, Asteraceae) pubescence: its relation to drought and implications for selection in variable environments. American Journal of Botany 90:1481-1486.

Sandquist, J. R. and J. R. Ehleringer. 1996. Potential adaptability and constraints of response to changing climates for Encelia farinosa var. phenicodonta from southern Baja California, Mexico. Madroño 43:465-478.

Sawyer, J. O., T. Keeler-Woolf, and J. M. Evans. 2009. A manual of California vegetation. 2nd edition. California Native Plant Society, Sacramento, California.

Steers, R. J. and E. B. Allen. 2011. Fire effects on perennial vegetation in the western Colorado Desert, USA. Fire Ecology 7:59-74.

Tesky, J. L. 1993. *Hymenoclea salsola*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

Webb, R. H., D. E. Boyer, and R. M. Turner. 2010. Repeat photography: Methods and Applications in the Natural Sciences. Island Press.

Webb, R. H., M. B. Muroy, T. C. Esque, D. E. Boyer, L. A. DeFalco, D. F. Haines, D. Oldershaw, S. J. Scoles, K. A. Thomas, J. B. Blainey, and P. A. Medica. 2003. Perennial vegetation data from permanent plots on the Nevada Test Site, Nye County, Nevada. U.S. Geological Society, Tucson, AZ.

WRCC, W. R. C. C. 2002. Western U.S. Climate Historical Summaries [Online]. Desert Research Institute, Reno, NV.

Contributors

Allison Tokunaga
Marchel Munnecke, Alice Miller

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:**