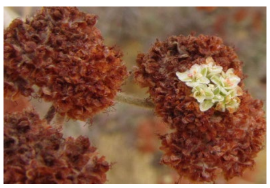
I. SPECIES — *Eriogonum fasciculatum* Benthum [Updated 2018]

NRCS CODE: ERFA2

Family: **Polygonaceae**
Subfamily: **Eriogonoideae**
Order: **Caryophyllales** (was Polygonales)
Class: **Magnoliopsida**

E. f. var. *polifolium*
top: flowers in June.
bottom: fruits maturing and a few late flowers in August.



E. f. var. *foliolosum* (bottom May 2005, top left June 2006) Riverside Co., A. Montalvo.

E. f. var. *polifolium* (bottom May 2010, top July 2015) Riverside Co., A. Montalvo.

A. Subspecific taxa

Four varieties are currently recognized in the USA (Reveal & Rosatti 2012, FNA 2018, Jepson eFlora 2018). (An additional variety, *E. f.* var. *emphereium* Reveal from central Baja California, Mexico (FNA 2018) will not be treated here.)

1. **ERFAF3**	1. *E. f.* var. *fasciculatum* Benth
2. **ERFAF2**	2. *E. f.* var. *foliolosum* (Nutt.) Abrams
3. **ERFAP**	3. *E. f.* var. *polifolium* Torr. & A. Gray
4. **ERFAF**	4. *E. f.* var. *flavoviride* Munz & I. M. Johnston

B. Synonyms
(numbered as above)

1. *E. f.* ssp. *fasciculatum, E. rosmarinifolium* Nutt., *E. fasciculatum* var. *maritimum* Parish, *E. fasciculatum* var. *oleifolium* Gand., *E. aspalathoides* Gand., *E. fasciculatum* ssp. *aspalathoides* S. Stokes, *E. f.* ssp. *typicum*
2. *E. rosmarinifolium* Nutt. var. *foliolosum* Nutt., *E. f.* Benth. ssp. *foliolosum* (Nutt.) S. Stokes, *E. f.* var. *obtusiflorum* S. Stokes.
3. *E. p.* Benth., *E. f.* Benth. ssp. *polifolium* (Benth.) S. Stokes , *E. f.* Benth. var. *revolutum* (Goodding) S. Stokes
4. *E. f.* ssp. *flavoviride* S. Stokes

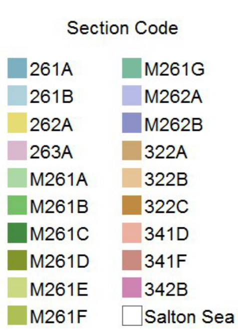
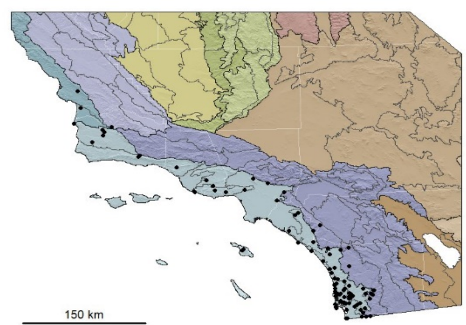
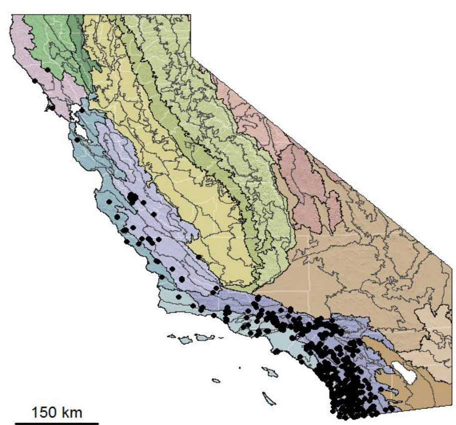
C. Common name

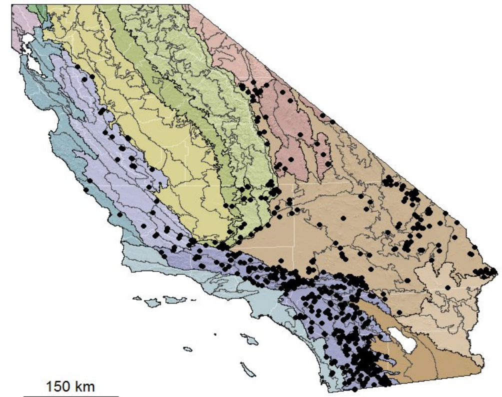
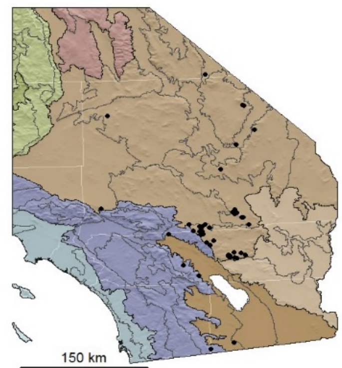
Generally, California buckwheat or flat-topped buckwheat. Many overlapping common names have been assigned to the different varieties over the years (Painter 2016a,b). Local annotated checklists sometimes note different common names for each variety. USDA PLANTS (2018) uses eastern Mojave buckwheat for all four varieties; this is not recommended.
1. Coastal California buckwheat, coast California buckwheat (Rebman & Simpson 2006, Reveal & Rosatti 2012),
2. Leafy California buckwheat (Reveal & Rosatti 2012), Coastal California buckwheat, inland California buckwheat, (Rebman & Simpson 2006), interior flat-topped buckwheat (Roberts 2008)
3. Mojave Desert California buckwheat (Reveal & Rosatti 2012), mountain buckwheat (Rebman & Simpson 2006), gray-leaved California buckwheat, and many others (Painter 2016a)
4. Sonoran Desert California buckwheat, bright green California buckwheat (Painter 2016b, Reveal & Rosatti 2012)

D. Taxonomic relationships	*Eriogonum* is a large genus of about 250 species in a family of about 48 genera (FNA 2018). It is one of the largest genera in California. Kempton (2012) constructed a phylogeny of *Eriogonum* and related genera in the Eriogonoideae based on multiple genes and found evidence for paraphyly in *Eriogonum,* the closely allied *Chorizanthe,* and most of their subgenera. *E. f.* var. *polifolium* (the only variety studied) was found to be most closely related to *E. cinereum, E. molle,* and *E arborescens.*
E. Related taxa in region	The four varieties of *E. fasciculatum* overlap in distribution with many species of *Eriogonum.* However, many of them are annual or perennial herbs with basal rosettes of leaves, or if shrubby they lack the tightly clustered, "fascicled", narrow leaves typical of *E. fasciculatum.* The coastal varieties of *E. f.* overlap in distribution with the subshrub *E. parvifolium* Smith along the immediate coast from Monterey Co. south into Baja California (Jepson eFlora 2018); plants are easily separated by leaf structure and arrangement. *E. parvifolium* has larger, generally broader leaves (0.3–0.8 (1.2) cm wide) that are linear to round, and the leaves do not cluster or look fascicled as they do in *E. f.* (Jepson eFlora 2018). *E. f.* may also overlap with the uncommon subshrub *E. cinereum* Benth. along the immediate coast or where *E. c.* has naturalized after planting. Its larger and broad leaves are whitish with tomentose hairs on both leaf surfaces and are not in clusters.
F. Taxonomic issues	The taxonomy of this species has been relatively stable since the publication of the supplement in Munz & Keck (1968). The varieties can be difficult to tell apart in some areas of overlap and if there is hybridization of the n = 20 varieties *fasciculatum* and *polifolium.* Plantings outside the native range of the varieties in the past few decades have made it more difficult to separate them based on distribution. Odd overlaps in varieties occur along powerline corridors, roadsides, and utility projects where plants have been placed without specifying the local native variety.
G. Other	California buckwheat is a widespread and morphologically variable shrub of high importance within sagebrush scrub, desert scrub, coastal sage scrub, alluvial scrub, and lower elevation chaparral (Kirkpatrick & Hutchinson 1977, Westman 1981, Sawyer et al. 2008). It is an important bee plant for honey production and a food source for numerous insects and mammal species. It also provides cover and microsites for many others. In Riverside Co., this shrub has decreased dramatically since the 1940s, with the largest decreases on alluvial soils (Minnich & Dezzani 1998). Decreases are attributed to a combination of development, competition with exotic annual grasses and forbs, too frequent a fire interval exacerbated by weeds that carry fire, and atmospheric deposition of nitrogen, which encourages growth of competing weeds (Montalvo 2004, Paolini et al. 2014).

II. ECOLOGICAL & EVOLUTIONARY CONSIDERATIONS FOR RESTORATION

A. Attribute summary list (based on referenced responses in full table)	Taxonomic stability - medium Longevity - long-lived Parity - polycarpic Flowering age - 3+ yr Stress tolerance - moderate to high and likely to differ among varieties Environmental tolerance - broad in adults, but may vary across varieties Reproduction after fire - facultative seeder Fragmentation history - historical and recent Habitat fragmentation - high at low elevations Distribution - wide distributions for vars. *foliolosum* and *polifolium;* narrower for vars. *fasciculatum* and *flavoviride* Seeds - dormant; moderately long lived; > 7 yr Seed dispersal distance - short to medium Pollen dispersal - intermediate to far Breeding system - estimated as outbreeding Population structure - low in varieties *fasciculatum* and *foliolosum*; likely low for all varieties. Adaptive trait variation - patterns suggests variation within varieties, with larger differences among varieties Chromosome number - polyploid complex: var. *foliolosum* 2n = 80, all others 2n = 40. Genetic marker polymorphism - high Average total heterozygosity - high Hybridization potential - high among taxa with same chromosome number, both within and among species of *Eriogonum*. Species Distribution Model (SDM) (see V. A-C below) projected midcentury suitable habitat: for var. *fasciculatum* 8–100% stable; for var. *foliolosum* 84–100% stable; and for var. *polifolium* 62–95% stable. (No SDM available for var. *flavoviride*) SDM projected midcentury habitat loss for var. *fasciculatum,* loss > gain for 3 of 5 future scenarios; for var. *foliolosum* loss > gain for 2 of 5; and var. *polifolium* loss > gain for 4 of 5 future scenarios (all assuming unlimited dispersal).

B. Implications for seed transfer (summary based on referenced responses in full table)	This species is hardy, easy to use, and of great benefit to many types of planting projects; however, care needs to be taken to avoid accidental range expansions and to match the variety native to the region of the planting site. Plants have become weedy when planted outside their natural range. There are differences among varieties in the pattern of geographic variation (see VIII. C.), local adaptation (see VII. F), associated habitat (see IV. B. habitat affinities, E. Precipitation, and F. Drought tolerance), and differences in ploidy and potential for hybridization with close relatives, including among varieties (see VI. H. Hybridization potential). There is evidence for high rates of genetic variation and gene dispersal which may help the natural migration and adaptation of this species over the landscape in a rapidly changing environment. However, in areas with extensive habitat fragmentation and short fire return intervals, expansion of seed collection and seed deployment ranges to adjacent ecological subsections may be necessary and beneficial. Seed transfer will likely be most successful if done in the direction of the projected retention or expansion of future suitable habitat rather than toward areas of habitat suitability loss, paying attention to elevational bands that may correlate with differences in susceptibility to cold temperatures (see IV. B−F and V. A−C).
III. GENERAL	
A. Geographic range (numbered as above)	1. ERFAF3. Common along coastal regions of California from San Luis Obispo Co. south to central Baja California (planted outside this natural range). 2. ERFAF2. Widespread and common in California from Monterey Co. south into northwestern Baja California (seldom on immediate coast, planted extensively, sometimes outside natural range). 3. ERFAP. Widespread and common from California's San Luis Obispo and Fresno Cos., south to San Diego Co., eastward into the Mojave Desert to southern Nevada, Utah, and Arizona, and south into northwestern Sonora Mexico and central Baja California (planted extensively). 4. ERFAF. Widespread but uncommon in southeastern Great Basin, Mojave, Colorado, and Sonoran deserts of California from San Bernardino Co., southward to central Baja California (Montalvo 2004, Sawyer et al. 2009, FNA 2018, Jepson eFlora 2018).
B. Distribution in California; ecological section and subsection (sensu Goudey & Smith 1994; Cleland et al. 2007) 	Map includes validated herbarium records (CCH 2016) as well as occurrence data from CalFlora (2016) and field surveys (Riordan et al. 2018). Legend has Ecological Sections; black lines are subsections. *Eriogonum fasciculatum* var. *fasciculatum*  Ecological Section/subsection: Central California Coast 261A: h,k,l Central Valley Coast Ranges M262A: e (sw edge) Southern California Coast 261B: a,b,e-j Southern California Mountains and Valleys M262B: d,f,n *Eriogonum fasciculatum* var. *foliolosum*  Ecological Section/subsection: Central California Coast 261A: c,e,f,j,k,l, Southern California Coast 261B: a,b,d,e,f,g,i,j Great Valley 262A: y Mojave Desert 322A: g,h,m,p Calorado Desert 322C: a Sierra Nevada Foothills M261F: e Central Calif. Coast Ranges M262A: c,e,f,h,j,k, Southern Calif. Mountains and Valleys M262B: a-h, j-p

	Ecological Section/subsection: Central California Coast 261A: k Southern Calif. Coast 261B: a,b,e,g,i,j Great Valley 262A: g,q,y,z Mojave Desert 322A: a, c-p Sonoran Desert 322B: a,c,e Colorado Desert 322C: a,b Mono 341D: i,j Southeastern Great Basin 341F: b-f Sierra Nevada M261E: o,p,r,s,u Sierra Nevada Foothills M261F: d,e Central Calif. Coast Ranges M262A: c-k Southern Calif. Mountains and Valleys M262B: a-p *Eriogonum fasciculatum* var. *polifolium*  *E. f. var. flavoviride*  Ecological Section/subsection: Southern California Mountains and Valleys M262B: i, p (bordering Colorado Desert 322Ca) Mojave Desert 322A: c,g,h,j,k,l,o,p Colorado Desert 322C: b
C. Life history, life form	Polycarpic subshrub; facultatively drought deciduous. Generally long-lived (five to over 50 years; Sawyer et al. 2009).
D. Distinguishing traits 1. **ERFAF3** 2. **ERFAF2** 3. **ERFAP** 4. **ERFAF**	Although the four taxonomic varieties partly overlap in geographic distribution, each is associated with a different range of climatic zones and trait combinations, especially color, chromosome number, leaf shape, degree of inrolled leaf margins, and pubescence (Munz & Keck 1968, Reveal & Rosatti 2012, FNA 2018). All have alternate cauline leaves that are linear to narrow and broader toward the top of the leaf (oblanceolate), with white, woolly, appressed hairs beneath, and darker, generally less hairy to glabrous above. Leaves are 1−2 cm long and clustered tightly at nodes on very short shoots that arise from the axils of the main leaves, giving the leaves a fascicled appearance. Flowers are small (about 3 mm long), with six white to pinkish sepals (often referred to as tepals in this family) that are fused at their bases, and are borne in heads of tightly to loosely packed involucres with few flowers per involucre (involucre is a ring of bracts that form a cup around flower clusters). The "heads" (or dense cymes) are born singly or in umbels subtended by long, naked peduncles (often > 5 cm). Branching of the umbels varies from one to four levels, even within varieties. Umbels are rounded to flat-topped depending on the extent of branching. Flowers produce small (about 1.5−2 mm long), single seeded achenes that are partially enclosed in a dry, persistent calyx. The main differences among the varieties in morphology are indicated below (numbered as above): **1.** Leaves green above, linear to broader toward the top of the leaf (oblanceolate); upper leaf surface, sepals and petals mostly lacking hairs (glabrous); leaf margins tightly rolled under. Plants mostly dark green, reclining (decumbent) and matt-forming, 1−5 dm tall. Coastal. **2.** Leaves generally grey-green to dark green above, linear (sometimes obovate), upper leaf surface usually with scattered hairs; lower surface with dense, floccose hairs; leaf margins generally tightly rolled under; involucres and perianth usually pubescent; plants generally dark green, upright to spreading and rounded, 6−15 dm tall. Inner coastal foothills and valleys.

D. ….continued	**3.** Leaves mostly oblanceolate and grayish; leaves with dense hairs on both surfaces, upper surface usually densely pubescent with short hairs (tomentose); margins of leaves mostly flat to barely rolled under; involucres and sepals of flowers are densely hairy and the hairs are obvious when processing seeds; plants are generally rounded (sometimes spreading) subshrubs, 2−6 dm (sometimes to 8 dm) tall, grayish. Deserts and interior valleys. **4.** Leaves yellowish-green, top surface of leaves mostly smooth and lacking hairs; flowers with hairs inside perianth. Plants yellowish-green, generally rounded subshrub, 6−15 dm tall. Deserts; color difference is obvious where it overlaps with var. *polifolium* (FNA 2018).
E. Root system, rhizomes, stolons, etc.	Woody, branched fibrous roots (Hellmers et al. 1995, Kummerow et al. 1977). Lateral spread of roots was generally about three times the spread of the canopy (Hellmers et al. 1995); this study in the San Gabriel Mountains of California likely could have involved *E. f.* var. *foliolosum* or var. *polifolium.*
F. Rooting depth	Often to less than 1.5 m, with maximum depth in one study reported as 8 ft (2.46 m) (Hellmers et al. 1995, Kummerow et al. 1977).
IV. HABITAT	
A. Vegetation alliances, associations 1. ERFAF3 2. ERFAF2 3. ERFAP 4. ERFAF	Shrubs of many alliances within coastal sage scrub, chaparral, alluvial scrub, desert scrub, and dry woodlands, depending on variety. 1. Co-dominant in coastal sage scrub with *Artemisia californica, Salvia mellifera, Baccharis pilularis, Encelia californica, Acmispon glaber.* 2. Co-dominant to dominant in sage scrub with other shrubs such as *Artemisia californica, Salvia apiana, S. mellifera, Encelia californica, Acmispon glaber;* codominant in alluvial scrub with *Lepidospartum squamatum, Salvia apiana, Hesperoyucca whipplei.* Also in many low-elevation chaparral communities. 3. Scattered to co-dominant in dry parts of inland coastal sage scrub; in deserts, co-dominant with *Ambrosia dumosa, A. salsola, Coleogyne ramosissima;* in saltbush, blackbrush, and creosote scrub, pinyon-juniper and juniper woodlands; also in low-elevation chaparral plant communities including areas with *Adenostoma fasciculatum* and *Eriodictyon* species (FNA 2018, Sawyer et al. 2009). 4. Saltbush and creosote scrub, pinyon-juniper woodland (FNA 2018).

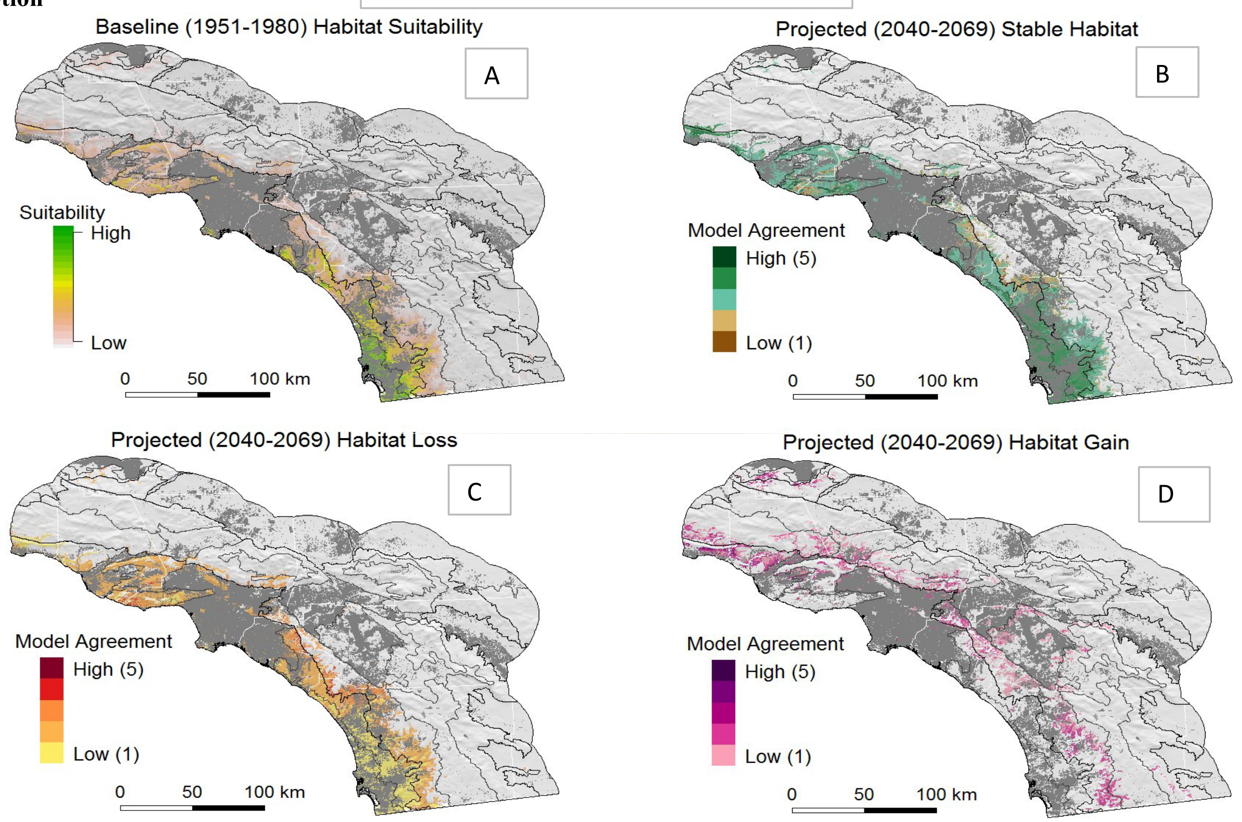
B. Habitat affinity and breadth of habitat 1. ERFAF3 2. ERFAF2 3. ERFAP 4. ERFAF	Much published research does not indicate varietal status of *E. fasciculatum.* In coastal sage scrub, plants occur equally on north and south facing aspects and on flat to steep slopes, washes and canyons (Kirkpatrick & Hutchinson 1980). Plants are often in areas where low, open vegetation maintained is by cycles of disturbance such as fire (K. Lair personal communication). 1. Sandy coastal areas and coastal bluffs. 2. Sandy to gravelly flats and slopes, rocky areas; coarse alluvial deposits along washes and rivers. 3. Generally gravelly and rocky areas, flats, slopes, and washes. 4. Gravelly to sandy flats and slopes in warm desert regions.
C. Elevation range	Generally, below 1200 m (Sawyer et al. 2009) 1. 0−300 m (Jepson eFlora 2018) 2. 600−2300 m (FNA 2018); 60−1300 m (Jepson eFlora 2018); CCH data agree with higher estimate. 3. generally 300−2500 m (FNA 2018, Jepson eFlora 2018) 4. 50−1300 m (FNA 2018, Jepson eFlora 2018)
D. Soil: texture, chemicals, depth	Prefers coarse, well-drained soils that are moderately acidic to slightly saline (Sawyer et al. 2009). In coastal sage scrub vegetation, Kirkpatric & Hutchinson (1980) found *E. fasciculatum* (broad sense) avoided unconsolidated soils but occurred on a variety of parent materials. Common in young alluvial deposits (Buck-Diaz et al. 2011). Occurs on substrates derived from many parent rocks, including serpentinite.

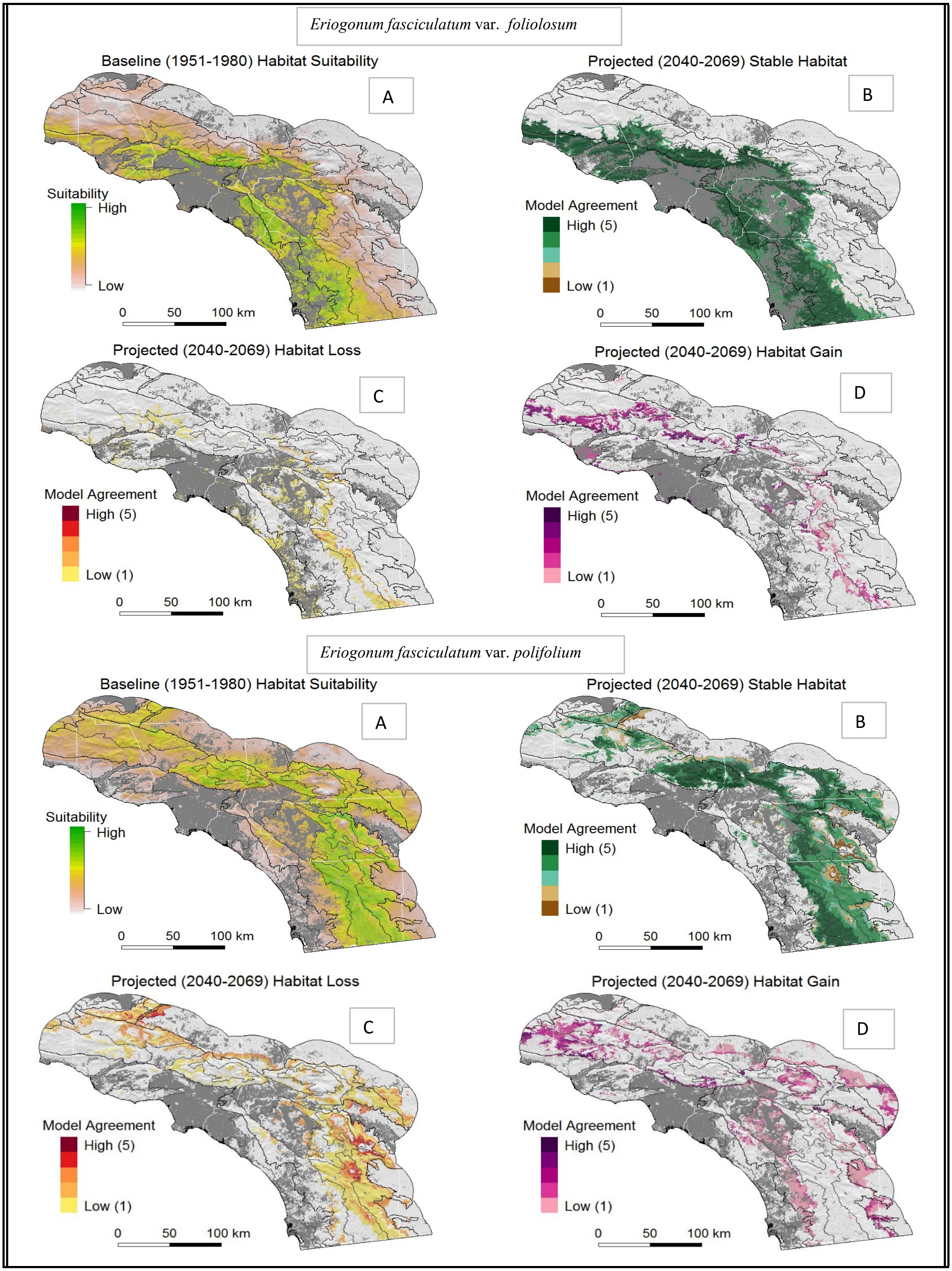
E. Precipitation	Plants of varieties *fasciculatum* and *foliolosum* occur in Mediterranean climate regions of California that are typically dry in summer, wet in the winter, becoming dry mid to late spring depending on location. Total annual precipitation ranges from about 10 to 25 in but can be higher in coastal locations. Plants of variety *polifolium* occur in lower rainfall areas (10−15 in) of the Mediterranean climate region and to < 10 inches in desert region that often receive some summer rain. *E. f.* var. *flavoviride* occurs in warm deserts (less than 10 in) where there may be occasional summer rains.
F. Drought tolerance	Drought tolerant (Dyer & O'Beck 2006). Plants can shed leaves during drought (DiSimone & Zedler 2001). However, plants can suffer dieback during extreme droughts. Cole (1967) found evidence for differences in drought tolerance among populations of varieties *fasciculatum* and *foliolosum* (see VIII. C. Geographic variation). Feng et al. (2017) found high desert populations were vulnerable to hydraulic failure and branch dieback and death during extensive droughts. At a study site in Morongo Valley, California (ecological subsection M262Bi), where both var. *flavoviride* and var. *polifolium* grow and where summer rainfall is more abundant than toward the coast, plants lost 71% cover through dieback during a severe drought in the 2006/2007 season where summer rain was anomalously low. Plants at another population at nearby Joshua Tree National Park (ecological subsection 322Ap) suffered 95% mortality in a 2002 drought (Miriti et al. 2007).
G. Flooding or high water tolerance	Upland species of well-drained soils; however, plants occur in well-drained substrates in alluvial scrub and along washes that receive occasional ephemeral winter flood waters (Burk et al. 2007, Buck-Diaz et al. 2011).
H. Wetland indicator status for California	None
I. Shade tolerance	Shade intolerant. Requires full sun or nearly full sun.
J. Cold tolerance	Winter kill of naturally recruited young seedlings and young transplants have been observed at Mojave Desert sites (Ken Lair personal communication). Unusual cold events and freezing temperatures in cold air drainages may limit plant establishment and distribution, especially at higher elevations.

V. CLIMATE CHANGE AND PROJECTED FUTURE SUITABLE HABITAT

scroll down to V. A. for caption

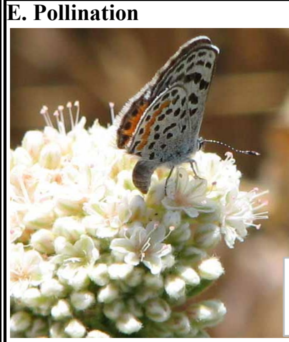
Eriogonum fasciculatum var. *fasciculatum*




Eriogonum fasciculatum var. foliolosum
Baseline (1951-1980) Habitat Suitability
A
Suitability
High
Low
0 50 100 km
Projected (2040-2069) Stable Habitat
B
Model Agreement
High (5)
Low (1)
0 50 100 km
Projected (2040-2069) Habitat Loss
C
Model Agreement
High (5)
Low (1)
0 50 100 km
Projected (2040-2069) Habitat Gain
D
Model Agreement
High (5)
Low (1)
0 50 100 km
Eriogonum fasciculatum var. polifolium
Baseline (1951-1980) Habitat Suitability
A
Suitability
High
Low
0 50 100 km
Projected (2040-2069) Stable Habitat
B
Model Agreement
High (5)
Low (1)
0 50 100 km
Projected (2040-2069) Habitat Loss
C
Model Agreement
High (5)
Low (1)
0 50 100 km
Projected (2040-2069) Habitat Gain
D
Model Agreement
High (5)
Low (1)
0 50 100 km

A. Species Distribution Models (SDM forecasts, Riordan et al. 2018) Map descriptions	Modeled habitat suitability under (A) baseline (1951–1980) and (B–D) projected midcentury (2040–2069) climate conditions for three varieties of *Eriogonum fasciculatum.* Projected future habitat suitability maps show agreement across five different climate model scenarios: (B) stable = suitable under both baseline and future conditions; (C) loss = suitable under baseline but unsuitable under future conditions; (D) gain = unsuitable under baseline and becoming suitable under future conditions. In all maps, land area that has already been converted to urban and agriculture land uses is masked in dark gray (FRAP 2015 Assessment; http://frap.fire.ca.gov/data/frapgisdata-sw-fveg_download). High resolution maps are available for download (see Riordan et al. 2018).
B. SDM summary SDM projected midcentury suitable habitat	Species distribution modeling results differed for the three varieties of California buckwheat studied. Results predicted the inland varieties *foliolosum* and *polifolium* would maintain more of their suitable habitat in southern California than the coastal var. *fasciculatum* under 21st century climate change. Assuming unlimited dispersal and a future of continued high greenhouse gas emissions, Riordan et al. (2018) predicted 8–100% of baseline habitat for var. *fasciculatum* would remain suitable (stable) under mid-century conditions across future climate scenarios from five different general circulation models (GCMs) (SDM maps Fig. B). They also predicted loss in suitable habitat exceeded gain under 3 of 5 future climate scenarios for this variety (SDM maps Figs. C-D), with the area of suitable habitat projected to decrease by 92% under the hottest, wettest climate scenario (CNRM). In contrast habitat suitability was projected to increase by 15–20%, primarily at higher elevations, under two scenarios that predicted hotter and drier conditions. The more inland var. *foliolosum* was projected to have 84–100% stability of suitable habitat, with predicted suitable habitat loss exceeding gain in only 2 of 5 future scenarios. The farthest inland var. *polifolium* was projected to have 62–95% stability of suitable habitat, with predicted loss higher than gain for only one scenario. Under the wet CNRM scenario, it had a 19% projected gain in habitat, much more than for other varieties. For coastal varieties, Riordan & Rundel (2014) predicted moderate stability of suitable habitat: with 26–27% habitat loss by mid-century and 49–51% loss by the end of the 21st century. In contrast, Principe et al. (2013) reported having run models for var. *fasciculatum* and predicted high climate stress (habitat suitability loss) of 80% by midcentury. Land use, altered fire regimes, invasive species, and their interaction with climate change could negatively affect the California buckwheats, even if projected loss in suitable habitat from climate change alone is relatively low. In southern California human activity is the primary driver of fire (Keeley & Syphard 2016) with fire ignitions and fire frequency increasing with human population growth (Syphard et al. 2009). California buckwheats are facultative seeders, but under high fire intensities and frequencies they may be extirpated owing to insufficient seed banks, shoot kill, or to competition from more aggressive resprouters (see VI. D. Regeneration after fire or other disturbance). In addition, the high level of habitat conversion and fragmentation throughout the species' range at low elevations creates a considerable barrier to dispersal and gene flow that could negatively impact the adaptive capacity and ability of the species to respond to changing conditions. Of the three varieties studied, var. *fasciculatum* from the coast is the most vulnerable to climate shifts and to habitat fragmentation. Much of the currently suitable habitat for *E. f.* var. *fasciculatum* in southern California has been developed. Riordan & Rundel (2014) caution that human land use may compound projected climate-driven losses in habitat suitability in southern California shrublands. Their prediction of 49–51% loss of suitable habitat by the end of the 21st century mentioned above, combined projected land use and climate change (Riordan & Rundel 2014).
C. SDM caveat (concerns)	The five GCMs used to predict future habitat suitability assume a 'business-as-usual' scenario of high greenhouse gas emissions that tracks our current trajectory (IPCC scenario RCP 8.5). They show how climate may change in southern California and highlight some of the uncertainty in these changes. The true conditions at mid-21st century, however, may not be encompassed in these five models. Predictions of current and future habitat suitability should be interpreted with caution and are best applied in concert with knowledge about the biology, ecology, and population dynamics/demographics of the species. They are best interpreted as estimates of exposure to projected climate change. Our models characterize habitat suitability with respect to climate and parent geology but do not include other factors, such as biotic interactions or disturbance regimes, that may also influence species distributions. Additionally, they do not include the adaptive capacity of a species, which will affect its sensitivity to changes in climate. See Riordan et al. (2018) for more information on SDM caveats.

VI. GROWTH, REPRODUCTION, AND DISPERSAL

A. Seedling emergence relevant to general ecology	 seedling of *E. f.* var *foliolosum* Seedlings emerge in the rainy season in mid to late winter (later at highest elevations) within light gaps and open areas (e.g., DeSimone & Zedler 1999), primarily within 2 m of the mother plant (Schultz 1996). Early germination in habitats that experience freezing temperatures can be detrimental (see IV. J. Cold tolerance).
B. Growth pattern (phenology)	Most initial growth, shoot elongation, and leaf flush is in the rainy season from February to May and ceases when inflorescences start to grow (Cole 1967). In California, plants flower from early spring through summer. The four varieties have slightly shifted flowering times, with var. *flavoviride* having the earliest season (Munz &Keck 1968) and var. *polifolium* flowering before the other two. Plants lose some leaves in the dry season and can shed many leaves in severe drought (Montalvo 2004). Mazer et al. (2015) reported on three years of a phenological study that included plants at Sedgewick Ranch Reserve in Santa Barbara Co. (likely var. *foliolosum*), the Santa Monica Mtns (likely *foliolosum* and/or *fasciculatum*), and inland sites at Joshua Tree National Park (likely var *polifolium*). Variation in the timing of growth of young leaves, flowers, maturing fruits, and ripe fruits was highly associated with climatic variables, but the relationships varied among plant parts, among years, and location. The conditions during winter explained the greatest amount of variation in the onset of leaf and flower growth, especially variation in the timing of winter precipitation and minimum temperatures. For example, high January precipitation coupled with low February precipitation was associated with early flowering, while high February precipitation was associated with early fruiting.
C. Vegetative propagation	Resprouts after fire and mowing. Plants occasionally root from buried stems in the wild. Plants for horticulture are frequently propagated from cuttings, especially native cultivars that have been selected for their low, mat-forming growth form.
D. Regeneration after fire or other disturbance	Facultative seeder. *E. fasciculatum* has been found to resprout more readily from above ground stems than below ground organs, which makes it vulnerable to high intensity fire (Westman et al. 1981). In addition, resprouting success is lower in larger shrubs (Keeley 1998, 2006) and there can be much competition from other, more aggressive resprouters such as *Eriodictyon trichocalyx* (K. Lair personal communication). There may be significant differences in interior compared to coastal locations (Keeley et al. 2006). In a study of many coastal and inland post-fire sites in southern California, *E. fasciculatum* (variety unspecified) resprouted about 10 percent of the time within inland areas and 9 percent of the time in coastal areas (Keeley et al. 2006). Regeneration from seeds was relatively more frequent, and there was a much higher seedling-to-parent ratio in coastal locations compared to interior locations (136 vs. 34). Over a five-year period after fire, about 71% of seedlings emerged in the first year after fire, 21% in the second year, dropping to 5% and lower in subsequent years. In an area that burned 2 consecutive years, all previous year seedlings were killed in the second fire and new seedling recruitment was halved (Zedler et al. 1983), indicating that high fire frequency can devastate populations. In addition to competing with seedling establishment, invasion of non-native grasses such as *Bromus* species and forbs such as *Centaurea melitensis* lead to an unnaturally high accumulation of fine fuels that can result in heightened habitat flammability, shorter fire return intervals, and loss of shrubs (Talluto & Suding 2008, Paolini et al. 2014).
E. Pollination 	In all varieties, stamens and stigmas are exerted and open to generalist pollinators, including honey bees and many species of small native bees, flies, wasps, and beetles (Montalvo 2004). A number of bee (e.g., especially *Hylaeus, Halictus* , *Dialictus* , and *Perdita* , but also *Megachile, Hesperapis, Heriades, Aandrena, Colletes, Ashmeadiella*), bombyliid fly (*Villa, Toxophora, Geron, Exoprosopa)* , butterfly (*Plebeuus axmon, Apodemia mormo, Callophyrs*), wasp (*Vespula, Philanthus, Paratiphia, Oxybelus, Eucerceris, Leptochilus, Isodontia*), beetle (*Euryscopa, Mordella*), and fly (*Tachinidae, Paradidyma*) species visit and presumably pollinate the flowers (Moldenke & Neff 1974). The Bernardino blue butterfly is a common flower visitor. *Euphilotes bernardino,* the Bernardino blue commonly drinks nectar from flowers of *E. f.* var. *polifolium*. Note hairy flower buds. (photo: A. Montalvo, Mission Creek, CA, May 2010)

F. Seed dispersal	The dry calyx provides buoyancy to detached achenes and assists dispersal by wind and water. Harvester ants also disperse achenes (DeSimone & Zedler 1999). Conlisk et al. (2016) found dispersal of *E. fasciculatum* seeds into seed traps was common in unburned plots and reflected above ground cover of the shrub at the Motte Rimrock Reserve in Riverside County. However, dispersal into seed traps placed in open burned areas about 60 − 120 m away from the occupied unburned areas caught few seeds. In contrast, looking at Google Earth, expansion of an experimental planting of var. *foliolosum* (Montalvo et al. 2002) into the adjacent, barren areas from seed dispersal reached at least 30 feet from 2002 to 2006, and to at least 35 feet by 2009. These are minimum distances because further distance colonization was prevented by disking (A. Montalvo pers. obs.).
G. Breeding system, mating system	The flowers have both male and female organs and there are many at different stages presented on a plant at the same time. The flowers are open to pollen movement by many species of insects and likely receive pollen from both self and other plants. Flowers have been noted as self-incompatible (Moldenke & Neff 1974), but data were not provided. However, in genetic studies the high levels of polymorphic loci and heterozygosity and the low level of population structure are consistent with an outbred mating system (Montalvo 2004).
H. Hybridization potential	Among varieties: Stebbins (1942) hypothesized that 2n = 80 "octoploid" populations of var. *foliolosum* arose from hybridization between 2n = 40 "tetraploid" var. *fasciculatum* and var. *polifolium* (noted as *E. f.* subsp. *foliolosum* , *E. f.* subsp. *typicum* , and *E. f.* subsp. *polifolium* , respectively, in the paper). He examined the distribution of taxa in relation to climatic factors and concluded that the morphology and ecological tolerances of var. *foliolosum* combined the morphology and tolerances of the two tetraploid taxa. The variety *polifolium* was in areas with some snow, frost, and only 10−13 cm of rainfall; *fasciculatum* was in the areas with no frost, often frequent fog, and 2−37 cm of rainfall; and *foliolosum* often occurred in habitats intermediate to the two tetraploids. Among species: Reveal (1989) reports hybridization between var. *polifolium* and *E. cinereum* Benth in areas were *E. cinereum* has been introduced within the range of var. *polifolium.* In gardens, var. *polifolium* hybridizes with *E. giganteum* from the Channel Islands and produces offspring with intermediate leaves (A. Montalvo pers. obs.).
I. Inbreeding and outbreeding effects	It is unlikely that anyone will do experimental pollinations or hybridizations to determine the breeding system, genetics of local adaptation, or outbreeding depression in this species. The flowers of all *Eriogonum* species are notoriously small and difficult to work with, and so genetic work requiring crosses has been avoided for many years (e.g., Stokes & Stebbins 1955).

VII. BIOLOGICAL INTERACTIONS

A. Competitiveness	Emerging seedlings do not compete well with non-native grasses or mustards. Schultz (1996) found that seedlings in weeded plots survived longer than seedlings growing in competition with non-native grasses. Experimental plots seeded with a mixture of coastal sage scrub shrubs in Riverside had very few seedlings in plots where grasses were not controlled; spring densities of *E. fasciculatum* seedlings were four times higher in plots treated with grass-specific herbicide in January than in plots where grasses were hand-weeded after they emerged in December (Cione et al. 2002). After fire at a lower montane chaparral site in the San Jacinto Mtns, weeding seeded plots resulted in increased cover of *E. fasciculatum* (likely was var. *foliolosum*) compared to plots that were seeded but not weeded, or left without either treatment. The main invaders were annual grasses (*Avena barbata, Vulpia myuros, Broumus tectorum, B. madritensis* subsp. *rubens*), and the forb *Erodium brachycarpum* . For *E. f.* var. *faciculatum* in Orange Co., *Brassica nigra* had strong negative effects on seedling growth, but plots with established buckwheats resisted invasion by the annual mustard (Bell et al. 2018). The NRCS Plant Guide (Dyer & O'Beck 2006) warns that if planted at too high a proportion of a seeding mixture, *E. fasciculatum* plants can become very dense and outcompete other desirable species. They state that plants "may become weedy or invasive in some regions or habitats and may displace desirable vegetation if not properly managed." In controlled greenhouse studies, Bozzolo & Lipson (2013) found *E. fasciculatum* from San Diego Co. grew less in sterile soil but the non-native weeds with which it competes grew better in sterile soil (*Centaurea melitensis*), or the weeds grew the same in sterile and unsterilized soil (*Brassica nigra* and *Bromus madritensis*). The study showed that growth of *Eriogonum* and all three weeds increased with ammonia nitrogen fertilization, but that *C. melitensis* grew larger with all forms of added N, including nitrate. The results indicated the lower relative success of *Eriogonum* vs weeds can be influenced by the microbial community as well as by nitrogen deposition from air pollution. In addition to competing with *E. fasciculatum* , *C. melitensis* accumulates a disproportionate amount of the fine fuels that carry fire through habitats (Paolini et al. 2014).

B. Herbivory, seed predation, disease	The larvae of the moth *Hemileuca electra* Wright feed on leaves (Rubinoff 1998) and can defolilate whole branches. The distributions of different subspecies of *H. electra* are somewhat correlated with the distribution of varieties of *E. fasciculatum* (Tuskes & McElfresh 1995); for example, *H. e. mojavensis* feeds on *E. f.* var. *polifolium.* Similarly, *Philotes battoides* (Behr.) *bernardino* Barnes & McDunnough feeds on all four varieties of *E. fasciculatum* whereas *Philotes battoides* (Behr.) *martini* Mattoni larvae feed on var. *polifolium.* Howe (1975) lists additional butterflies as using *E. fasciculatum* as larval food plants, including *Apodemia mormo* Felder & Felder, *Lycaena* (*Tharsalea*) *heteronea* Boisduval, and *Satyrium tetra* Edwards. Harvester ants collect the achenes (DeSimone & Zedler 1999).
C. Palatability, attractiveness to animals, response to grazing	Eaten by many domestic livestock and browsed by big game; rated good to fair for deer, fair for goats, fair to poor for cattle and sheep, and poor to useless for horses (Sampson & Jespersen 1963). Plants grow back after clipping or mowing.
D. Mycorrhizal? Nitrogen fixing nodules?	Greenhouse studies indicate that California buckwheat forms facultative associations with arbuscular mycorrhizal fungi (Egerton-Warburton, Montalvo, and Allen, unpublished report to Metropolitan Water District). The plant's facultative dependence on mycorrhizal fungi may be instrumental to successful colonization of barren sites, while improved growth within biologically active soil may help the plant to compete with some weeds (see VII. A. Competitiveness). When soils are particularly sterile, practitioners may wish to explore methods of inoculating soil to improve beneficial soil organisms.

VIII. ECOLOGICAL GENETICS

A. Ploidy	1. ERFAF3. $2n = 40$ chromosomes (Stebbins 1942, Stokes & Stebbins 1955) noted as tetraploid 2. ERFAF2. $2n = 80$ chromosomes (Stebbins 1942, Stokes & Stebbins 1955) noted as octoploid 3. ERFAP. $2n = 40$ chromosomes (Stebbins 1942, Stokes & Stebbins 1955) noted as tetraploid 4. ERFAF. $2n = 40$ chromosomes (FNA 2018). n = 20 chromosomes (Reveal 1989). Reveal & Rosatti (2012) report numbers as n = 40, 80, 40, 40 respectively, instead of as 2n. The counts reported in Stokes & Stebbins (1955) were from root tips and are therefore 2n counts.
B. Plasticity	No data found.
C. Geographic variation (morphological and physiological traits)	Cole (1967) compared the distribution of morphology and ecological tolerances of vars. *fasciculatum* and *foliolosum* and compared their physiologies over an ecological gradient from the cool coast across the mountains to the hot inland valleys of California. The var. *fasciculatum* plants were the least hairy, and populations of var. *foliolosum* became more hairy inland. There was a clear morphological cline from the coast to the interior among and within varieties that correlated with habitat. Photosynthesis vs. respiration ratios, photosynthetic rates, and respiration rates all varied in a manner that correlated with morphological characters (suggestive of adaptive clinal variation).
D. Genetic variation and population structure	Analysis of eight allozyme loci for eight populations of var. *foliolosum* and four of var. *fasciculatum* (from Santa Barbara, Los Angeles, Orange, San Diego, and Riverside counties) revealed ample genetic variation (Montalvo, Ellstrand, & Clegg, unpublished data in Montalvo 2004). All loci were polymorphic, and there was an average of 5.7 alleles/locus. Expected heterozygosity was high at 0.42. Nei's genetic distances among populations ranged from 0 to 0.074, with the largest distance between varieties. Overall, the proportion of total variation explained by differences among populations (G_{ST}) was 0.025. By itself, the tetraploid (possibly octoploid) var. *foliolosum* had no significant structure ($G_{ST} = 0.005$), while $G_{ST} = 0.028$ for var. *fasciculatum* indicated that only about 3% of the variation was explained by differences among populations. These values are consistent with high levels of gene flow and outbreeding (Montalvo 2004). Riley et al. (2011) developed microsatellite primers for the related *E. giganteum* that also worked for *E. fasciculatum.* In a sample of eight *E. fasciculatum* plants collected from near Santa Paula, Ventura Co., 6 of 7 primers were polymorphic with an average of 2.8 alleles. This is a promising level of variation for future studies of range-wide variation and gene flow patterns.
E. Phenotypic or genotypic variation in interactions with other organisms	No studies found; however, there are some geographic associations between the distribution of subspecific taxa of *E . fasciculatum* and the distribution of subspecific taxa of butterflies that use the plants as larval hosts.

F. Local adaptation	The morphological clines described above (VIII. C. Geographic variation) suggest that there are adaptive differences among varieties. The variety *fasciculatum* forms a distinctly adaptive coastal ecotype, while var. *foliolosum* forms an inland ecotype (Montalvo 2004). There are also some habitat distinctions in var. *polifolium* and var. *flavoviride* relative to the other two more coastal forms; for example, var. *polifolium* can tolerate colder temperatures and hotter, lower rainfall environments than can the coastal var. *fasciculatum.* Work is needed to determine if var. *polifolium,* the most widespread of the four varieties, has adaptive variation across its range. Differences are likely given the large change in environment and ecoregion characteristics from the western to the eastern extent of its range.
G. Translocation risks	Planting taxa into the wrong habitat can cause maladaptation of plants to sites and unintentional cascading effects. For example, *E. parvifolium* Sm. in Rees. is the host of the rare El Segundo blue butterfly (*Euphilotes bernardino allyni* Shields), but when earlier flowering California buckwheat was planted in its habitat, competing insect species used California buckwheat, built up populations, and then competed with the rare butterfly for *E. parvifolium* flowers (Longcore et al. 2000).

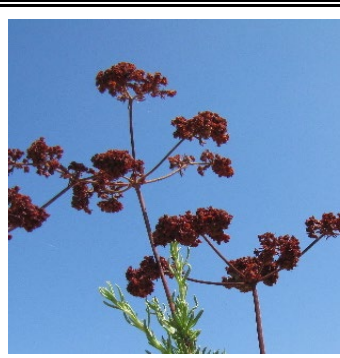
IX. SEEDS

2 mm

E. fasciculatum var. *fasciculatum*
note lack of hairs on sepals

E. fasciculatum var. *foliolosum*
note sepals less hairy than in var. polifolium

E. fasciculatum var. *polifolium*
note very hairy sepals

A. General	The small, reddish-brown seeds (1.5−2 mm long) are individually enclosed by the fruit wall. The dried calyx is attached to the base of these one-seeded fruits (achenes), even after dispersal. In *Eriogonum* the dry perianth is considered part of the unit seed in seed testing for seed purity and seed weight. A recommended target for minimum quality of purchased seeds is 15 percent purity and 65 percent germination (when the dried perianth is considered part of the seed; Dyer & O'Beck 2006).
B. Seed longevity	Long lived in soil seed bank and in cool, dry storage. Seeds can remain viable for at least 8 years if stored dry under laboratory conditions (Keeley 1991).
C. Seed dormancy	Seeds can remain dormant in a soil seed bank where the lack of light inhibits germination (Atwater 1980). Seeds deprived of light do not germinate as readily as seeds exposed to light (Cole 1967, Keeley 1987, Emery 1988).
D. Seed maturation	Achenes mature from June to September and disperse when dried inflorescences shatter in autumn. Seeds tend to hold on plants for several weeks until strong winds or other disturbance break up the heads.
E. Seed collecting and harvesting	 Seeds are collected after heads have dried and turned rusty brown. The heads can be easily hand-stripped into open bags or tubs. Reveal (1989) noted that *E. f.* var. *foliolosum* was widely planted and established along roadsides along the interstate highways far out of its native range, including as far north as Trinity Co. and east into the Mojave and Sonoran Deserts. He also noted that *E. f.* var. *polifolium* was widely planted along roadsides but at that time did not appear to be outside of its native range. Such planting practices reinforce the idea that source-identified seed collections should never be collected from along roadsides.

F. Seed processing	Many flowers do not set fruit; many achenes lack a developed seed. For seed banking and testing, the chaff can be separated from seeds by pushing seeds (achenes) through a screen and then separating seeds from chaff with an air separator or fan (Montalvo 2004, Wall & Macdonald 2009). For seeding projects and container plant production, it is not necessary to separate seeds from the persistent sepals or from the empty flowers. Commercial seed companies usually skip the screening and just break up the chaff, air separate the seeds from crude chaff, and sell seeds with the persistent calyx intact. This level of processing is sufficient for direct seeding. As per Wall & Macdonald (2009), remove large chaff and sieve through #14 and #25 sieves; separate seeds from chaff with blower set to 1.5 (blower speed can vary with machine). If naked achenes are needed for seed bank storage or experiments, you can remove persistent sepals by gently rubbing fruits over #25 sieve. The set blower speed to 2.0 to sort out empty, aborted seeds, and repeat rubbing and blowing as needed.
G. Seed storage	Store seeds dry. They store best under cool and dry storage conditions.
H. Seed germination	When seeds germinate, the embryonic root emerges first from the narrow end, then the two cotyledons (Cole 1967, Atwater 1980). The persistent calyx is on the bottom, wide end of the achene and does not interfere with germination (Meyer 2008). Light improves germination (Cole 1967, Keeley 1987). Germination of untreated, filled seeds averages about 70% under cool winter temperatures and natural light. Untreated, seeds collected in summer 1994 from 13 populations of vars. *foliolosum* and *fasciculatum* were individually planted on the surface of soil in flats (in randomized blocks with 480 sets of 80 seeds) in January 1995 in a greenhouse, kept moist, and tracked for seedling emergence for three months. In the first four weeks, daytime temperatures ranged from 18 to 24°C and nighttime from 14 to 16°C. Seedlings began to emerge at day four and most had germinated by two weeks. Seedlings continued to emerge for three weeks, with very few emerging afterwards; an average of 70.3% of seeds produced a seedling by the end of three weeks (range 37−94%). In a preceding trial under similar temperatures, application of gibberellic acid (500 ppm) did not improve germination over water controls (A. Montalvo, unpublished data). In another study, after 14 days incubation at 20°C without light, seeds with outer seed coats removed had 74% germination compared to only 38% when left intact, suggesting that light increases permeability of seed coats, water adsorption, and possibly leaching of inhibitors, allowing seeds to germinate (Atwater 1980). Cole (1967) found coastal populations germinated at 15 to 25°C, while inland populations germinated over a larger range of 5 to 35°C. Keeley (1987) examined the effects of light, dark, heat, and "charate" (leachate made by running water through charred wood) on germination. Seeds germinated equally well on soil vs. filter paper, and light controls had twice the germination rate of dark controls (83 vs. 45 percent germination). Charate did not affect germination. In light, seeds exposed to 120°C for 5 min suffered a large decrease in germination under all conditions relative to seeds heated to 70 or 100°C.
I. Seeds/lb	334,000 seeds/PLS lb for release *E. f.* 'duro' achenes, fully cleaned, with calyx intact (Dyer & O'Beck 2006). The farmed seeds had a germination rate of about 25%. 45,000 live seeds/bulk lb (S&S Seeds 2018) reported as average from seed testing of multiple, wild-collected seed lots.
J. Planting	Plants can be propagated from seeds or rooted from cuttings, but plants produced from cuttings provide very little genetic variation unless each cutting is collected from a different mother plant that was itself produced from seed. At low elevations, seeds and container plants should be planted in the fall to early winter to take advantage of the moist cool season for growth. However, in areas where winter temperatures are expected to frequently fall below 20°F, planting in late winter to early spring at mesic sites may be needed to prevent winter kill of seedlings or young transplants (K. Lair personal communication). Shallow planting methods are preferred. In western Riverside Co., seeds of var. *foliolosum* were planted in replicated plots by drilling, seed imprinting, and hydroseeding. The two shallow methods allowed more light to reach planted seeds and had at least twice the emergence success as drilling, which covered seeds with 0.5−1 cm of soil (Montalvo et al. 2002). The seeding rate of 12 PLS per square meter yielded an average of 3, 8, and 6 individuals per square m by the first spring for drilling, hydroseeding and imprinting, respectively, with very high survival to spring 1999 (Montalvo et al. 2002). Plant density was highest in plots that were not ripped and that had low organic matter (0.02−0.09 %) compared to higher levels (0.10−0.37%). For monoculture, older guides recommended planting 9 lbs per acre drilled and 14 lbs per acre broadcast (Dyer & O'Beck 2006). These numbers have been revised in the NRCS eVeg Guide to 3.3 lbs PLS and 6.6 lbs PLS (with the unit seed containing the tepals) for drilled vs broadcast seeding, respectively to obtain a target distribution of 25 PLS per square foot. Consult the Calflora/NRCS e-Veg Guide (see XIII Links, below) or local NRCS field office for help in calculating amounts for multispecies seed mixtures.

K. Seed increase activities or potential	Irvine Ranch Conservancy planted seedlings of *E. fasciculatum* var. *fasciculatum* at 4-ft on center into 4-ft wide raised beds (density of 2400 plants/acre, sandy loam, 453 ft elevation, near Bee Canyon, Orange Co.) where the only irrigation was drip for 8 hours on one day in year 1 (J. Burger & M. Garrambone personal communication). About 25−40 % of plants produced seeds in year 1, whereas 100% produced seeds in year 2. Trials were also done at another nearby site for two years. Over four years of growing, yield was dependent on year of growth and rainfall patterns with the highest yield in the highest rainfall year. All other years had low precipitation. At the Bee Canyon site, plants produced 275 bulk pounds (25 PLS lb/ac) in year 1 and 444 bulk pounds (40 PLS lb/ac) in year 2. Over two sites and four production years, the average yield was 59 PLS lb/ac. This was considered a low maintenance, easy to harvest species. One cultivar, 'Duro' California buckwheat, was shown to succeed in production, but seeds of this varietal mixture may not be commercially available (NSN 2018). Fields produced about 145kg/ha (300 lbs/ac) of seed (bulk lbs with achene with calyx intact, Dyer & O'Beck 2006). Large quantities of seeds are commonly collected from wild populations, but seed quantity and quality are highly variable from year to year. USDA PLANTS (2018) provides detailed information about the tolerances of this species in its "Characteristics" profile (https://plants.usda.gov/java/charProfile?symbol=ERFA2). Unlike the new Calflora/NRCS e-Veg Guide (see XIII Links, below), the profile does not report the differences between varieties and focuses on the cultivar Duro and likely on var. *polifolium.*
X. USES	
A. Revegetation and erosion control	*E. fasciculatum* is an important, fast growing shrub used extensively in roadside revegetation, erosion control, post-fire mitigation, and habitat restoration in southern California (Reveal 1989, Newton & Claassen 2003, Montalvo 2004). Newton and Claassen (2003) recommend use of this plant for disturbed lands within the Cascade Range, Sierra Nevada, Central Western California, Southwestern California, and Mojave Desert Regions, but they don't offer clues as to how to match varieties to different regions.
B. Habitat restoration	These plants are valued for their wildlife value, attractiveness to native pollinators, and ability to control erosion in restoration settings. Seeds have been widely planted for restoration, roadside erosion control, slope stabilization, landscaping, and apiary (Schopmeyer 1974, Perry 2010). Despite the clear geographic pattern and ecological affinities of the four taxonomic varieties, many researchers and consultants fail to designate taxonomic variety on publications, plant lists, or plant palettes. They also commonly fail to specify the appropriate ecological zone for the source of seeds used in wildland plantings. This has resulted in extensive plantings outside natural ranges and habitats (Reveal 1989). Projects should use seeds of appropriate taxa to maximize project success and natural biodiversity. If practitioners request that seed companies and nurseries document infrataxa (or at least collection location), it will increase the likelihood of matching the correct taxon to a planting project location. Establishment from seed can vary considerably among years, sites, and exposures. In experimental plots near the coast in Orange County in 2011-2015, Kimball et al. (2017) compared the success of seeding with *E. fasciculatum* (variety not stated) on south vs. north facing slopes. The first year was wet (11.8 in, 30 cm ppt) and good for recruitment while the remaining years suffered drought (4.7−6.7 in, 12−17 cm ppt). Plants continued to grow during the drought and by the fourth year, percent cover was about 65% on the south-facing slopes and about 45% on the north-facing slopes. At western Riverside County inland sites (ecological subregion M262Bk), since 2010, *E. f.* variety *foliolosum* recruited and established naturally from seed and reached higher cover on flat to north or northwest facing slopes at much higher rates than in areas with easterly to southerly exposures (A. Montalvo pers. obs.). Many plants on southerly exposures died during the long, hot drought in the same period. In a review of restoration projects in the Mojave Desert, seeded *E. fasciculatum* (common name used suggests var. *polifolium*), established best on sandy loam and loam soils (Abella & Newton 2009). Kimball et al. (2014) found that seeding trials in Orange Co. resulted in more successful shrub establishment when mixtures of shrub/perennial grass species (*E. fasciculatum* var. *fasciculatum, Acmispon glaber, Artemisia californica, Encelia californica, Salvia apiana, Elymus condensatus*) were seeded separately from ruderal native forb species (*Deinandra fasciculata, Calandrinia ciliata, Phacelia cicutaria, Eschscholtzia californica, Lupinus succulentus, Malacothrix saxatilis*). In further studies, Bell et al. (2018) found that seedling establishment of the perennials was reduced more by competition with black mustard (*Brassica nigra*) than by the native annuals, but plots with mature plants and the highest cover of the perennial species were the most successful at resisting invasion by *Brassica nigra.* The study underlined the importance of weeding during establishment.

C. Horticulture or agriculture	Montalvo et al. (2002) found that plants of var. *foliolosum* grew quickly from seed to maturity on a graded site with low organic matter and nutrients, but establishment, growth, and flowering all decreased significantly with decreasing soil nitrogen (NO_3-N mean = 7.89 mg/g, range = 0.8−69 mg/g in the study plot). Plants require full sun and good drainage. No irrigation is required if seeds are planted before seasonal rains. Survival of seedlings can be unusually high for shrubs as shown by studies in a variety of sites and years, often ranging from 80 to 90 percent (Wright & Howe 1987, Miriti et al. 1998, Montalvo et al. 2002). Agriculture: Irrigation can reduce successful establishment from seeds. Padgett et al. (2000) examined the effect of four types of supplemental irrigation on establishment of plants from seeds planted in Riverside field plots (variety not indicated), including no supplemental water, spring water (March 1−July 1), summer water (July 1−Oct. 1), and continuous water (Dec. 1995−Oct 1996). Seedling emergence was highest and most rapid in the continuous irrigation treatment, but seedling mortality was high under irrigation. Spring watering suppressed emergence. The control and summer water plots produced the most live seedlings by the early summer, but overall, irrigation resulted in a decline in seedlings. The survival rate was 9%, 1.6%, 1.7%, and 0% for the no-water, spring irrigation, summer irrigation, and continuous irrigation plots, respectively. Recommended for hedgerows (Kreman et al. 2002). Native pollinators showed a clear preference for *Eriogonum fasciculatum* and *Salvia* spp. within hedgerow restoration sites made up of both native and non-native plants (Morandin & Kremen 2012). In subsequent studies, significant increases in crop seed yields were found in fields containing such hedgerows compared to fields lacking them (Morandin et al. 2016). The increased yields were attributed to an increase in natural pest control agents and native bees that are attracted to hedgerows. An abundance of beneficial predatory arthropods were found in the hedgerows (Morandin et al. 2014), a finding consistent with data collected on *E. fasciculatum* in wildland settings (see X. D. Wildlife value). Landscaping: The grey-green var. *polifolium* provides a nice contrast to the other green varieties in the garden, but all do well in dry landscaping. The flowers last far into the summer and become an attractive rusty-brown in fruit. Some prostrate cultivars exist, including *E. f.* 'Theodore Payne', *E. f.* 'Prostrata' , *E. f.* 'Dana Point', and *E. f.* 'Warriner Lytle' (Perry 2010). Everett (2012) recommended occasional dry season irrigation to reduce the fire hazard during fire season. He also noted that *E. f.* var. *polifolium* requires sharply draining soil and dry spots in the garden.
D. Wildlife value	The rare orange-throated whiptail is associated with open vegetation with this shrub (Brattstrom 2000). Federally listed (threatened) California gnatcatchers (*Polioptila californica californica*) forage and nest in the shrub. California buckwheat and *Artemisia californica* Less. are dominant shrubs used by gnatcatchers (Mock & Bolger 1992). The rare bighorn sheep (*Ovis canadensis nelsoni*) browses on California buckwheat in the San Gabriel Mountains of southern California (Perry et al. 1987), and deer eat the inflorescences (Schopmeyer 1974). Flowers provide an important food resource for many species of insects, among them wasps, butterflies, beetles, and bees, including the non-native honeybee (*Apis mellifera*) (Moldenke & Neff 1974). In one study, 31 species of bees were identified as visitors, 8 of which were important to pollination of crops (Kremen et al. 2002). Osborne (1998) found high abundance and diversity of arthropod species on California buckwheat. Some are species-specific feeders such as the larvae of the moth, *Hemileuca electra* Wright (Rubinoff 1998). Numerous species of butterfly larvae feed on the plants and specialize on different plant parts and taxa (Howe 1975), sometimes according to timing of growth. For example, the larvae of the butterfly *Apodemia mormo* Felder & Felder occur in three biotypes in the Mojave Desert. The spring morph feeds on California buckwheat while the others feed on species with different flowering times. Pratt & Emmel (2010) found that diapausing larvae of the endangered quino checkerspot butterfly aggregated beneath *Eriogonum fasciculatum* shrubs to a much greater extent than other plants.
E. Plant material releases by NRCS and cooperators	*Eriogonum fasciculatum* 'Duro' was developed by the NRCS for erosion control. It is a blend of six accessions collected in 1964 from six native stands in Kern, San Luis Obispo, and Modoc counties (Dyer & O'Beck 2006). Container plants of these accessions were planted together in three rows at the Pleasanton Plant Materials Center. All subsequent plantings were made with blended seed collected from these rows. The resulting open-pollinated seeds are 'Duro' California buckwheat. NRCS reports that this cultivar performs better than most shrubs in both container plantings and direct seedlings.

F. Ethnobotanical	Many uses by indigenous people have been recorded for this plant. The variety used most likely was the one native to the area where the plant was reported to have been used. Garcia & Adams (2009) reported that the primary use was seeds for food. Secondary uses included medicinal uses for which the active compounds had not been studied. These included, for example: stems and leaves in a tea for colds, headaches, painful menstruation, backaches and urinary tract infections; flowers for stomach ache, mouthwash, and as a laxative; and roots for head and stomach aches. The Cahuilla were reported to steep the flowers for an eyewash and made a decoction of the leaves for headache and stomach ache (Barrows 1967). There is some confusion over the common names of plants used by the Chumash; some of the uses for bathing, rheumatism, respiratory problems, or to suppress menstruation reported in the literature might be for a plant in the mint family with the same Chumash name rather than *E. fasciculatum* (Timbrook 2007). The Native American Database shows use of decoctions for urinary problems by the Costanoans, as an antidiarrheal and to "throw up badness in the stomach" by the Diegueno, and as anti-witchcraft by the Navajo (NAE 2018). Other medicinal uses included a poultice of powdered root applied to wounds by the Omaha and Zuni. Non-medicinal uses are also listed in the database, such as use of wood by the Kawaiisu to pierce ears.
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XII. CITATION	Montalvo, A. M., E. C. Riordan, and J. L. Beyers. 2018. Plant Profile for *Eriogonum fasciculatum,* Updated 2018. Native Plant Recommendations for Southern California Ecoregions. Riverside-Corona Resource Conservation District and U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Riverside, CA. Online: http://rcrcd.org/#Plant_Materials

XIII. LINKS TO REVIEWED DATABASES & PLANT PROFILES

(last accessed October 2018)

Fire Effects and Information System (FEIS)	http://www.feis-crs.org/feis/ No matches.
Calflora	http://www.calflora.org/cgi-bin/species_query.cgi?where-calrecnum=3243
CalScape	https://calscape.org/Eriogonum-fasciculatum-()
Jepson Interchange	http://ucjeps.berkeley.edu/interchange/
Jepson eFlora (JepsonOnline, 2nd ed.)	http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=24773
USDA PLANTS	http://plants.usda.gov/java/
NRCS/CalFlora e-Veg Guide (log in to Calflora)	https://www.calflora.org/nrcs/plant4.html#taxon=eriogonum
Native Plant Network Propagation Protocol Database (NPNPP)	http://npn.rngr.net/propagation
Native Seed Network (NSN)	http://www.nativeseednetwork.org/
GRIN (provides links to many recources)	https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx
Wildand Shrubs	https://data.fs.usda.gov/research/pubs/iitf/iitf_gtr026.pdf
Flora of North America (FNA) (online version)	http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=250060281
Flora of North America (FNA) (families covered)	http://floranorthamerica.org/families

Native American Ethnobotany (NAE)	http://naeb.brit.org/uses/search/?string=Eriogonum+fasciculatum
Woody Plant Seed Manual	https://www.fs.usda.gov/nsl/nsl_wpsm.html
Rancho Santa Ana Botanic Garden Seed Program, seed photos	http://www.hazmac.biz/seedphotoslistgenus.html
XIV. IMAGES	Seed images by John Macdonald used with permission from Rancho Santa Ana Botanic Garden Seed Program (RSABG Seed Program), with rights reserved by RSABG. Images may not be used for commercial purposes. All other images by Arlee Montalvo (copyright 2010 and 2018) unless otherwise indicated with rights reserved by the Riverside-Corona Resource Conservation District (RCRCD). Photos may be used freely for non-commercial and not-for-profit use if credit is provided. All other uses require permission of the authors and the Riverside-Corona Resource Conservation District.

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