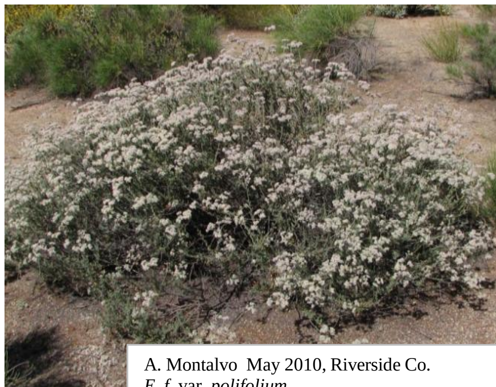
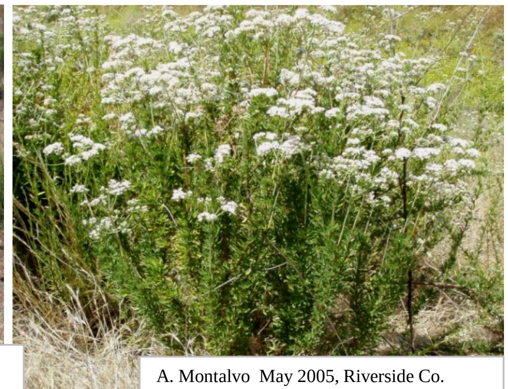
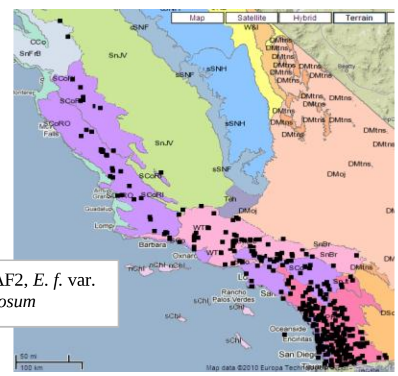
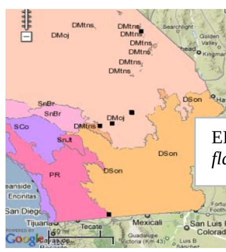
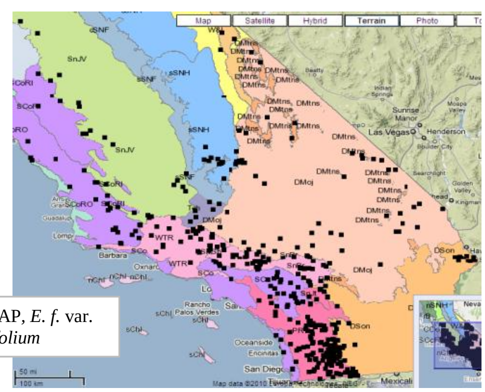
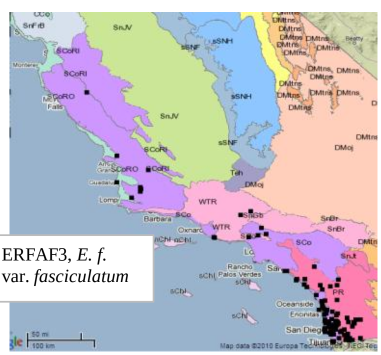
SPECIES	***Eriogonum fasciculatum* Benthum**
NRCS CODE: ERFA2  A. Montalvo 2003 *E. f.* var. *polifolium*	Family: **Polygonaceae** Order: **Polygonales** Subclass: **Caryophyllidae** Class: **Magnoliopsida**  achenes, sepals removed, ERFA2, Steve Hurst @USDA-NRCS PLANTS Database  seedling  Montalvo, Riverside Co. *E. f.* var. f*oliolosum*  A. Montalvo May 2010, Riverside Co. *E. f.* var. *polifolium*  A. Montalvo May 2005, Riverside Co. *E. f.* var. f*oliolosum*
Subspecific taxa 1. **ERFAF3** 2. **ERFAF2** 3. **ERFAP** 4. **ERFAF**	Four varieties are currently recognized in the USA (JepsonOnline 2nd Ed 2010, FNA 2010). An additional variety, *E. f.* var. *emphereium* Reveal from central Baja California, Mexico (FNA) will not be treated here. 1. *E. f.* var. *fasciculatum* Benth 2. *E. f.* var. *foliolosum* (Nutt.) Abrams 3. *E. f.* var. *polifolium Torr. & A. Gray* 4. *E. f.* var. *flavoviride* Munz & I. M. Johnston  A. Montalvo August 29, 2010, Riverside Co. *E. f.* var. *polifolium* , fruits maturing and a few late flowers
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
Common name (numbered as above)	Generally, California buckwheat or flat-topped buckwheat. Many overlapping common names have been assigned to the different varieties over the years (Painter 2009). Local annotated checklists sometimes note different common names for each variety. USDA PLANTS (2010) uses eastern Mojave buckwheat for all four varieties; this is not recommended. 1. Coastal California buckwheat, coast California buckwheat (Rebman & Simpson 2006), 2. Coastal California buckwheat, inland California buckwheat, (Rebman & Simpson 2006), interior flat-topped buckwheat (Roberts 2008) 3. Mojave Desert California buckwheat, mountain buckwheat (Rebman & Simpson 2006), gray-leaved California buckwheat, and many others (Painter 2009) 4. Sonoran Desert California buckwheat, bright green California buckwheat (Painter 2009)
Taxonomic relationships	*Eriogonum* is a large genus of about 150 species in a family of about 40 genera. It is one of the largest genera in California.

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. f*. 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 (JepsonOnline 2010); 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.* (JepsonOnline 2010). *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.
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 diploid 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.
Other	California buckwheat is a widespread and morphologically variable shrub and is one of the most important plants of sagebrush scrub, desert scrub, and especially coastal sage scrub (Kirkpatrick & Hutchinson 1977, Westman 1981). 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 1940's, with the largest decreases on alluvial soils (Minnich & Dezzani 1998). Decreases are attributed to a combination of competition with exotic annual grasses, too frequent a fire interval exacerbated by weeds that carry fire, and atmospheric deposition of nitrogen, which encourages growth of competing weeds (Montalvo 2004).
GENERAL	
Map	Data provided by the participants of the Consortium of California Herbaria ERFAF2 represent 119, 398, 37, and 502 records with with coordinate data for ERFAF2, ERFAF3, ERFAF, ERFAP, respectively. Berkeley Mapper, accessed 8/18/10 http://ucjeps.berkeley.edu/consortium. Likely includes range extensions caused by planting projects.  ERFAF2, *E. f.* var. *foliolosum*  ERFAF, *E. f. var. flavoviride*  ERFAP, *E. f.* var. *polifolium*  ERFAF3, *E. f.* var. *fasciculatum*
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 Senora 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 (FNA, JepsonOnline 2010, Montalvo 2004, Sawyer et al. 2009).

Distribution in California; Ecological section and subsection (numbered as above)	1. Central Coast and South Coast. Ecological Subsections: primarily in Central and Southern California Coast (261A, 261B); western portion of Southern California Mountains and Valleys (M262B, n). 2. Central and South Coast, San Francisco Bay Area, Inner and Outer Coast Ranges, northern and southern Channel Islands, Western Transverse and Peninsular Ranges, San Gabriel, San Bernardino, and San Jacinto Mountains. Ecological Sections: Primarily eastern portions of Central and Southern California Coast (261A, 261B); Central California Coast Ranges (M262A); Southern California Mountains and Valleys (M262B). 3. Primarily in Southeastern Great Basin, Mojave, Colorado, and Sonoran deserts; Desert Mountains; also in southern Sierra Nevada and High Sierra Foothills, Western Transverse Ranges, San Gabriel and San Bernardino Mountains, and eastern part of South Coast and Peninsular Ranges. Ecol. Sections: Primarily eastern portions of Central and Southern California Coast (261A, 261B); Central California Coast Ranges (M262A); Southern California Mountains and Valleys (M262B); eastward through Mojave Desert (322A, into Southeastern Great Basin (341F). 4. Mojave, Colorado, and Sonoran deserts; Desert Mountains. Overlaps with var. *polifolium* in warm desert regions. Primarily in Mojave Desert (322A) and Colorado Desert (322C).
Life history, life form	Polycarpic subshrub; facultatively drought deciduous. Generally long-lived (five to over 50 years; Sawyer et al. 2009).
Distinguishing traits (numbered as above)	Although the four taxonomic varieties partly overlap in geographic distribution, each is associated with a different climatic zone and combination of traits, especially color, chromosome number, leaf shape, degree of inrolled leaf margins, and pubescence (Munz & Keck 1968, Hickman 1993). 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 to 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 to 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 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 to 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 to 15 dm tall. Inner coastal foothills and valleys. **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 parienth. Plants yellowish-green, generally rounded subshrub, 6-15 dm tall. Deserts; color difference is obvious where it overlaps with var. *polifolium* (FNA).
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.*
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).
HABITAT	
Plant association groups	A shrub of 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, Lotus scoparius.* 2. Co-dominant in sage scrub with other shrubs such as *Artemisia californica, Salvia apiana, S. mellifera , Encelia californica, Lotus scoparius;* codominant in alluvial scrub with *Lepidospartum squamatum, Salvia apiana, Yucca whipplei.* Also in chaparral. 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 (FNA, Sawyer et al. 2009). 4. saltbush and creosote scrub, pinyon-juniper woodland (FNA 2010)

Habitat affinity and breadth of habitat (numbered as above)	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 (Kirkpatrick & Hutchinson 1980). 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.
Elevation range (numbered as above)	Generally, below 1200 m (Sawyer et al. 2009) 1. 0-300 m (JepsonOnline 2nd Ed. 2010) 2. 600 - 2300 m (FNA); 60-1300 m (JepsonOnline 2nd Ed. 2010). 3. generally 300-2500 m (FNA, JepsonOnline 2010) 4. 50-1300 m (FNA, JepsonOnline 2010)
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 occured on a variety of parent materials. Occurs on substrates derived from many parent rocks, including serpentinite.
Drought tolerance	Drought tolerant.
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 in) of Mediterranean climate region and with var. *flavoviride* in warm deserts (less than 10 in) where there may be occasional summer rains.
Flooding or high water tolerance	Upland species of well-drained soils; however, plants occurs in well-drained substrates in alluvial scrub and along washes that receives occasional ephemeral winter flood waters (Burk et al. 2007, A. Montalvo, pers. obs.).
Wetland indicator status for California	None
Shade tolerance	Shade intolerant. Requires full sun or nearly full sun.

GROWTH AND REPRODUCTION

Seedling emergence relevant to general ecology	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).
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. *flavoviridae* 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).
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 low, mat-forming growth form.
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). 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 has halved (Zedler et al. 1983), indicating that high fire frequency can devastate populations.
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).
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).

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).
Hybridization potential	Among varieties: Stebbins (1942) hypothesized that tetraploid populations of var. *foliolosum* arose from hybridization between diploid 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 diploid taxa. The variety *polifolium* was in areas with some snow, frost, and only 10 to 13 cm of rainfall; *fasciculatum* was in the areas with no frost, often frequent fog, and 22 to 37 cm of rainfall; and f*oliolosum* often occurred in habitats intermediate to the two diploids. 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.).
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).
BIOLOGICAL INTERACTIONS	
Competitiveness	Emerging seedlings do not compete well with non-native grasses. 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 ERFA 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). The NRCS Plant Guide (Dyer & O'Beck 2006) warns that if planted at too high a proportion of a seeding mixture, 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."
Herbivory, seed predation, disease	The larvae of the moth *Hemileuca electra* Wright feed on leaves (Rubinoff 1998) and can defoliolate 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).
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.
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.
ECOLOGICAL GENETICS	
Ploidy (numbered as above)	1. 2*n* = 40 chromosomes (Stokes & Stebbins 1955) 2. 2*n* = 80 chromosomes (Stebbins 1942) (noted as tetraploid) 3. 2*n* = 40 chromosomes (Stebbins 1942) 4. 2*n* = 40 chromosomes (FNA). n = 20 chromosomes (Reveal 1989).
Plasticity	No data found.
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 manner that correlated with morphological characters (clinal variation).

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 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).
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.
Local adaptation	The morphological clines described above (Geographic variation section) 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.
Translocation risks	Mis-specification into 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).
SEEDS	For RSABG seed images: ERFAF3? (likely, glabrous sepals): http://www.hazmac.biz/021118/021118EriogonumFasciculatum.html ERFAF2: http://www.hazmac.biz/100111/100111EriogonumFasciculatumFoliolosum.html ERFAP (note hairy sepals): http://www.hazmac.biz/090223/090223EriogonumFasciculataPolifolium.html
General	The small, reddish-brown seeds (1.5 to 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. A recommended target for minimum quality of purchased seeds is 15 percent purity and 65 percent germination (when the dried perienth is considered part of the seed; Dyer & O'Beck 2006).
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).
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).
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.
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.
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. 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. To remove persistent sepals, gently rub fruits over #25 sieve; set blower speed 2.0 to sort out empty, aborted seeds, and repeat rubbing and blowing as needed.
Seed storage	Store seeds dry. They store best under cool storage conditions.

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 18-24°C and nighttime from 14-16°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 gibberelic 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.
Seeds/lb	334,000 seeds/lb for release *E. f.* 'duro' achenes with calyx intact (Dyer & O'Beck 2006) 350,000 seeds/lb with standard purity of 10% and germination of 65% (Stover Seeds 2010) 450,000 seeds/lb (S&S Seeds 2010)
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. Seeds and container plants should be planted in the fall to early winter to take advantage of the moist cool season for growth. 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 to 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 to 0.37%). For monoculture, seeds can be planted at 9 pounds per acre drilled and 14 pounds per acre broadcast (Dyer & O'Beck 2006). In mixtures, the NRCS Plant Guide recommends 1-2 lb/acre (about 7 to 14 PLS/square meter) (Dyer & O'Beck 2006).
Seed increase activities or potential?	High potential. One cultivar, 'Duro' California buckwheat, was shown to succeed in production, but seeds of this varietal mixture may not be commercially available (NSN 2010). Fields produced about 145kg/ha (300 lbs/ac) of seed (bulk lbs with achene with calyx intact). Large quantities of seeds are commonly collected from wild populations, but seed quantity and quality is highly variable from year to year. USDA PLANTS (2010) provides detailed information about the tolerances of this species in its Conservation Plant Characteristics profile. The profile does not report about the differences between varieties and focuses on the cultivar Duro and likely on *var. polifolium* (http://plants.usda.gov/java/charProfile?symbol=ERFA2&format=print).
USES	
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, Montalvo 2004, Newton & Claassen 2003). 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.
Habitat restoration	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, most 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.

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 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 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. Used in hedgerows in Yolo and Solono Counties (Kreman et al. 2002). 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.* 'W arriner Lytle' (Perry 2010).
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.
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.
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. The Cahuilla steeped 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). Moerman's database shows use of decoctions for urinary problems by the Costanoans, as an anidiarrheal and to "throw up badness" by the Diegueno, and as anti-witchcraft by the Navajo (NAE 2010). 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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LINKS TO REVIEWED DATABASES & PLANT PROFILES
(last accessed October 1, 2010)

Fire Effects Information System (FEIS)	No matches: http://www.fs.fed.us/database/feis/
Jepson Flora, Herbarium (JepsonOnline)	http://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?24773

Jepson Flora, Herbarium, 2nd Edition Review (JepsonOnline, 2nd ed.)	http://ucjeps.berkeley.edu/tjm2/review/treatments/polygonaceae_all.html#24773
USDA PLANTS	http://plants.usda.gov/java/profile?symbol=ERFA2
Native Plant Network Propagation Protocol Database (NPNPP)	http://www.nativeplantnetwork.org/Network/
Woody Plant Seed Manual (Meyer--*Eriogonum*)	http://www.nsl.fs.fed.us/nsl_wpsm.html
Native Seed Network (NSN)	http://www.nativeseednetwork.org/
Germplasm Resources Information Network (GRIN)	http://www.ars-grin.gov/cgi-bin/npgs/html/paper.pl?language=en&chapter=scient
GRIN--additional links	http://www.ars-grin.gov/cgi-bin/npgs/html/taxgenform.pl
Wildand Shrubs	http://www.fs.fed.us/global/iitf/pdf/shrubs/Eriogonum%20fasciculatum.pdf
Flora of North America (FNA) (online version)	http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=250060281
Native American Ethnobotany Database (NAE)	http://herb.umd.umich.edu/
Calflora	http://www.calflora.org/
Rancho Santa Ana Botanic Garden Seed Program, (RSABG) seed photos	http://www.hazmac.biz/rsabghome.html

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