EASTERN MOJAVE BUCKWHEAT

Eriogonum fasciculatum Benth.

Polygonaceae - buckwheat family

Sophia Goss and Ashlee Wolf |2023

ORGANIZATION

NOMENCLATURE

Eastern Mojave buckwheat (*Eriogonum fasciculatum* Benth.) belongs to the Polygonaceae or buckwheat family (USDA NRCS 2023).

NRCS Plant Code.

ERFA2 (USDA NRCS 2023).

Subtaxa.

The Flora of North America (Reveal 2023) and the Integrated Taxonomic Information System (ITIS 2023) both recognize four subtaxa for eastern Mojave buckwheat:

- var. *polifolium* Torr. & A. Gray (Mojave Desert California buckwheat)
- var. *fasciculatum* Munz and Keck (Coastal California buckwheat)
- var. *flavoviride* Munz & I.M. Johnst (Sonoran Desert California buckwheat)
- var. *foliolosum* Nutt. (leafy California buckwheat)

The variety *emphereium* is confined to Baja California Sur, Mexico and will not be described further in this account (SEINet 2023).

Synonyms.

E. f. subsp. *aspalathoides* (Gand.) S. Stokes
E. f. subsp. *aspathaloides* (Gand.) S. Stokes
E. f. subsp. *flavoviride* (Munz & I.M. Johnst.) S. Stokes
E. f. subsp. *foliolosum* (Nutt.) S. Stokes
E. f. subsp. *typicum* S. Stokes
E. f. var. *aspalathoides* Gand
E. f. var. *emphereium* Reveal
E. f. var. *obtusiflorum* S. Stokes
E. f. var. *revolutum,* (Goodd.) S. Stokes
E. polifolium Benth.
E. revolutum Goodd.
E. rosmarinifolium var. *foliolosum* Nutt.
E. rosmarinifolium Nutt.
E. fasciculatum var*. maritimum* Parish
E. fasciculatum var*. oleifolium* Gand.
E. aspalathoides (Gand.) A. Heller

Common Names.

Eastern Mojave buckwheat, Eastern Mojave Wild Buckwheat, flat-top buckwheat, California buckwheat, Mojave buckwheat, flattop buckwheat, yellow buckwheat. Common names in Spanish include maderista, valeriana, and gordo lobo (SEINet 2023).

Chromosome Number.

The chromosome number for Eastern Mojave buckwheat is 2n=40, 80 (CCDB 2023).

Varieties of Eastern Mojave buckwheat occur in distinct ploidy races. Varieties that have the same chromosome counts are typically able to hybridize (Reveal 2023). There have been no studies assessing ploidy variation within or among populations of varieties of Eastern Mojave buckwheat.

Hybridization.

Var. *foliolosum* can hybridize with coastal buckwheat (*E. cinereum*) (Reveal 2023). Montalvo (2018) anecdotally notes that var. *polifolium* can hybridize with St. Catherine's lace (*E. giganteum*) in gardens and produce offspring with intermediate leaf morphology.

Var. *foliolosum* may have evolved from an ancient hybridization event between var. *fasciculatum* and var. *polifolium* (Stebbins 1942, Cole 1967).

The four varieties can be difficult to distinguish from each other where they geographically overlap, especially if there is hybridization of the n=20 varieties, *fasciculatum* and *polifolium* (Montalvo et al. 2018).

DESCRIPTION

Eastern Mojave buckwheat is a morphologically variable shrub or subshrub, growing 20-150 cm as a mat or subshrub, and 20-250 centimeters as a shrub (Reveal and Rosatti 2012b). The branched, fibrous lateral roots can spread three times beyond the radius of the canopy and tap roots reach 150 centimeters belowground (Hellmers et al. 1955). The shrub grows more or less erect but is sometimes decumbent with branches spreading along the ground. Branches and stems are spreading to erect with hairless to hairy flowering stems (Reveal and Rosatti 2012b). Leaves are arranged in clusters that alternate up the stem. Although rare, it can also grow scapose, leafless stems (Reveal 2023). The leaves are linear to narrow at the base and broader toward the tip (oblanceolate), with margins plane to rolled underneath (Reveal 2023). Leaf surfaces range from white tomentose to hairless (Reveal and Rosatti 2012b). Eastern Mojave buckwheat's inflorescence is cymose with heads (or cymes) of flowers tightly to loosely

packed in involucres with few flowers per involucre (Reveal 2023). Flowers are small (3 mm long) with six white to pinkish tepals that are fused at the base (Reveal 2023). Flowers produce brown, single seeded, and glabrous achenes, ranging from 1.5 to 2.5 mm long, and enclosed in a persistent calyx (Reveal and Rosatti 2012, Reveal 2023).

Figure 1: A robust Eastern Mojave buckwheat individual. Photo: BLM SOS AZ932

Figure 2: Eastern Mojave buckwheat in bloom. Photo: BLM SOS NV052

Varieties.

Leaf traits (color, shape and pubescence) and growth form are the main morphological differences in the four varieties (Reveal and Rosatti 2012b, ITIS 2023). The four varieties can be distinguished as follows:

Var. *polifolium* (2n=40): Shrubs or subshrubs are spreading to rounded or compact (Reveal and Rosatti 2012b, Reveal 2020c). The aerial flowering stems are are typically thinly tomentose or covered with short white hairs (canescent) and grayish in color (SEINet 2023). The flowering stems are rarely hairless. Leaf blade shape is oblanceolate with dense hairy surfaces on both sides of the leaf blade (SEINet 2023). Unlike var. *fasciculatum* and var. *foliolosum*, var. *polifolium* leaf margins are often plane; if rolled under, it is infrequent and subtle (Montalvo et al. 2018, Reveal 2020c). Involucres and flowers are hairy with a pubescent perianth (Reveal 2020c).

Var. *fasciculatum* (2n=40): Shrubs are low, spreading, and mostly dark green, often decumbent and mat-forming (Reveal 2020a). Leaves are green and glabrous on the upper surface and typically thinly tomentose under, with the leaf margin tightly rolled under (Reveal 2020a). Flowers are generally without hairs (glabrous) or with a few hairs proximally on the corolla (Reveal 2020a).

Var. *foliolosum* (2n=80): Shrub shape is rounded to erect with leaf blade shape linear to oblanceolate (0.6-1.2 x 0.1-0.4 cm) (Reveal and Rosatti 2012b, Reveal 2020b). The upper leaf surface is grey-green to dark green with scattered hairs (Reveal and Rosatti 2012b). The bottom of the leaf has white-tomentose, wooly or floccose hair with leaf margins tightly rolled under (Reveal and Rosatti 2012). The perianth and involucre are glabrous to pubescent (Reveal and Rosatti 2012b).

Var. *flavoviride* (2n=40): Shrubs or subshrubs are rounded and somewhat compact, covered with short white hairs (floccose) or hairless with a yellowish green color (Reveal 2020a). Leaf blade shape is linear or linear-oblanceolate, and slightly tomentose on the bottom surface and mostly smooth and lacking hairs on the top surface, with margins tightly revolute (Montalvo et al. 2018, Reveal 2020d). Inflorescences are mostly capitate with hairless branches (Reveal 2020d). Involucres are pubescent and perianths glabrous or infrequently thinly pubescent inside (Reveal 2020d). Variety *flavoviride* distribution overlaps with var. *polifolium*, but *flavoviride* can be distinguished by the yellowish-green hue of the flowering stems and leaves (Reveal 2020d).

DISTRIBUTION AND HABITAT

Eastern Mojave buckwheat occurs on the California and western Mexico coasts and warm deserts of the western U.S. and northwestern Mexico (Figure 3). Its distribution extends from the central California coast, south into Baja California, and east into Arizona and Nevada, with some observations in Utah. The four varieties can overlap in their geographic distribution, but their associated species and climatic zones can differ from one another.

Var. *polifolium* is a common and an occasionally dominant shrub in the Mojave and Sonoran deserts in Arizona, southern California, southern Nevada and southwestern Utah (SEINet 2023). This variety is commonly planted as an ornamental in the Southwest (Montalvo et al. 2018, Reveal 2023).

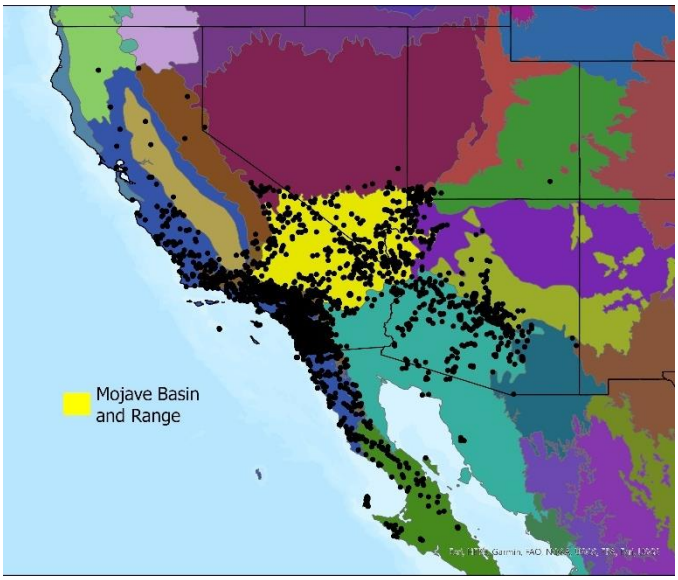

Figure 3: Distribution of Eastern Mojave buckwheat (black circles) from georeferenced herbarium specimens and verified observations (SEINet 2022) with EPA Level III Ecoregions (US EPA 2015). The Mojave Basin and Range ecoregion is shown in yellow.

Var. *fasciculatum* is common in coastal scrub and chaparral from the south central California coast of at San Louis Obispo County to central Baja California (Montalvo et al. 2018). This variety can be found outside of its normal range due to restoration plantings that do not identify variety and appropriate planting ranges (Montalvo 2023, personal communication).

Var. *foliolosum* is common across California in mixed grassland, oak and conifer woodlands and chaparral vegetation communities. Its native distribution ranges from central California's coastal chaparral to northwestern Baja California (Montalvo et al. 2018). Var. *foliolosum* has been observed outside of its native range in northern California counties and southern Oregon (Jackson County). Roadside seeding has also led to introductions in Maricopa and Graham Counties in Arizona (Reveal 2023).

Var. *flavoviride* is widespread but less frequent than the other varieties of Eastern Mojave buckwheat. It primarily occurs in the Southern

California mountain and valley ranges of the Mojave and Sonoran deserts (Montalvo et al. 2018). Although it is a warm-desert shrub in the Mojave and Sonoran, it rarely occurs outside of California (SEINet 2022, Calflora 2023).

Habitat and Plant Associations.

Eastern Mojave buckwheat occurs in a range of habitats and elevations, including dry slopes, alluvial fans, washes and canyons in a range of vegetation communities including chaparral, coastal scrub, sagebrush scrub, valley grasslands, pinyon-juniper woodland and dryland deserts (Dyer and O'Beck 2005, Sawyer et al. 2009, Calflora 2023).

Var. *fasciculatum* is a co-dominant shrub in chaparral, sage scrub mix and coastal bluffs with elevation starting at sea level and going up to 1000 meters (3280 ft) (Reveal and Rosatti 2012b, Montalvo et al. 2018, SEINet 2022). It is a co-dominant species in coastal scrub communities with California sagebrush (*Artemesia californica*), chamise (*Adenostoma fasciculatum*), black sage (*Salvia mellifera*), purple sage (*Salvia leucophylla*), coyote brush (*Baccharis pilularis*), California brittlebush (*Encelia californica*) and deerweed (*Acmispon glaber*) (Montalvo et al. 2018, SEINet 2022).

Var. *foliolosum* is a co-dominant shrub found in sandy or gravelly flats, slopes and alluvial deposits along washes and rivers, and low-elevation chaparral communities (Montalvo et al. 2018, SEINet 2023). Common associated species in sage scrub are California sagebrush (*Artemisia californica*), white sage (*Salvia apiana*), black sage (*S. mellifera*), black elderberry (*Sambucas nigra*), California brittlebush (*Encelia californica*), brittlebush (*Encelia* farinose), and deerweed (*Acmispon glaber*).

Var. *polifolium* is scattered to co-dominant in dry-inland coastal scrub and the Mojave and Sonoran deserts. It grows in sandy to gravelly flats and slopes, rocky areas, as well as coarse alluvial deposits along washes and rivers (Montalvo et al. 2018, SEINet 2023). In deserts, it is a co-dominant shrub with bursage (*Ambrosia dumosa*), cheesebush (*Hymenoclea salsola*), blackbrush (*Coleogyne ramosissima*) and Tehachapi woollystar (*Eriastrum pluriflorum*) (Sawyer et al. 2009, Montalvo et al. 2018). It is also a co-dominant shrub in saltbush, blackbrush, and creosote scrub, pinyon-juniper and juniper woodlands, as well as in low-elevation chaparral plant communities including areas with chamise (*Adenostoma fasciculatum*) and yerba santa (*Eriodictyon* spp.) (Sawyer et al. 2009, Montalvo et al. 2018, Reveal 2023). In drier inland sage, this variety is associated with brittlebush (*Encelia farinosa*), black sage (*Salvia mellifera*), white sage (*Salvia apiana*), and coastal sagebrush (*Artemisia californica*) (Montalvo 2023, personal communication).

Var. *flavoviride* grows in saltbush and creosote scrub, as well as pinyon-juniper woodland on sandy to gravelly (sometimes rocky) flats and slopes in warm desert regions (Montalvo et al. 2018, SEINet 2022, 2023). Common associated species in saltbush and creosote scrub include creosote (*Larrea tridentata*), bursage (*Ambrosia dumosa*), catclaw acacia (*Senegalia greggii*) and desert almond (*Prunus fasciculata*) (SEINet 2022).

Figure 4: Eastern Mojave buckwheat growing in Mojave desert shrublands in California. Photo: Jean Pawek

Figure 5: Eastern Mojave buckwheat in a rocky Mojave desert habitat in Nevada. Photo: BLM SOS CA930A

Climate.

The Mojave Desert is characterized by low annual precipitation (2-10 inches or 5-25 cm in valley areas), with most rainfall occurring in the winter and a smaller amount during summer thunderstorms (Randall et al. 2010). Heterogenous climate patterns across the region are influenced by large-scale patterns and regional topography and are important drivers of local adaptation and intraspecific variation (Shryock et al. 2018, Baughman et al. 2019) and phenological events (Beatley 1974). Specifically, the reproductive phenology of many desert plant species is highly responsive to pulses in rainfall over short time scales (Bowers and Dimmitt 1994, Zachmann et al. 2021).

Climate information is derived from the climate-based provisional seed transfer zones (PSZs) where Eastern Mojave buckwheat occurs (Shryock et al. 2018; Table 1). Based on herbarium specimen locations (SEINET 2022), Eastern Mojave buckwheat occurs in all PSZs in the Mojave Desert ecoregion but is most frequently documented in Zones 20 and 21 and least documented in Zones 22 and 28 (Table 1). The average annual precipitation in the PSZs where Eastern Mojave buckwheat occurs in the Mojave Desert ecoregion is 17.8 cm (7.0 inches), with an average of 5.7 cm (2.2 inches) falling in the summer and an average of 12.1 cm (4.8 inches) falling in the winter. Note, herbarium specimen locations may not represent the full distribution and abundance of Eastern Mojave buckwheat due to sampling biases.

The four varieties described tend to occur in distinct climatic zones, although there is overlap as well as movement of varieties through restoration project plantings. Varieties *fasciculatum* and *foliolosum* are more dominant in Mediterranean climates with dry summers and wet winters where total annual precipitation ranges from 25.4-63.5 cm (10-25 inches), although precipitation can be higher in coastal areas (Montalvo et al. 2018). Var. *polifolium* also occurs in Mediterranean climates but generally in areas with lower rainfall, averaging 25.4-63.5 cm (10-15 inches) annually (Montalvo et al. 2018). In the desert regions where var. *polifolium* predominates, precipitation is less than 25.4 cm (10 inches) with some summer rain (Montalvo et al. 2018). Var. *flavoviride* generally occurs in warm desert areas that get less than 25.4 cm (10 inches) of rain with rare summer rains (Montalvo et al. 2018).

Table 1: Climate of the provisional seed zones (PSZ) where Eastern Mojave buckwheat occurs within the Mojave Desert ecoregion (Shryock et al. 2018), showing the number of herbarium records or verified observations that occur within the PSZ. Mean annual precipitation (MAP) is the mean of yearly rainfall. Summer precipitation (SP) is the mean precipitation that falls in the summer (May-October). Winter precipitation (WP) is the mean precipitation that falls in the winter (November-April). Monthly average temperature (MAT) is the average of the monthly temperatures. Range is the average of the monthly temperature ranges (monthly maximum minus monthly minimum).

Seed Zone	#	MAP (cm)	SP (cm)	WP (cm)	MAT (C)	Range (C)
20	150	25.5	10.5	14.9	15.3	34.5
21	137	15.6	6.2	9.4	18.8	38.4
29	128	25.5	4.2	21.4	13.8	31.7
25	123	16.5	6.2	10.3	18.9	34.6
26	98	14.5	2.7	11.8	16.8	34.9
23	83	15.8	5.4	10.4	16.1	35.9
24	29	10.7	2.8	7.9	18.8	38.6
27	12	9.6	3.3	6.3	20	36.7
22	8	36.1	13.3	22.8	10	32.4

Elevation.

Eastern Mojave buckwheat is typically found at elevations between zero to 7500 ft (2286 m) (Reveal and Rosatti 2012a, 2012c, 2012d, 2012e). Varieties *polifolium*, *foliolosum* and *flavoviride* can occur at higher elevations in pinyon-juniper or Joshua tree woodland, while var. *fasciculatum* generally occurs in lower elevations in coastal scrub (Montalvo et al. 2018, SEINet 2022).

Soils.

Eastern Mojave buckwheat prefers coarse, well drained soils derived from granitic or volcanic rock that are moderately acidic to slightly saline (Sawyer et al. 2009). It can also occur on substrates derived from low nutrient parent rock, such as serpentine (Dyer and O'Beck 2005). Seed has been collected in areas with gravel, sandy, loam, silt and clay soil textures (BLM SOS 2022).

No association with biological soil crusts were noted in literature.However, Montalvo (2023, personal communication) notes that there are abundant biological crusts in var. *foliolosum* habitats, especially in alluvial scrub and inland sage scrub communities.

ECOLOGY AND BIOLOGY

Eastern Mojave buckwheat is a generally long lived, polycarpic shrub, living from five to over 50 years (Sawyer et al. 2009). It is considered to be a drought tolerant species, but tolerance can vary between varieties (Montalvo et al. 2018). Drought response of eastern Mojave buckwheat can include reduced vegetation growth but continued production of inflorescences and fruits (Cole 1967). Leaves may also be lost facultatively in response to severe drought (DeSimone and Zedler 2001). In cases of extreme drought in the Colorado desert, Eastern Mojave buckwheat experienced die back of 99% (Miriti et al. 2007).

Reproduction.

Breeding System.

Eastern Mojave buckwheat appears to be highly outcrossing, as indicated by its flower morphology (flowers are open to pollen movement) and genetic analyses—populations exhibit low levels of population structure and

high genetic diversity, suggesting high rates of outcrossing (Montalvo et al. 2018).

Reproductive Phenology.

Eastern Mojave buckwheat typically flowers from April to September (Calflora 2023). Wildland seed collection data indicate seeds typically mature from May through October (BLM SOS 2022). Coastal populations of Eastern Mojave buckwheat can flower as early as February (var. *fasciculatum*) while inland valley populations typically start flowering in March (var. *polifolium*) (Cole 1967). Individual plants can display all phenology stages (Montalvo et al. 2018).

Pollination.

Eastern Mojave buckwheat is insect pollinated. Stamens and stigmas are exserted beyond the corolla making the flowers open to generalist pollinators including honey bees, small native bees, flies, wasps, and beetles (Montalvo 2004). All varieties of Eastern Mojave buckwheat provide food for several butterflies, such as the Bernardino dotted-blue (*Euphilotes bernardino*), lupine blue (*Plebeius lupini*), Mormon metalmark (*Apodemia mormo*), and Behr's metalmark (*A. virgulti*) (Reveal 2023). The nut-brown hairstreak (*Satyrium saepium*) is the most frequently observed butterfly visitor when plants are in full flower (Reveal 2023). Moths are also confirmed pollinators for Eastern Mojave buckwheat (Calflora 2023).

Eastern Mojave buckwheat is an important resource for honey production in California (Reveal 2023).

Seed and Seedling Ecology.

Eastern Mojave buckwheat relies on wind, animals, and water for seed dispersal. Seed typically disperses in the fall, although phenology varies across habitat and distribution (DeSimone and Zedler 1999). Harvester ants (*Pogonomyrmex* spp.) are frequently observed removing propagules, but are not confirmed as effective dispersers of Eastern Mojave buckwheat seed (DeSimone and Zedler 1999). The seed's dry, persistent calyx may lend it buoyancy and aid in dispersal via wind and water (Montalvo et al. 2018).

Cole (1967) studied the physiological ecology of *Eriogonum fasciculatum* growing in the Santa Monica Mountains, not identifying variety. He found that during germination, the radicle, or embryonic root of the plant, emerges first and the green cotyledons follow, expanding within three days (Cole 1967). Seeds are non-refractory, meaning they do not germinate following fire, and germination requires extended time with no fire events (Cole 1967).

Within coastal chaparral systems, seedlings are typically found in open areas between plants where they likely benefit from light-stimulated germination (Cole 1967, DeSimone and Zedler 1999). In chaparral systems, seedlings establish more frequently in thicker layers of litter and high soil organic matter (Keeley 1991).

No information specific to Mojave Desert environments and Eastern Mojave buckwheat seed and seedling ecology was found in the literature.

Species Interactions.

Belowground Interactions.

In California coastal ecosystems, Eastern Mojave buckwheat does not have high rates of root colonization by arbuscular mycorrhiza fungi (AMC), nor is it associated with common mycorrhizae networks (CMN) (Egerton-Warburton et al. 2007). However, coastal Eastern Mojave buckwheat can still benefit from CMN by acquiring water from adjacent mycorrhizal plant networks (Egerton-Warburton et al. 2007). No

information on belowground relationships for Eastern Mojave buckwheat specific to the Mojave Desert was found in the literature.

Insect Interactions.

Eastern Mojave buckwheat is associated with a high abundance and diversity of insects, including a range of butterfly and moth larvae that feed on various parts of the plant (Osborne 1998, as cited in Montalvo et al. 2018).

Species in the buckwheat genera are host plants to the Electra buckmoth (*Hemileuca electra*) (Collins 1974). This species of moth is colonial when young and feeds on the leaves of Eastern Mojave buckwheat (Will et al. 2020).

A species of thrips (*Leptothrips fasciculatus*) has been documented on the inflorescence of var. *polifolium* in the Mojave Desert (Wiesenborn 2012). The eggs of the thrips were mostly found within the involucres on the pedicels of open flowers, while adults were primarily found feeding on the flowers and documented eating the filaments (Wiesenborn 2012). The specialization of thrips on var. *polifolium* suggests the insect closely evolved with Eastern Mojave buckwheat (Wiesenborn 2012).

Wildlife and Livestock Use.

Eastern Mojave buckwheat is an important forage and cover plant for the endangered Mojave desert tortoise (*Gopherus agassizii*), as well as the Sonoran desert tortoise (*Gopherus morafkai)* (Shryrock et al. 2015, Esque et al. 2021). The plant provides high dietary mineral and nutrient values for the Mojave desert tortoise, with a notably high percent (15.26%) of total nonstructural carbohydrates (TNC) (McArthur et al. 1994). Eastern Mojave buckwheat grows as a dominant perennial shrub at the Desert Tortoise Research Natural Area in southern California which serves as a reference site for desert tortoise habitat because of the area's protection from human disturbance (Brooks 2000).

Eastern Mojave buckwheat is browsed by domestic livestock and big game (Sampson and Jesperson 1963). It provides good to fair forage for deer, fair for goats, fair to poor for cattle and sheep and poor for horses which browse sparingly on the leaves and new growth stems (Sampson and Jesperson 1963).

Eastern Mojave buckwheat provides canopy cover, nesting, and foraging habitat for the California gnatcatcher (*Polioptila californica*) in coastal sage scrub where the gnatcatcher is sensitive to fire-induced habitat fragmentation (van Mantgem et al. 2015).

Disturbance Ecology.

Eastern Mojave buckwheat is considered an early to late successional species, meaning it can be an early colonizer after disturbance, as well as a component of a mature community post disturbance (Abella et al. 2012). In chaparral communities, Eastern Mojave buckwheat seeds do not readily germinate after fire, but plants will resprout after a fire if the root crown is left in place (Keeley 1991, Montalvo et al. 2018). Studies examining burned sites in both chaparral and Sonoran Desert communities found a higher percent cover of Eastern Mojave buckwheat in unburned sites and reduced cover in burned sites over time (Franklin et al. 2004, Shryrock et al. 2015). Eastern Mojave buckwheat exhibited higher abundance in unburned sites in coastal scrub communities compared to burned sites where native annuals were dominant (Conlisk et al. 2016).

Eastern Mojave buckwheat can colonize disturbed sites dominated by exotic species at higher rates compared to other associated species (Stylinski and Allen 1999). Its

establishment in manmade and natural disturbance could be attributed to the lack of specialized germination requirements (Zedler et al. 1983). It was more successful in disturbance that caused soil compaction compared to disturbance that caused loose soils and topsoil excavation, such as tilling (Stylinski and Allen 1999). While still able to colonize disturbed sites, southern California chaparral communities have seen a decrease in Eastern Mojave buckwheat stands and associated vegetation communities, particularly on alluvial soils. The decrease in stands is linked to increased wildfire intervals and increased nitrogen deposition (Minnich and Dezzani 1998). These conditions can favor exotic annual grasses, such as red brome (*Bromus madritensis* ssp. *rubens*) and ripgut brome (*Bromus diandrus*), which may be related to the decline of Eastern Mojave buckwheat in chaparral (Minnich and Dezzani 1998).

Ethnobotany.

Eastern Mojave buckwheat has been used medicinally for a variety of ailments by several groups of people (Reveal 2023). The Cahuilla people made leaf tea for headache and stomach pain and soaked the flowers in water to use it as eye medicine and gastrointestinal aid (Barrows 1967, Dyer and O'Beck 2005). Ohlone people made a decoction to treat urinary problems (Bocek 1984). The Zuni made a powder derived from the roots of the shrub to treat wounds (Reveal and Rosatti 2012b). Navajo (Diné) people used a decoction derived from var. *polifolium* as anti-witchcraft medicine (Reveal 2023). Studies have also identified leucoanthocyanidins beneficial to the heart in buckwheat species (Dyer and O'Beck 2005).

Horticulture.

Eastern Mojave buckwheat is a recommended xeriscape landscaping and horticultural plant because of its showy flowers, drought tolerance and high pollinator attraction (Montalvo 2004, Meyer 2008, Montalvo et al. 2018). Plants require full sun and well drained soils (Montalvo et al. 2018). The distinctive grey-green color of the foliage of var. *polifolium* provides contrasting color in arid landscaping (Everett 2012, Montalvo et al. 2018). Var. *foliolosum* is one of the hardier and more abundant of the wild buckwheats (Everett 2012).

Low growing forms of Eastern Mojave buckwheat have been brought into cultivation from cuttings and seeds including the cultivar *E. fasciculatum* 'Theodore Payne' (Everett 2012). It is used in landscaping as a ground cover (Everett 2012).

DEVELOPING A SEED SUPPLY

A robust and stable supply of genetically appropriate seed is needed to meet restoration demands in response to expanding environmental stressors from land degradation, invasive species, and climate change. Restoration success is, in part, predicated on applying the right seed in the right place, at the right time (PCA 2015). Developing a restoration seed supply involves coordination across many partners in all steps of the process: from conducting wildland collections to propagating materials in nurseries and agricultural fields to eventual seeding or outplanting at restoration sites. Appropriate protocols for preserving genetic diversity and adaptive capacity should be in place (Erickson and Halford 2020) and seed origin should be documented for certification purposes and other seed planning considerations.

Seed Sourcing.

Seed sourcing can influence restoration outcomes due to local adaptation (Custer et al. 2022), landscape genetic patterns (Massatti et al.

2020, Shryock et al. 2021) and differing ability to adapt to current and future climate conditions (Bucharova et al. 2019). However, there has been relatively little research evaluating seed sourcing strategies in actual restoration settings where many additional factors influence performance (Pizza et al. 2023). While non-local sources can perform well in meeting initial restoration goals such as establishment and productivity (Pizza et al. 2023), evidence of local adaptation and its influence on restoration outcomes can take decades to emerge for long-lived species (Germino et al. 2019). Further, plants have coevolved with interacting organisms, such as pollinators and herbivores, that can exhibit preferential behavior for local materials (Bucharova et al. 2016, 2022).

Empirical seed transfer zones have not yet been developed for Eastern Mojave buckwheat. The Desert Southwest Provisional Seed Zones (PSZs) may be used to plan seed sourcing in absence of species-specific information. The Desert Southwest PSZs use twelve climatic variables that drive local adaptation to define areas within which plant materials may be transferred with higher probability of successful establishment and reduced risk of introducing maladapted ecotypes (Shryock et al. 2018). Overlaying PSZs with Omernick Level III ecoregions can serve to further narrow seed transfer by identifying areas of both climate similarity inherent in the PSZs and ecological similarity captured by the ecoregion, namely vegetation and soils. Within the PSZs and ecoregion areas, further site-specific considerations such as soil, land use, species habitat and microclimate affinities, and extant plant community may be relevant to seed sourcing decisions.

Taxonomic identity and adhering to the natural distribution of the four varieties is also important to consider when sourcing Eastern Mojave buckwheat seed.

The USGS Climate Distance Mapper Tool incorporates the Southwest Deserts Seed Transfer Zones with climate models and can serve to guide seed sourcing according to current and projected climate conditions.

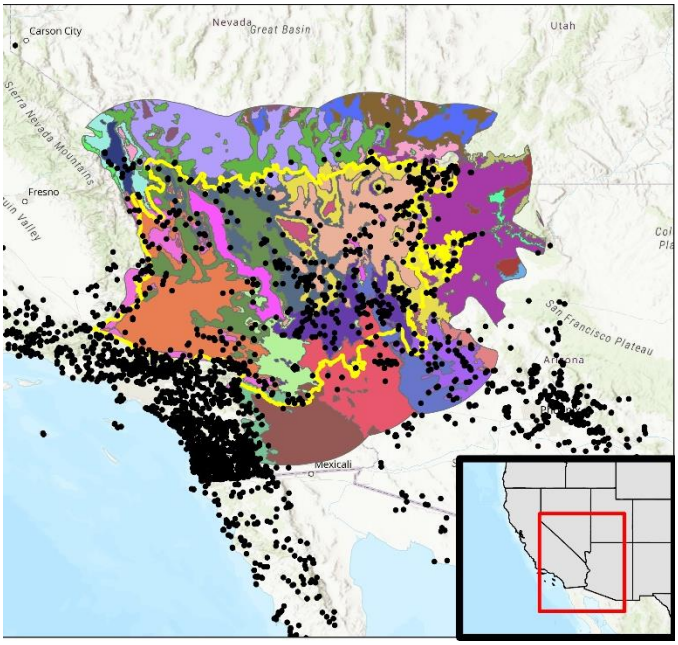

Figure 6: The distribution of documented Eastern Mojave buckwheat (black dots) across the Desert Southwest Provisional Seed Zones (Shryock et al. 2018). Occurrences are based on georeferenced herbarium specimens and verified observations (SEINet 2022). The Mojave Basin and Range Level III ecoregion (yellow outline) is buffered up to 100km in all directions. PSZs do not always extend a full 100km beyond the Mojave ecoregion.

Commercial Seed Availability and Germplasm Releases.

Eastern Mojave buckwheat is sometimes available for purchase from large-scale commercial seed vendors. However, availability may be inconsistent, and sources may be limited to a narrow range of appropriate seed zones. Commercial seed is often sourced from coastal populations, leaving desert-sourced seed from wild collections unavailable. Commercially available seed may not be source identified, and source seed zone information may not be

available. Commercial seed is usually identified only to the species level, and not to variety.

There has been one Natural Resources Conservation Service (NRCS) conservation plant release of Eastern Mojave buckwheat—the cultivar, 'Duro', was sourced from a blend of six accessions from Mediterranean climates in California (USDA NRCS 2012). Foundation seed is maintained by the USDA-NRCS Plant Material center in Lockeford, California (USDA NRCS 2023). Plants and seed for the variety 'Duro' are available from specialized growers and nurseries in California (USDA NRCS 2023).

Wildland Seed Collection.

Wildland seed collection involves visiting naturally occurring populations of target species to provide source seed for propagation, restoration, and research. Ethical practices are intended to prevent overharvesting by limiting harvests to no more than 20% of available seed (BLM 2021). However, in arid regions and in drought conditions, it may be best to adapt this guidance to collect no more than 10% of available seed due to limited regeneration and low-density populations (Asbell 2022, personal communication). Several practices are in place to ensure proper genetic diversity is captured from the source population. These include collecting from the entire population uniformly, sampling a diversity of phenotypes and microclimates, and collecting in various time windows to capture phenological and temporal diversity (BLM 2021).

Seed Collection Timing.

Eastern Mojave buckwheat is typically collected between April and October, with the majority of collections occurring in June in the Mojave Desert (BLM SOS 2022).

Collection Methods.

Eastern Mojave buckwheat seed can be collected by hand by stripping seeds off heads when seeds are dry on the plant and mature for harvest (USDA NRCS 2023; Johnson 2023, personal communication).

Prior to collection, it is important to check seed fill because Eastern Mojave buckwheat flowers are noted to have low seed production (Wall and MacDonald 2009). Due to the species' frequent use in revegetation seeding, populations along roads and other disturbed sites (i.e. powerlines, pipelines, etc.) should be avoided to prevent collection of seed from introduced sources (Montalvo et al. 2018).

Post-Collection Management.

Immediately following collection, seeds should be properly managed to avoid damage or declines in viability during transport and temporary storage. Seed should be dried and ventilated to prevent molding (Pedrini and Dixon 2020). Ventilation can be achieved by collecting and storing seed in breathable containers, such as paper or cloth bags. To dry material before storage or processing, spread it in a single layer on trays or newspaper indoors in a well-ventilated room, or outdoors in a shaded area (BLM 2021). Collected material should be visually inspected for seed-predating insects (Pedrini and Dixon 2020). If seed predation is observed, consider fumigation with No-Pest Strips. After collection, prevent exposure to excessively hot or cold temperatures during transportation and temporary storage by keeping seed in a dry, insulated container (e.g., a cooler) in a shaded area while in the field (BLM 2021).

Seed Cleaning.

Seed can be cleaned by rubbing over medium screen to break up heads and remove large chaff, then shaking periodically when moving through #14 and #25 sleeves (Wall and MacDonald 2009). Removing the outer husk can be accomplished with either a seed blower at 1.5 speed or by gently rubbing fruits over a #25 sieve (Wall and MacDonald 2009). A seed blower can also be used at a higher speed to remove poor quality, empty or aborted seeds (Wall and MacDonald 2009). Note, speeds will vary with blower type. To remove remaining large chaff and vegetation, sift seeds through #12 sieve (Wall and MacDonald 2009).

Figure 7: Collected material with seeds and chaff. Photo: BLM SOS CA930C

Figure 8: Cleaned seed without chaff. Photo: BLM SOS CA930D

Seed Storage.

Eastern Mojave buckwheat seed is orthodox (SER SID 2023). There was no loss in seed viability after nine years in hermetic storage (-15 C) (SER SID 2023).

In general, seeds should be stored in cool and dry conditions, out of direct sunlight, to maintain viability. Optimal conditions for medium-term storage of orthodox seeds (up to 5 years) are 15% relative humidity and 15° C (59° F). For long-term storage (>5 years), completely dried seeds should be stored at -18° C (0° F) (De Vitis et al. 2020, Pedrini and Dixon 2020).

Seed Testing.

After collection, a representative sample of each seed lot must be tested in an appropriate seed lab to ensure purity and germination meet minimum standards defined by AOSA (2016) and species standards from state-level certification programs as available. A set of "principles and standards for native seeds in ecological restoration" (Pedrini and Dixon 2020) outlines further guidelines specific to native plants, including procedures for obtaining representative samples of seed lots and incorporation of dormancy measures into seed testing and labels.

Wildland Seed Yield and Quality.

After processing at a professional facility, wild-collected Eastern Mojave buckwheat seed is generally high quality, with an average of 86% fill, 93% purity and 92% viability indicated by tetrazolium tests across 18 Seeds of Success collections (BLM SOS 2022, Table 2). Wild collections contain an average of over 347,000 pure live seeds (PLS) per pound (BLM SOS 2022, Table 2).

Table 2: Eastern Mojave buckwheat seed yield and quality from Mojave Basin and Range collections, cleaned by the Bend Seed Extractory and tested by the Oregon State Seed Lab or the USFS National Seed Lab (BLM SOS 2022). Fill (%) was measured using a 100 seed X-ray test. Viability (%) was measured using a tetrazolium chloride test.

Seed lot characteristics	Mean	Range	Samples (no.)
Bulk weight (lbs)	5.1	0.4-14.86	18
Clean Weight (lbs)	0.27	0.0076-1.77	18
Purity (%)	93	83-99	18
Fill (%)	87	41-96	18
Viability (%)	92	85-98	18
Pure live seeds/lb	347,782	211,305-515,701	20

Wildland Seed Certification.

The Association of Official Seed Certifying Agencies (AOSCA) sets the standards for seed certification and provides guidance on production, identification, distribution, and promotion of all certified seed, including pre-varietal germplasm. Pre-varietal germplasm (PVG) refers to seed or other propagation materials that have not been released as varieties (AOSCA 2022). Pre-varietal germplasm certification programs for source-identified materials exist in several states encompassing the Mojave Desert ecoregion including California (CCIA 2022), Utah (UTCIA 2015), and Nevada (NDA 2021). Arizona does not have a PVG certification process at this time. Source Identified (SI) germplasm refers to seed collected directly from naturally occurring stands (G0), or seed grown from wildland-collected seed in agricultural seed increase fields (G1-Gx) that have not undergone any selective breeding or trait testing. These programs facilitate certification and documentation required for wildland-collected seed to be legally eligible for direct sale or seed increase in an agricultural setting. Certified SI seed will receive a yellow tag, also referred to as an SI-label, noting key information about the lot including the species, the generation of seed (G0-Gx), source location, elevation, seed zone, etc. (UTCIA 2015, NDA 2021, CCIA 2022).

Wildland seed collectors should be aware of documentation required for seed certification. The Seeds of Success data form and protocol (BLM 2021) include all appropriate information and procedures for site documentation and species identification verification to meet certification requirements for wildland sourced seed. Seed certifying agencies may also conduct site inspections of collection locations prior to certification—specific requirements for inspections vary by state and are at the discretion of the certifying agency.

AGRICULTURAL SEED PRODUCTION

Agricultural Seed Field Certification.

As with wildland source seed (see Wildland Seed Certification section), seed grown in an agricultural seed increase field must also be certified by an official seed certifying agency, where programs exist. Field grown seed is also certified and labeled as Source-Identified (SI), as long as it has not undergone selective breeding or testing. Seed field certification includes field inspection, seed testing for purity and germination (see Seed Testing section), and proof of certification for all source or parent seed used to start the field (AOSCA 2022). The SI-label or "yellow tag" for seed from a seed increase field denotes information about source seed, field location, and generation level (G1-Gx) indicating if there is a species-specific limitation of generations allowed to be grown from the original source (e.g., in a species with a three-generation limit, G1/G3, G2/G3, G3/3) (AOSCA 2022). Fields must be free of any prohibited noxious weeds. Restricted noxious weeds and common weeds difficult to separate must be

controlled. Fields may be refused certification due to unsatisfactory appearance caused by weeds, poor growth, poor stand, disease, insect damage, and any other condition which prevents accurate inspection or creates doubt as to identity of the variety.

Table 3 outlines the pre-variety germplasm certification standards for Eastern Mojave buckwheat seed in the state of California with a minimum of 5 ounce sample size to be submitted for testing (CCIA 2022). The Nevada and Arizona Departments of Agriculture do not specify standards for PVG crops. The Utah Crop Improvement Association does not specify standards for PVG crops, but may apply standards of similar species or crop groupings (UCIA 2023).

Table 3: Pre-varietal germplasm (PVG) standards for seed analysis results of Eastern Mojave buckwheat seed increase crops in California.

Factor	G1	G2	G3 to G10
Pure Seed (minimum)	85%	85%	85%
Inert Matter (maximum)	15%	15%	15%
Total Other Crop Seed (maximum)	0.10%	0.25%	0.50%
Weed Seed (maximum)	0.15%	0.30%	0.50%
Noxious Weed	None	None	None
Germination and Hard Seed (minimum)	70%	70%	70%

Isolation Distances.

Sufficient isolation distances are required to prevent cross-pollination across seed production crops of Eastern Mojave buckwheat from different sources or other *Eriogonum* species. Table 4 summarizes the isolation distances required for PVG certification in both Utah and California. California standards are described specifically for Eastern Mojave buckwheat (CCIA 2022), while the Utah standards are general for outcrossing perennial species (UCIA 2023). Nevada and Arizona do not specify these standards for Source Identified PVG seed.

Table 4: Crop years and isolation distance requirements for pre-varietal germplasm crops of Eastern Mojave buckwheat. CY=crop years, or the time that must elapse between removal of a species and replanting a different germplasm entity of the same species on the same land.I= isolation distance, or the required distance (in feet) between any potential contaminating sources of pollen.

	G1		G2		G3+	
State	CY	I	CY	I	CY	I
Utah	3	900-600	2	450-300	1	330-165
California	5	60	5	30	2	15

Site Preparation.

Fields should be as weed-free as possible prior to planting. Site preparation to reduce undesirable vegetation should be planned and implemented well in advance of field establishment (USDA NRCS 2004). If fields are uncultivated or fallow and have perennial or annual weeds, one or more years of intensive cultivation (e.g., cover cropping) and herbicide treatment may be necessary (USDA NRCS 2004). After managing undesirable species, final seedbed preparation can include shallow tilling followed by packing to promote a finely granulated, yet firm seedbed that allows soil to seed contact, as well as facilitation of capillary movement of soil moisture to support seedling development (USDA NRCS 2004).

Seed Pre-treatments.

Eastern Mojave buckwheat germination of coastal varieties improves under light treatment (Cole 1967), with light exposure resulting in close to twice the germination rate of dark controls (Keeley 1991). Seeds germinate equally well on

soil and filter paper (Keeley 1991, Montalvo et al. 2018). Without pre-treatment, Eastern Mojave buckwheat had 4-34% germination rate, though no information on variety, seed age or source was provided for these results (Meyer 2008b). A study using highly cleaned, filled seeds from 13 different populations found an average of 70% germination (range 37-94%) for untreated Eastern Mojave buckwheat seeds of vars. *foliolosum* and *fasciculatum* (Montalvo et al. 2018).

Growers in the Mojave Desert using local, wildland sources report variable success with germinating Eastern Mojave buckwheat seeds. Some experience low germination rates necessitating higher seeding rates to produce plants (Sturwold et al. 2022, personal communication; Graham 2023, personal communication).

At the Song Dog Nursery at Lake Mead National Recreation Area (NRA), growers had decent germination success with both untreated seed and after soaking the seed in a low concentration of gibberellic acid. However, germination rates were not quantified to compare methods (Wallace 2024, personal communication).

Germination trials at the California Botanic Garden resulted in 89% germination with no treatment for seed stored for about eight months after collection (CalBG 2023).

A trial with Mojave Desert seed sources found that soaking seed in water for 24 hours resulted in faster germination, but did not increase germination rates (Corona 2023, personal communication).

Seeding Techniques.

Seeding rates for Eastern Mojave buckwheat are 9 lbs/acre for drill seeding and 14 lbs/acre for broadcast (Dyer and O'Beck 2005). Seeding or outplanting is best done in the fall (Thomas et al. 2022, personal communication; Asbell 2023, personal communication).

Eastern Mojave buckwheat seed increase crops can also be established from container stock (plugs), outplanted into a production field (Schaff 2023, personal communication) The 'Duro' cultivar has been established in fields from plugs with a spacing of 10 feet between rows and four feet within the row (USDA NRCS 2012). In general, plug planting may be preferrable if there is a limited amount of seed available, if seed has low viability, or if the seed lot has weed seed contaminants that can be more easily weeded out in a nursery (Winters 2023, personal communication).

Establishment and Growth.

Seedlings can be susceptible to 'damping off,' caused by several different fungi organisms and sensitivity to the cold (USDA NRCS 2012).

Weed Control.

There is little information available on weed control specific to Eastern Mojave buckwheat crops, however it is noted from experimental plots that seedlings do not compete well with non-native grasses (Montalvo 2004).

Generally, weeds can be manually removed or carefully spot-sprayed with a non-selective herbicide as they emerge. There are limited number of herbicides registered and labeled for use on native plant crops. See the Native Seed Production guide from the Tucson Plant Materials Center (USDA NRCS 2004) for further details on weed management in native seed production fields. In smaller fields, hand rogueing weeds can be sufficient (Hagman 2023, personal communication).

Pest Management.

No specific information on Eastern Mojave buckwheat's pest susceptibility or management was described in literature or through personal communication.

Pollination Management.

Growing native plants in or near their native range increases the likelihood that compatible pollinators will be able to find and pollinate the crop (Cane 2008). In general, growers can consider implementing pollinator management and stewardship practices to augment and attract existing pollinator communities. Specific practices will depend on the plant species' pollination needs, and the biology of the pollinators. For example, if a plant relies on native solitary bees, growers can create nesting opportunities adjacent to or within the field perimeter with downed woody material or crafted bee boxes (Cane 2008, MacIvor 2017). In some cases, there may be a need to supplement with managed pollinators through honeybee or bumblebee rental services to ensure pollination of wildflower crops for seed increase (Cane 2008).

Because Eastern Mojave buckwheat blooms for long periods it can be used as an insectary plant, providing nectar sources and support for beneficial insects when planted next to other crops (Dyer and O'Beck 2005). Before planting next to a crop, check with local IPM Integrated Pest Management specialists to ensure compatibility with target beneficial insect populations (Dyer and O'Beck 2005).

Irrigation.

At a coastal site, the Irvine Ranch Conservancy, seedlings of variety *fasciculatum* were planted into raised beds with drip irrigation for eight hours a day in the first year following planting (Montalvo et al. 2018). About 25-40% of those plants produced seed in year one, and 100% produced seed in year two (Montalvo et al. 2018). Desert varieties may respond best with different irrigation regimes.

Seed Harvesting.

Seeds are ready to harvest by hand when the inflorescence heads have turned a rusty brown (Montalvo et al. 2018). Heads can be placed into open cloth bags or tubs while harvesting. Seeds will remain on the plant for several weeks until strong winds or other disturbances break up the heads (Montalvo et al. 2018).

Figure 9: Eastern Mojave buckwheat when the inflorescence heads have turned a rusty brown and are ready for collection. Photo: BLM SOS CA690

Seed Yields and Stand Life.

The cultivar 'Duro' yields around 145kg/ha (300 lbs/acre) (USDA NRCS 2012).

Plants grown at the Irvine Ranch Conservancy in raised beds yielded 59 lbs pure live seed/acre after four years of growth (Montalvo 2018).

No information on yields for Source Identified crops from Mojave Desert sources was found in the literature or through personal communication.

NURSERY PRACTICE

Eastern Mojave buckwheat can be propagated from seeds or rooted from cuttings. Cuttings will yield limited genetic diversity, which is less desirable for restoration or seed increase (Montalvo et al. 2018).

Seeding directly into 3.8-to-4-liter plastic containers was found to be more successful than rose pots or paper pots when transplanting Eastern Mojave buckwheat and other desert perennials (Bean et al. 2004, Dyer and O'Beck 2005, Abella et al. 2012).

Under uniform conditions in a 70 ° F (21.1 °C) greenhouse with a relative humidity of 85-95%, coastal Eastern Mojave buckwheat took six months to produce inflorescences (Cole 1967). In this experiment, plants were grown in 3 x 6" plastic pots with sterilized greenhouse soil composed of 70% loam and 30% peat (Cole 1967).

Growers in the Mojave Desert report difficulty getting seeds to germinate (Graham 2022, personal communication; Sturwold et al. 2022, personal communication), but that plants are hardy and require little maintenance once established (Graham 2022, personal communication). The germination rate of seeds at the Joshua Tree National Park Native Plant Nursery (JTNP) was 16% (Graham 2022, personal communication). Seeds were soaked overnight before sowing in a mix of 5 parts perlite, 2 parts coarse vermiculite and a small amount of soil mix. The plants were germinated in a greenhouse under mist for 2-4 weeks before being moved to another greenhouse without mist where they were watered twice a week. Plants grown at JTNP are typically ready for restoration site outplanting after 12 to 32 months. (Graham 2022, personal communication).

At Song Dog Nursery at Lake Mead NRA, Eastern Mojave buckwheat is being grown in 8" conetainers to allow the roots to establish before transplanting into larger, 1-gallon pots (Wallace 2024, personal communication).

REVEGETATION AND RESTORATION

Eastern Mojave buckwheat provides environmental enhancement in restoration sites because of its showy flowers that attract pollinators for most of the season (Dyer and O'Beck 2005). It can be used as a conservation plant on eroded areas on sandy to clay loam, moderately to well drained soils (Dyer and O'Beck 2005). Eastern Mojave buckwheat is noted to establish better on sandy loam and loam soils in restoration study sites in the Mojave (Abella and Newton 2009). Eastern Mojave buckwheat has also performed well in difficult, low nutrient soils, such as serpentine, decomposed granite, and high pH soils (Dyer and O'Beck 2005). In chaparral and sage scrub systems, it is beneficial to use spot treatments with a selective grass herbicide or hand weeding to remove exotic grass (Cione et al. 2002).

While the species has had success in restoration sites, late-successional species, such as Eastern Mojave buckwheat, have been estimated to take decades to centuries to naturally recover to former abundance after disturbances in arid ecosystems (Vasek 1979, Webb et al. 1988).

Wildland Seeding and Planting.

Wildland Seedings.

Mojave Desert:

Eastern Mojave buckwheat was seeded in experimental plots in the Mojave Desert (Abella et al. 2012). Seeds were collected locally and hand-broadcasted at a rate of 234 pure live seed per meter squared. No seedlings were observed throughout the duration of the three-year study (Abella et al. 2012). See Wildland Plantings for a comparison of how containerized plantings performed at the same site.

Eastern Mojave buckwheat was seeded to mitigate fugitive dust associated with abandoned farmland in the Mojave Desert (Slayback et al. 1992). The variety used for the seeding were not specified and seeds were sourced from seed companies who collected from "similar growth regions", though whether they were from Mojave Desert populations is not specified. Seed was applied aerially with a helicopter and suspended bucket seeder at a rate of 4.9 lbs/acre. Eastern Mojave buckwheat had the best establishment across all native species seeded, with about 5.3 plants per square meter growing to an average of 14 cm tall one year after the seeding took place. Although Eastern Mojave buckwheat had high establishment, rodents severely grazed the Eastern Mojave buckwheat plants (Slayback et al. 1992). No recommendations for rodent deterrence following seeding at restoration sites was described.

In a study of establishment techniques for highway roadside revegetation in the Mojave Desert, Eastern Mojave buckwheat was trialed to compare establishment in directly seeded versus container planted plots (Clary and Slayback 1984). Seed was collected by project personnel, though it is not specified if the collected sources were from the Mojave Desert. The direct seeding methods involved first roughening the soil surface with a modified harrow before broadcasting the seed and then applying a straw (4,000 lb/acre) and a slurry of wood fiber and paper product (2,000 lb/acre). Eastern Mojave buckwheat was one of the most successful species at two of the five sites in the study with about three plants per 10 x 20-foot plot present in the fifth year of monitoring (Clary and Slayback 1984).

Coastal:

There is additional information on seeding Eastern Mojave buckwheat with coastal varieties in coastal ecosystems. This information is provided here as well, but the methods and responses are likely to differ from effective methods in desert ecosystems, and with desert sourced seed.

Following fire disturbance, it is recommended that 1-2 pounds of seed per acre be used in a seed mixture (Dyer and O'Beck 2005). In severely burned chaparral systems, weeding seeded areas can result in increased cover of Eastern Mojave buckwheat (Cione et al. 2002) If initial germination is less than 25%, the seeding rate can be doubled (Dyer and O'Beck 2005).

Germination rates for Eastern Mojave buckwheat increase with light exposure (Keeley 1991). Therefore, methods that place seeds close to the surface, such as broadcast or hydro seeding, will likely result in more successful establishment (Tamura et al. 2017). In a study comparing effectiveness of seeding techniques on sloped sites in a coastal scrub community, hand seeding and a jute netting cover (a woven, natural fiber cloth to reduce soil erosion) was shown to be a cost-effective technique to increase emergence of seeded Eastern Mojave buckwheat on steep slopes (Tamura et al. 2017). On moderate slopes, hydro seeding resulted in the highest

number of second year seedlings for Eastern Mojave buckwheat, but drill seeding was ranked as the most cost-effective method (based on number of seedlings per dollar spent) (Tamura et al. 2017). In this experiment, researchers used a seeding rate of 2.5 PLS lbs/acre of Eastern Mojave buckwheat seed (Tamura et al. 2017). Seed source was not mentioned.

In another study in coastal sage scrub, Eastern Mojave buckwheat was included in a seed mix with five other species and seeded at a rate of 12 pure live seeds per square meter (900 pure live seeds per square meter for the overall mix). The study investigated three different seeding methods (hydroseeding, drilling, imprinting) and three soil ripping treatments (no ripping, 20-cm deep rip, and 40-cm deep rip) (Montalvo et al. 2002). Eastern Mojave buckwheat exhibited 57% emergence across all treatments and persisted in the seeding area two years after the seeding, with about 7 plants per meter squared averaged across all treatments. It had the highest densities in imprinted and hydroseeded treatments, likely because these methods deposit seed close to the surface and this species requires light exposure for germination. After two years of growth, percent cover did not differ among ripping treatments (Montalvo et al. 2002).

Wildland Plantings.

An outplanting experiment in the Mojave found Eastern Mojave buckwheat to be among the most successful species planted, with a 23% to 28% survival rate (Abella et al. 2012). Eastern Mojave buckwheat individuals also showed rapid growth once established (Abella et al. 2012). To avoid container shaping and root growth restriction, it is recommended that container plants be transplanted immediately (within a few days) of arrival at a restoration site (Gunawan and Bowler 2019).

In the highway roadside revegetation study described above, containerized planting of Eastern Mojave buckwheat was used to test effective plant establishment techniques (Clary and Slayback 1984). Two container types were tested: 1-gallon cans and plastic plant bands (1.5 x 8 "). Two ounces of slow-release fertilizer were mixed with the backfill material and all plants were watered immediately. A portion of each pot-size treatment group was watered monthly with one gallon of water per plant from May to October. Rodent herbivory caused high mortality across all shrubs in the first year of establishment, so plastic mesh cages we placed around the plants in the second through fifth years. Eastern Mojave buckwheat had fair establishment with 33% average survival in irrigated plots and 50% average survival in nonirrigated plots by the five years after the original planting (Clary and Slayback 1984).

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LITERATURE CITED

Abella, S., and A. Newton. 2009. A systematic review of species performance and treatment effectiveness for revegetation in the Mojave Desert, USA. Arid Environments and Wind Erosion:45–74.

Abella, S. R., D. J. Craig, and A. A. Suazo. 2012. Outplanting but not seeding establishes native desert perennials. Native Plants Journal 13:81–90.

AOSA. 2016. AOSA Rules for Testing Seeds, Volume 1. Principles and Procedures. Association of Official Seed Analysts, Wichita, KS.

AOSCA. 2022. How AOSCA tracks wildland sourced seed and other plant propagating materials. Association of Official Seed Certifying Agencies, Moline, IL.

Asbell, M. 2022, November 17. Director of Plant Conservation Programs, Mojave Desert Land Trust. Phone call about *Encelia actoni* and *Encelia farinosa*.

Asbell, M. 2023, May 3. Conversation about growing practices for Mojave Desert Native Plant Species.

Barrows, D. P. 1967. BRIT - Native American Ethnobotany Database. http://naeb.brit.org/uses/13999/.

Baughman, O. W., A. C. Agneray, M. L. Forister, F. F. Kilkenny, E. K. Espeland, R. Fiegener, M. E. Horning, R. C. Johnson, T. N. Kaye, J. Ott, J. B. St. Clair, and E. A. Leger. 2019. Strong patterns of intraspecific variation and local adaptation in Great Basin plants revealed through a review of 75 years of experiments. Ecology and Evolution 9:6259–6275.

Bean, T., S. Smith, and M. Karpiscak. 2004. Intensive Revegetation in Arizona's Hot Desert: The Advantages of Container Stock. Native Plants Journal 5:173–180.

Beatley, J. C. 1974. Phenological Events and Their Environmental Triggers in Mojave Desert Ecosystems. Ecology 55:856–863.

BLM. 2021. Bureau of Land Management technical protocol for the collection, study, and conservation of seeds from native plant species for Seeds of Success. U.S. Department of the Interior, Bureau of Land Management.

BLM SOS. 2022. USDI Bureau of Land Management, Seeds of Success. Seeds of Success collection data.

Bocek, B. R. 1984, June. Ethnobotany of Costanoan Indians, California, based on collections by John P. Harrington. Springer on behalf of New Yor Botanical Garden Press.

Bowers, J. E., and M. A. Dimmitt. 1994. Flowering phenology of six woody plants in the northern Sonoran Desert. Bulletin of the Torrey Botanical Club 121:215–229.

Brooks, M. L. 2000. Does protection of Desert Tortoise habitat generate other ecological benefits in the Mojave desert? United States Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Bucharova, A., O. Bossdorf, N. Hölzel, J. Kollmann, R. Prasse, and W. Durka. 2019. Mix and match: regional admixture provenancing strikes a balance among different seed-sourcing strategies for ecological restoration. Conservation Genetics 20:7–17.

Bucharova, A., M. Frenzel, K. Mody, M. Parepa, W. Durka, and O. Bossdorf. 2016. Plant ecotype affects interacting organisms across multiple trophic levels. Basic and Applied Ecology 17:688–695.

Bucharova, A., C. Lampei, M. Conrady, E. May, J. Matheja, M. Meyer, and D. Ott. 2022. Plant provenance affects pollinator network: Implications for ecological restoration. Journal of Applied Ecology 59:373–383.

CalBG. 2023. Germination Data April 2023. California Botanic Garden, Claremont, California.

Calflora. 2023. Eriogonum fasciculatum Calflora. https://www.calflora.org/app/taxon?crn=3243.

Calscape. 2023. Eriogonum fasciculatum - Butterflies. https://calscape.org/plantleps.php?hostsloc=california&species=Eriogonum+fasciculatum.

Cane, J. H. 2008. 4. Pollinating Bees Crucial to Farming Wildflower Seed for U.S. Habitat Restoration. Pages 48–65 Bee Pollination in Agricultural Eco-systems. First edition. Oxford University Press, Oxford, England.

CCDB. 2023. Chromosome Counts Database. http://ccdb.tau.ac.il/Angiosperms/Malvaceae/Sphaeralcea/Sphaeralcea%20ambigua%20A.%20Gray/.

CCIA. 2022. Pre-Variety Germplasm Program. California Crop Improvement Association. University of California, Davis, CA. https://ccia.ucdavis.edu/quality-assurance-programs/pre-variety-germplasm.

Cione, N. K., P. E. Padgett, and E. B. Allen. 2002. Restoration of a Native Shrubland Impacted by Exotic Grasses, Frequent Fire, and Nitrogen Deposition in Southern California. Restoration Ecology 10:376–384.

Clary, R. F. Jr., and R. D. Slayback. 1984. Wetlands and roadside management: Plant materials and establishment techniques for revegetation of California desert highways. Pages 28–30. National Research Council (U.S.) Transprotation Research Board, Washington, D.C.

Cole, N. H. A. 1967. Comparative Physiological Ecology of the Genus Eriogonum in the Santa Monica Mountains, Southern California. Ecological Monographs 37:2–24.

Collins, M. M. 1974, August. The population dynamics of moths in the genus Hemileuca on Monitor Pass, California. California State University, Hayward.

Conlisk, E., R. Swab, A. Martínez-Berdeja, and M. P. Daugherty. 2016. Post-Fire Recovery in Coastal Sage Scrub: Seed Rain and Community Trajectory. PLOS ONE 11:e0162777.

Corona, S. 2023, December 19. IAE California Correctional Facility: Conversation about Growing Mojave Desert Native Plants (video call).

Custer, N. A., S. Schwinning, L. A. DeFalco, and T. C. Esque. 2022. Local climate adaptations in two ubiquitous Mojave Desert shrub species, Ambrosia dumosa and Larrea tridentata. Journal of Ecology 110:1072–1089.

De Vitis, M., F. R. Hay, J. B. Dickie, C. Trivedi, J. Choi, and R. Fiegener. 2020. Seed storage: maintaining seed viability and vigor for restoration use. Restoration Ecology 28:S249–S255.

DeSimone, S. A., and P. H. Zedler. 1999. Shrub Seedling Recruitment in Unburned

Californian Coastal Sage Scrub and Adjacent Grassland. Ecology 80:2018–2032.
DeSimone, S. A., and P. H. Zedler. 2001. Do Shrub Colonizers of Southern Californian Grassland Fit Generalities for Other Woody Colonizers? Ecological Applications 11:1101–1111.
Dyer, D., and R. O'Beck. 2005. NRCS Plant Guide California buckwheat Eriogonum fasciculatum Benth.
Egerton-Warburton, L. M., J. I. Querejeta, and M. F. Allen. 2007. Common mycorrhizal networks provide a potential pathway for the transfer of hydraulically lifted water between plants. Journal of Experimental Botany 58:1473–1483.
Erickson, V. J., and A. Halford. 2020. Seed planning, sourcing, and procurement. Restoration Ecology 28:S219–S227.
Esque, T. C., L. A. DeFalco, G. L. Tyree, K. K. Drake, K. E. Nussear, and J. S. Wilson. 2021. Priority Species Lists to Restore Desert Tortoise and Pollinator Habitats in Mojave Desert Shrublands. Natural Areas Journal 41.
Everett, P. C. 2012. A second summary of the horticulture and propogation of california native plants at the Rancho Santa Ana Botanic Garden, 1950-1970. Rancho Santa Ana Botanic Garden, Claremont, California.
Franklin, J., C. L. Coulter, and S. J. Rey. 2004, October. Change over 70 years in a Southern California chaparral community related to fire history. Wiley.
Germino, M. J., A. M. Moser, and A. R. Sands. 2019. Adaptive variation, including local adaptation, requires decades to become evident in common gardens. Ecological Applications 29:e01842.
Graham, J. 2022, December 14. Joshua Tree National Park Native Plant Nursery. Conversation about nursery growing, seed collection and restoration practices (video call).
Gunawan, C. M., and P. A. Bowler. 2019. Mycorrhizae and Root Morphology in Potted and Wild Artemisia californica and *Eriogonum fasiculatum*. Ecological Restoration 37:148–151.
Hagman, T. 2023, March 6. Granite Seeds: Conversation about seed production practices (video call).
Hellmers, H., J. S. Horton, G. Juhren, and J. O'Keefe. 1955, October. Root systems of tsome chaparral plants in southern California. Ecological Society of America.
ITIS. 2023. Integrated Taxonomic Information System. https://www.itis.gov/.
Johnson, A. 2023, March 8. Las Vegas State Tree Nursery. Conversation about nursery growing, seed collection and restoration practices (video call).
Keeley, J. E. 1991. Seed Germination and Life History Syndromes in the California Chaparral. Botanical Review 57:81–116.
Kramer, A. T., T. E. Wood, S. Frischie, and K. Havens. 2018. Considering ploidy when producing and using mixed-source native plant materials for restoration. Restoration Ecology 26:13–19.
MacIvor, J. S. 2017. Cavity-nest boxes for solitary bees: a century of design and research. Apidologie 48:311–327.
van Mantgem, E. F., J. E. Keeley, and M. Witter. 2015. Faunal Responses to Fire in Chaparral and Sage Scrub in California, USA. Fire Ecology 11:128–148.
Massatti, R., R. K. Shriver, D. E. Winkler, B. A. Richardson, and J. B. Bradford. 2020. Assessment of population genetics and climatic variability can refine climate-informed seed transfer guidelines. Restoration Ecology 28:485–493.
McArthur, E. D., S. C. Sanderson, and B. L. Webb. 1994. Nutritive Quality and Mineral Content of Potential Desert Tortoise Food Plants. Plants.
Meyer, S. E. 2008a. The Woody Plant Seed Manual. U.S. Department of Agriculture, Forest Service.
Meyer, S. E. 2008b. The woody plant seed manual. United States Department of Agriculture.
Minnich, R. A., and R. J. Dezzani. 1998. Historical Decline of Coastal Sage Scrub in the Riverside-Perris Plain, California. Western Birds 29.4:366–391.
Miriti, M. N., S. Rodríguez-Buriticá, S. J. Wright, and H. F. Howe. 2007. Episodic Death Across Species of Desert Shrubs. Ecology 88:32–36.
Montalvo, A. M. 2004. Eriogonum fasciculatum, Benth. California buckwheat. U.S. Department of Agriculture, Forest Service,

International Institute of Tropical Forestry and Rocky Mountain Research Station.
Montalvo, A. M., P. A. McMillan, and E. B. Allen. 2002. The Relative Importance of Seeding Method, Soil Ripping, and Soil Variables on Seeding Success. Restoration Ecology 10:52–67.
Montalvo, A. M., E. C. Riordan, and J. L. Beyers. 2018. Plant profile for Eriogonum fasciculatum, Update 2018. Riverside-Corona Resource Conservation District and U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Riverside, CA.
Montalvo, A. M. 2023, December 4. Document review comments for *Eriogonum fasciculatum*.
NDA. 2021. Certified Seed Program. Nevada Department of Agriculture. Sparks, NV. https://agri.nv.gov/Plant/Seed_Certification/Certified_Seeds/.
Omernik, J. M. 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers 77:118–125.
PCA. 2015. National seed strategy for rehabilitation and restoration, 2015-2020. Plant Conservation Alliance. U.S. Department of the Interior, Bureau of Land Management, Washington, D.C.
Pedrini, S., and K. W. Dixon. 2020. International principles and standards for native seeds in ecological restoration. Restoration Ecology 28:S286–S303.
Pizza, R. B., J. Foster, and L. A. Brudvig. 2023. Where should they come from? Where should they go? Several measures of seed source locality fail to predict plant establishment in early prairie restorations. Ecological Solutions and Evidence 4:e12223.
Randall, J. M., S. S. Parker, J. Moore, B. Cohen, L. Crane, B. Christian, D. Cameron, J. B. Mackenzie, K. Klausmeyer, and S. Morrison. 2010. Mojave Desert Ecoregional Assessment. The Nature Conservancy of California:210.
Reveal, J. L. 2020a, July 30. Eriogonum fasciculatum var. fasciculatum - FNA. https://beta.floranorthamerica.org/Eriogonum_fasciculatum_var._fasciculatum.
Reveal, J. L. 2020b, November 5. Eriogonum fasciculatum var. foliolosum - FNA. http://beta.floranorthamerica.org/Eriogonum_fasciculatum_var._foliolosum.
Reveal, J. L. 2020c, November 5. Eriogonum fasciculatum var. polifolium - FNA. http://beta.floranorthamerica.org/Eriogonum_fasciculatum_var._polifolium.
Reveal, J. L. 2020d, November 5. Eriogonum fasciculatum var. flavoviride - FNA. http://beta.floranorthamerica.org/Eriogonum_fasciculatum_var._flavoviride.
Reveal, J. L. 2023. Eriogonum fasciculatum - FNA. http://floranorthamerica.org/Eriogonum_fasciculatum.
Reveal, J. L., and T. J. Rosatti. 2012a. Eriogonum fasciculatum var. fasciculatum. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=58543.
Reveal, J. L., and T. J. Rosatti. 2012b. Eriogonum fasciculatum. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=24773.
Reveal, J. L., and T. J. Rosatti. 2012c. Eriogonum fasciculatum var. foliolosum. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=58545.
Reveal, J. L., and T. J. Rosatti. 2012d. Eriogonum fasciculatum var. polifolium. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=58546.
Reveal, J. L., and T. J. Rosatti. 2012e. Eriogonum fasciculatum var. flavoviride. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=58544.
Sampson, A. W., and B. S. Jesperson. 1963. California Range and Brushlands and Browse Plants. University of California, Division of Agricultural Sciences, California Agricultural Experiment Station, Extension Service.
Sawyer, J. O., T. Keeler-Wolf, and J. M. Evens. 2009. A manual of California vegetation. 2nd edition. California Native Plant Society, Sacramento, CA.
Schaff, V. 2023, February 6. Converation about native plant seed increase practices (video call).
SEINet. 2022. SEINet Portal Network. http//:swbiodiversity.org/seinet/index.php.

SEINet. 2023. SEINet Portal Network. http//:swbiodiversity.org/seinet/index.php.
SER SID. 2023. Seed Information Database. https://ser-sid.org/.
Shryock, D. F., L. A. DeFalco, and T. C. Esque. 2018. Spatial decision-support tools to guide restoration and seed-sourcing in the Desert Southwest. Ecosphere 9:e02453.
Shryock, D. F., L. K. Washburn, L. A. DeFalco, and T. C. Esque. 2021. Harnessing landscape genomics to identify future climate resilient genotypes in a desert annual. Molecular Ecology 30:698–717.
Shryrock, D. F., T. C. Esque, and F. C. Chen. 2015. A 30 year chronosequence of burned areas in Arizona-- Effects of wildfires on vegetation in Sonoran Desert Tortoise habitats. US Geological Survey Open-File Report.
Slayback, R. D., W. A. Bunter, and R. L. Dean. 1993. Restoring Mojave Desert Farmland with Native Shrubs. Page Proceedings, Wildland Shrub and Arid Land Restoration Symposium: Las Vegas, NV, October 19-21, 1993. Intermountain Research Station, Forest Service, U.S. Department of Agriculture, Las Vegas, NV.
Stebbins, G. L. Jr. 1942. Polyploidy Complexes in Relation to Ecology and the History of Floras. University of Chicago Press for the American Society of Naturalists:36–45.
Sturwold, P., M. Nash, M. Reeder, and J. Marfori. 2022, December 15. The Living Desert Zoo and Botanic Gardens. Converstation with garden team about nursery growing, seed collection and restoration practices. (video call).
Stylinski, C. D., and E. B. Allen. 1999. Lack of native species recovery following severe exotic disturbance in southern Californian shrublands. Journal of Applied Ecology 36:544–554.
Tamura, N., M. E. Lulow, C. A. Halsch, M. R. Major, K. R. Balazs, P. Austin, T. E. Huxman, and S. Kimball. 2017. Effectiveness of seed sowing techniques for sloped restoration sites. Restoration Ecology 25:942–952.
Thomas, L., L. Beaty, and S. Winters. 2022, December 6. Living Desert Zoo and Botanic Gardens. Conversation about nursery growing, seed collection and restoration practices (video call).
Tropicos. 2023. Missouri Botanical Garden. http://www.tropicos.org.
UCIA. 2023. REQUIREMENTS AND STANDARDS | Utah Crop Improvement Association.
US EPA, O. 2015, November 25. Ecoregions of North America. Data and Tools. https://www.epa.gov/eco-research/ecoregions-north-america.
USDA NRCS. 2004, September. Native Seed Production, Tucson Plant Materials Center. Tucson Plant Materials Center.
USDA NRCS. 2012, August. "Duro" California Buckwheat (Eriogonum fasciculatum). USDA-Natural Resources Conservation Service, California Plant Materials Center. Lockeford, CA 95237.
USDA NRCS. 2023. The PLANTS Database. Natural Resources Conservation Service, National Plant Data Team, Greensboro, NC USA. https://plants.usda.gov/home.
UTCIA. 2015. Certified wildland. Utah Crop Improvement Association, Logan, UT. https://www.utahcrop.org/certified-wildland/.
Vasek, F. C. 1979. Early successional stages in Mojave Desert scrub vegetation. Israel Journal of Botany 80; 28:133–148.
Wall, M., and J. MacDonald. 2009. Processing seeds of California native plants for conservation, storage, and restoration. Rancho Santa Ana Botanic Garden, Claremont, Calif.
Wallace, K. 2024, January 30. Song Dog Nursery, Lake Mead National Recreation Area. Conversation about Mojave Desert native plant growing practices (video call).
Webb, R. H., J. W. Steiger, and E. B. Newman. 1988. The response of vegetation to disturbance in Death Valley National Monument, California. Page Bulletin. U.S. G.P.O.,.
Went, F. W., and P. A. Munz. 1949. A long term test of seed longevity. Aliso 2:63–75.
Wiesenborn, W. D. 2012. Life Stages of the Anthophilous Thrips Leptothrips fasciculatus (Crawford) (Thysanoptera: Phlaeothripidae). Journal of the Kansas Entomological Society 85:332–339.

Will, K., J. Gross, D. Rubinoff, and J. A. Powell. 2020. Field Guide to California Insects: Second Edition. Univ of California Press.

Winters, D. 2023, February 27. L&H Seeds: Conversation about seed collection and production practices (video call).

Zachmann, L. J., J. F. Wiens, K. Franklin, S. D. Crausbay, V. A. Landau, and S. M. Munson. 2021. Dominant Sonoran Desert plant species have divergent phenological responses to climate change. Madroño 68.

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. Ecological Society of America 64:809–818.

RESOURCES

AOSCA NATIVE PLANT CONNECTION

https://www.aosca.org/wp-content/uploads/Documents/AOSCANativePlantConnectionBrochure_AddressUpdated_27Mar2017.pdf

BLM SEED COLLECTION MANUAL

https://www.blm.gov/sites/default/files/docs/2021-12/SOS%20Technical%20Protocol.pdf

OMERNIK LEVEL III ECOREGIONS

https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states

CLIMATE SMART RESTORATION TOOL

https://climaterestorationtool.org/csrt/

MOJAVE SEED TRANSFER ZONES

https://www.sciencebase.gov/catalog/item/5ea88c8482cefae35a1faf16

MOJAVE SEED MENUS

https://rconnect.usgs.gov/MojaveSeedMenu/

AUTHORS

Sophia Goss, Ecologist, Institute for Applied Ecology, Santa Fe, NM | sophiagoss@appliedeco.org

Ashlee Wolf, Ecologist, Institute for Applied Ecology, Tucson, AZ | ashleewolf@appliedeco.org

Sophia Goss; Ashlee Wolf. 2023. Eastern Mojave buckwheat (*Eriogonum fasciculatum*). In: Mojave Desert Native Plants: Biology, Ecology, Native Plant Materials Development, And Use in Restoration. Corvallis, OR: Institute for Applied Ecology. Online: https://www.blm.gov/programs/natural-resources/native-plant-communities/native-plant-and-seed-material-development/ecoregional-programs

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