


<b>I. SPECIES</b>	<b><i>Ceanothus cuneatus</i> (Hook.) Nutt.</b>
<b>NRCS CODE: (CECU)</b>	Family: <b>Rhamnaceae</b> Order: <b>Rhamnales</b> Subclass: <b>Rosidae</b> Class: <b>Magnoliopsida</b> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto; margin-right: auto;"> <i>Ceanothus cuneatus</i> var. <i>cuneatus</i> in  Riverside Co. Photos by A. Montalvo. </div>
	
<b>A. Subspecific taxa</b>	<ol style="list-style-type: none"> <li>1. <i>C. cuneatus</i> (Hook.) Nutt. var. <i>cuneatus</i></li> <li>2. <i>C. cuneatus</i> (Hook.) Nutt. var. <i>fascicularis</i> (McMinn) Hoover</li> <li>3. <i>C. cuneatus</i> Nutt. var. <i>ramulosus</i> Greene</li> </ol> This profile will focus on <i>C. c.</i> var. <i>cuneatus</i> . The other varieties are provided for context.
<b>B. Synonyms</b>	Per Fross & Wilken (2006), Wilken & Burge (2016) <ol style="list-style-type: none"> <li>1. <i>C. c.</i> var. <i>dubius</i> J. T. Howell; <i>C. c.</i> var. <i>submontanus</i> (Rose) McMinn; <i>C. cuneatus</i> ssp. <i>cuneatus</i> (Hook.) Nutt.; <i>C. ramulosus</i> (Greene) McMinn; <i>Rhamnus cuneata</i> Hooker.</li> <li>2. <i>C. ramulosus</i> (Greene) McMinn var. <i>fascicularis</i> McMinn; <i>C. cuneatus</i> ssp. <i>fascicularis</i> (McMinn) C.L. Schmidt</li> <li>3. <i>C. ramulosus</i> (Greene) McMinn var. <i>ramulosus</i> McMinn; <i>C. ramulosus</i> (Greene) McMinn, in part.</li> </ol> Recently, <i>C. rigidus</i> Nutt. was removed from <i>C. cuneatus</i> (see Jepson eFlora, Wilken & Burge 2016). It had previously been considered as <i>C. cuneatus</i> (Hook.) Nutt. var. <i>rigidus</i> (Nutt.) Hoover and <i>C. cuneatus</i> ssp. <i>rigidus</i> (Nutt.) C.L. Schmidt. The changes have not been included in USDA PLANTS (2019).
<b>C. Common name</b>	<ol style="list-style-type: none"> <li>1. buckbrush, common buckbrush, wedgeleaf ceanothus (e.g., Painter 2012)</li> <li>2. Lompoc ceanothus, sedgeleaf buckbrush, sand buckbrush, clustered buckbrush (e.g. Painter 2012)</li> <li>3. Coast ceanothus (McMinn 1939); coast buck brush (FNA).</li> </ol>
<b>D. Taxonomic relationships</b>	<i>Ceanothus</i> is a diverse genus with over 50 taxa that cluster into two subgenera. <i>C. cuneatus</i> has long been recognized as part of the <i>Cerastes</i> group of <i>Ceanothus</i> based on morphology, life-history, and crossing studies (McMinn 1939a, Nobs 1963). In phylogenetic analyses based on RNA and chloroplast DNA, Hardig et al. (2000) found <i>C. cuneatus</i> clustered into the <i>Cerastes</i> group but they were not able to resolve a monophyletic <i>C. cuneatus</i> . Buckbrush appeared to be more closely related to taxa from northern California, including <i>C. masonii</i> , <i>C. gloriosus</i> , <i>C. purpureus</i> , and <i>C. sonomensis</i> . In later molecular and morphological analyses, Burge et al. (2011) also found <i>C. cuneatus</i> clustered into <i>Cerastes</i> , and into a clade with the same northern species plus <i>C. jepsonii</i> and <i>C. megacarpus</i> var. <i>insularis</i> (Eastw.) Munz. <i>Cerastes</i> included over 20 taxa and numerous subtaxa in both studies. Eight <i>Cerastes</i> taxa occur in southern California (see I. E. Related taxa in region).
<b>E. Related taxa in region</b>	In southern California, the most closely related taxon may be <i>C. megacarpus</i> var. <i>insularis</i> (Burge et al. 2011). All other southern California <i>Cerastes</i> taxa cluster into other clades, including: two varieties of <i>C. crassifolius</i> Torrey, two varieties of <i>C. megacarpus</i> Nutt., <i>C. ophiochilus</i> S. Boyd, T. Ross, & L. Arnseth, <i>C. otayensis</i> McMinn, <i>C. perplexans</i> Trel., and <i>C. vestitus</i> Greene (Burge et al. 2011).
<b>F. Taxonomic issues</b>	The taxonomy of <i>C. cuneatus</i> and <i>Ceanothus</i> section <i>Cerastes</i> is unstable. Overlapping variation in many traits among varieties make the taxonomy of <i>C. cuneatus</i> difficult (Wilken & Fross 2006). They note introgradation between <i>C. c.</i> var. <i>fascicularis</i> , var. <i>ramulosus</i> , and what is now known as <i>C. rigidus</i> , in coastal San Luis Obispo County. The most recent treatment of <i>Ceanothus</i> by Burge et al. (2015) suggests more morphological, ecological and genetic work is needed to determine if <i>C. c.</i> var. <i>dubius</i> J. T. Howell warrants status as a variety. It appears to have an unusual ecology and morphology and may be locally adapted.
<b>G. Other</b>	One of the main shrubs of chaparral in California (McMinn 1939a). It is the second most widespread species of <i>Ceanothus</i> and the most widespread <i>Cerastes</i> in the Sierra Nevada at low to mid elevations (Burge et al. 2015).

## II. ECOLOGICAL & EVOLUTIONARY CONSIDERATIONS FOR RESTORATION

### A. Attribute summary list (based on referenced responses in full table)

Focal taxon: *C. cuneatus* var. *cuneatus*

Taxonomic stability - low  
 Longevity - 20 to 100+ years  
 Parity - polycarpic  
 Flowering age - 5+ years  
 Stress tolerance - moderate to high  
 Environmental tolerance - broad  
 Reproduction after fire - obligate seeder  
 Fragmentation history - historical and recent  
 Habitat fragmentation - high at low elevation  
 Distribution - widespread; more common in central and northern California  
 SDM projected midcentury suitable habitat - 27–82% stable  
 SDM projected midcentury habitat gain - loss > gain under four of five future climate scenarios (assuming unlimited dispersal)

Seeds - dormant, form seed bank, long-lived  
 Seed dispersal distance - local to intermediate  
 Pollen dispersal - intermediate to far  
 Breeding system - likely outcrossed  
 Population structure - likely low at small geographic scales.  
 Adaptive trait variation - unknown  
 Chromosome number - stable  
 Genetic marker polymorphism - high  
 Average total heterozygosity - likely high  
 Hybridization potential - moderate to high within

### B. Implications for seed transfer (summary)



One-yr old *C. cuneatus*. R. Brandon Pratt © 2019.

Dispersal in *C. cuneatus* is likely to help counter the isolating effects of habitat fragmentation. The major form of gene dispersal in *C. cuneatus* is by pollen movement by bees, especially bumblebees and honeybees, which can move pollen hundreds of meters to over a kilometer away. Seed dispersal is less likely to combat fragmentation because seeds disperse primarily near the seed-bearing plant. Although plants may suffer and die back after prolonged drought, subsequent fire can rejuvenate populations from long-lived seed banks as long as soil moisture is sufficient, seedlings reach maturity, and fire return intervals are long enough to allow seed numbers to build up in the face of drought and seed losses to predation. In areas where populations become fragmented by development or type conversion, restoration may be needed to form migration corridors. For any planting site, best practices would include using seeds collected from many plants and potentially from several sites within the home ecological region and subregion of the plant, and within 1000 feet in elevation. Ample gene flow and broad tolerance to soil type, slope aspects, and temperature swings may make microhabitat matching unnecessary. However, plants from two neighboring ecological regions with different precipitation normals and minimum temperatures have been found to respond differently to water stress; and heritable adaptive differences have not been ruled out. There are insufficient data to justify relaxing seed transfer to outside the ecological region of the planting site. When moving seeds within ecological regions, the warming of the climate and increasing climatic water deficit suggests that moving seeds from warmer toward cooler ecological subregions would be more prudent than the reverse.

## III. GENERAL

### A. Geographic range

1. Widely distributed from southern Washington (Burge et al. 2015, Gordon & White 1994) southward through Oregon and California into northern Baja California (McMinn 1939a).
2. Rare and narrowly distributed in Central Coast of Santa Barbara and San Luis Obispo counties.
3. Narrowly and disjunctly distributed on serpentine soils in San Francisco Bay area and coastal slopes of western San Luis Obispo and Santa Barbara County (FNA 2019).

### B. Distribution in California; ecological section and subsection (sensu Goudey & Smith 1994; Cleland et al. 2007)

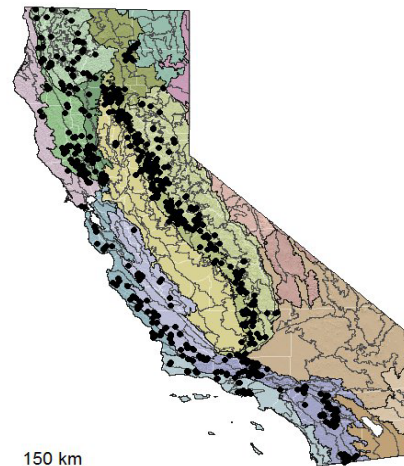
Section Code	
261A	M261G
261B	M262A
262A	M262B
263A	322A
M261A	322B
M261B	322C
M261C	341D
M261D	341F
M261E	342B
M261F	Salton Sea

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.

Southern California Mountains and Valleys  
 M262B: a-c,g,j-m,o,p  
 Southern California Coast 261B: a,b,d-g  
 Mojave Desert 322A: g, (bordering M262B)

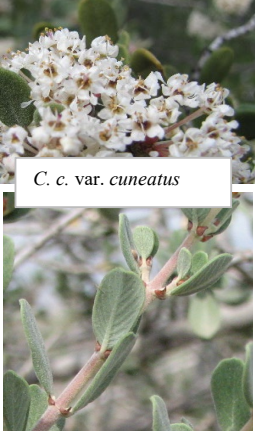
Central California Coast 261A: f,g,j,k  
 Central California Coast Ranges M262A: c-f,h,j  
 Great Valley 262A: a,c,g,h,o,y  
 Northern California Coast 263A: g,l,m  
 Northwestern Basin and Range: 342B: c  
 Klamath Mountains M261A: a-j, r,u,  
 Northern California Coast Ranges M261B: a,b,d,f  
 Northern California Interior Coast Ranges M261C: a-c  
 Southern Cascades M261D: h,j,l,m  
 Sierra Nevada M261E: d-g,h,m,p-s,u  
 Sierra Nevada Foothills M261F: a-e  
 Modoc Plateau: M261G: d,j

*Ceanothus cuneatus* var. *cuneatus*



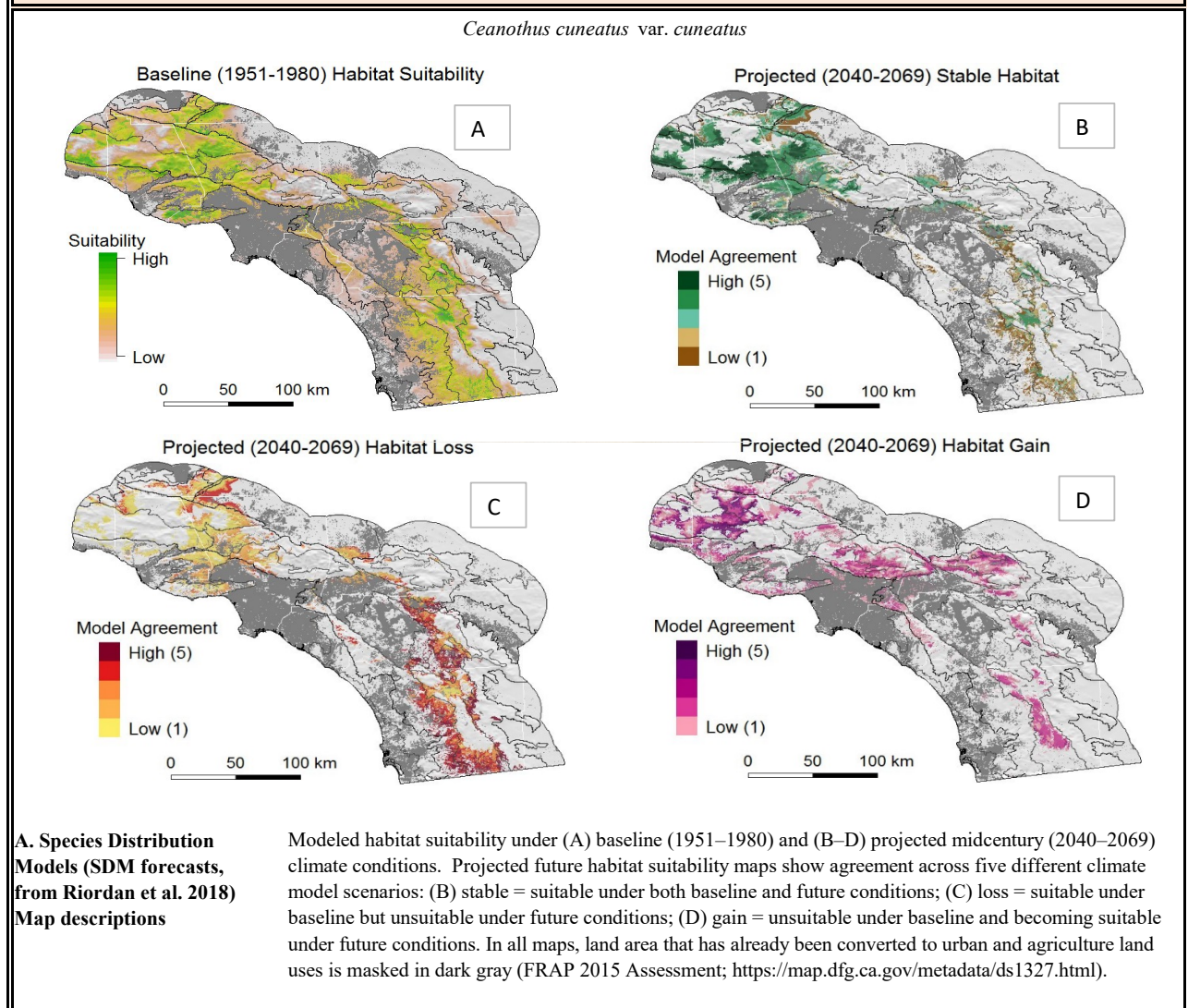
### C. Life history, life form

Shrub, polycarpic, evergreen, long-lived (to 100+ years), obligate seeder (Keeley 1975, Sawyer et al. 2009).

<p><b>D. Distinguishing traits</b></p>  <p><i>C. c. var. cuneatus</i></p>	<p>After (Wilken &amp; Berg 2016, Schmidt &amp; Wilken in FNA 2019), all varieties evergreen with opposite leaves, knoblike stipules, and capsules with short, erect horns. .</p> <ol style="list-style-type: none"> <li><i>C. c. var. cuneatus</i>. Rigid shrub, 1–3.5 m tall, twigs gray-brown; leaves on spur-like, divergent, rigid branchlets, opposite, sometimes several at a node, blade elliptic, oblanceolate or obovate, gray-green, hairless or pubescent above, 5–15 mm long, 3–10 mm wide, tip acute to rounded, margin generally entire; flowers white, February to May; capsules 5–6 mm.</li> <li><i>C. c. var. fascicularis</i>. Shrub erect, open, generally less than 2.5 m tall, twigs generally brown; some leaves clustered (fascicled), 9–15 mm long, 3–6 mm wide, oblanceolate to narrowly obovate, tip truncate to notched usually obtuse; flowers pale blue to lavender. Not associated with serpentine soils.</li> <li><i>C. c. var. ramulosus</i>. Shrub, erect, ascending to spreading, usually 1–2.5 m tall, twigs gray to grayish-brown; leaves generally two per node, cupped and widely oblanceolate to round, 5–15 x 3–12 mm, length less than two times the width, margin generally entire, occasionally 1–4 toothed, leaf tips rounded, truncate or notched; flowers lavender to blue; fruit 5–6 mm wide. On serpentine soils.</li> </ol>
<p><b>E. Root system, rhizomes, stolons, etc.</b></p>	<p><i>Ceanothus cuneatus</i> has been observed to produce sprouts occasionally from exposed roots (Conrad 1987). No species-specific descriptive information found, but based on physiological response to drought stress (Davis et al. 1999), the root system is likely similar to that of <i>C. crassifolius</i>, for which measurements exist. <i>Ceanothus crassifolius</i> has a branched, shallow spreading root system from a short tap root. Hellmers et al. (1955) found an average maximum radial spread of 7.3 ft (2.2 m) and many lateral roots up to 14 ft (4.3 m) long. Long lateral roots were found on plants growing in shallow soil. Roots did not appear able to penetrate fine cracks in unweathered rock.</p>
<p><b>F. Rooting depth</b></p>	<p>A species in the same subgenus <i>Cerastes</i> (<i>C. crassifolius</i>) has shallow roots, observed to about 1.2 m deep (Hellmers et al. 1955). <i>Ceanothus cuneatus</i> is assumed to be similar (Davis et al. 1999). Roots of seedlings have been found to grow rapidly, with taproots averaging 4.5 inches after 15 days, then branching and reaching 30–43 inches deep, and to 26 inches laterally in three months (Schultz et al. 1955).</p>
<p><b>IV. HABITAT</b></p>	
<p><b>A. Vegetation alliances, associations</b></p>	<p>The following information pertains to <i>C. c. var. cuneatus</i> generally. Known from many chaparral plant communities statewide and in the understory of woodland and forest types in central and northern California (Munz &amp; Keck 1968, Holland 1986, Gordon &amp; White 1994, Sawyer et al. 2009). In southern California, often co-codominant with <i>Adenostoma fasciculatum</i>, <i>Arctostaphylos glauca</i>, <i>Ceanothus integerrimus</i>, <i>Eriogonum fasciculatum</i>, <i>Hesperoyucca whipplei</i>, <i>Heteromeles arbutifolia</i>, <i>Malosma laurina</i>, <i>Juniperus californica</i>, <i>Quercus berberidifolia</i>, <i>Rhus ovata</i>, or <i>Salvia mellifera</i>. Historic fire frequencies for chaparral with <i>C. cuneatus</i> are estimated to be 25 to 40 years in southern California (Sawyer et al. 2009). In the Sierra Nevada, Keeley et al. (2005) found that the density of <i>C. cuneatus</i> in mature stands of chaparral that had burned within 50–60 years was much higher than in ancient stands that had not burned for about 90–150 years, suggesting this obligate seeder dies out and communities may shift toward dominance by resprouting species over time. This trend may depend on local conditions.</p> <p>Dominant within the <i>Ceanothus cuneatus</i> shrubland alliance (Sawyer et al. 2009). In southern California, it is also codominant in the following associations:</p> <p><i>Ceanothus cuneatus</i>–<i>Adenostoma fasciculatum</i>; <i>Ceanothus cuneatus</i>–<i>Eriodictyon californicum</i>; <i>Ceanothus cuneatus</i>–<i>Adenostoma fasciculatum</i>–<i>Salvia mellifera</i>–<i>Malosma laurina</i>.</p> <p>Also found in: <i>Adenostoma sparsifolium</i> shrubland alliance in <i>Adenostoma sparsifolium</i>–<i>Ceanothus cuneatus</i> association; <i>Arctostaphylos glandulosa</i> shrubland alliance in <i>Arctostaphylos glandulosa</i>–<i>Adenostoma fasciculatum</i>–<i>Ceanothus cuneatus</i> association; <i>Arctostaphylos glauca</i> shrubland alliance in <i>Arctostaphylos glauca</i>–<i>Adenostoma fasciculatum</i>–<i>Ceanothus cuneatus</i> association; <i>Cercocarpus betuloides</i> shrubland alliance in <i>Cercocarpus betuloides</i>–<i>Ceanothus cuneatus</i> association.</p>
<p><b>B. Habitat affinity and breadth of habitat</b></p>	<p>Typically found on ridges and upper slopes with shallow, well-drained soils (Sawyer et al. 2009). The most widely distributed species in the genus within the United States according to McMinn (1939a). Plants appear to have broad tolerances to soil type and slope aspect (see VIII. Local adaptation), and they are known to be more tolerant of cold temperatures and cold air drainages than some other co-occurring chaparral shrubs (Davis et al. 2007a). <i>C. c. var. cuneatus</i> occurs in chaparral and in dry forest openings or understories (Conrad 1987, Sawyer et al. 2009). It can be abundant after fire in the lower montane forest zone of the Sierra Nevada (van Wagtenonk et al. 2018, J. Beyers pers. obs.).</p>
<p><b>C. Elevation range</b></p>	<p>From 15 to 1800 m (Conrad 1987, Sawyer et al. 2009). <i>Ceanothus c. var. cuneatus</i> generally occurs below 2000 m (Jepson e-Flora 2019).</p>

<b>D. Soil: texture, chemicals, depth</b>	Found on shallow, well-drained soils derived from a variety of igneous and sedimentary rocks including volcanic, serpentine, gabbro, sandstone, diorite, granite, as well as on recent alluvial deposits (Nobs 1963, Burge & Manos 2011). However, plants prefer non-serpentine soils and when on gabbro soil, they tend to be on the more nutrient-rich forms of gabbro (Burg & Manos 2011, Bieger et al. 2014).
<b>E. Precipitation</b>	<i>Ceanothus cuneatus</i> var. <i>cuneatus</i> occurs in areas where precipitation falls primarily from November through May during the cool season in areas with 250-900 mm (10-35 in) annually (League 2005).
<b>F. Drought tolerance</b>	Considered highly drought tolerant as in other members of <i>Ceanothus</i> section <i>Cerastes</i> (Davis et al. 1999, Pratt et al. 2007). <i>Ceanothus cuneatus</i> var. <i>cuneatus</i> was found to have highly negative water potentials (predawn and midday) late in the dry season and high resistance to water stress-induced cavitation of stems and roots; however, after extreme droughts lasting multiple years, this shallow-rooted species suffered high mortality (Pratt et al. 2007, Venturas et al. 2016). In contrast, adult plants suffered less damage than other chaparral shrubs when a long and severe drought was accompanied by a hard freeze (Davis et al. 2007a). Seedlings that germinate after winter or spring prescribed burns may not have enough time to grow roots deep enough to survive summer drought (Florence & Florence 1988).
<b>G. Flooding or high water tolerance</b>	No information. Does not occur where flooding is frequent, but does occur in gravelly, well-drained floodplains that infrequently flood and where waterlogging is brief.
<b>H. Wetland indicator status for California</b>	none
<b>I. Shade tolerance</b>	Mature plants, full sun. Seedlings emerge in sun or shade (Adams 1962), but inhibition of nitrogen-fixing nodulation in the shade suggests a lack of shade tolerance (Pratt et al. 2012).


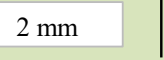
## V. CLIMATE CHANGE AND PROJECTED FUTURE SUITABLE HABITAT




<b>B. SDM summary</b>	<p>Species distribution model predictions of future suitable habitat for <i>C. cuneatus</i> var. <i>cuneatus</i> under 21st century climate change are highly variable. Assuming a future of continued high greenhouse gas emissions, Riordan et al. (2018) predicted 27–82% of baseline habitat for <i>C. c.</i> var. <i>cuneatus</i> in southern California would remain suitable (stable) under mid-century conditions across future climate scenarios from five different general circulation models (GCMs) (V. A. Fig. B). Predicted gain in suitable habitat in southern California was moderate (12–53%) and loss exceeded gain under four of five climate scenarios. Greatest loss in suitable habitat (73%) was predicted under the driest scenario. Suitability loss throughout much of the Peninsular ranges was projected under four of the five future climate scenarios considered. In contrast, Principe et al. (2013), predicted high stability in suitable habitat for <i>C. c.</i> var. <i>cuneatus</i> in the Peninsular Ranges under projected mid-century climate conditions.</p> <p>Land use, altered fire regimes, and their interaction with climate change could negatively affect <i>C. cuneatus</i>. Obligate seeding shrubs with shallow root systems are expected to suffer heightened mortality in response to extended drought and extreme heat events, and some climate change models predict an increase in extreme events (Jacobsen &amp; Pratt 2018). The resulting dead fuels are susceptible to ignition as ignition sources increase. In southern California human activity is the primary driver of fire (Keeley &amp; Syphard 2016) with fire ignitions and fire frequency increasing with human population growth (Syphard et al. 2009). Because it only reproduces from seed after fire (Keeley et al. 2006), <i>C. cuneatus</i> can be adversely affected by shortened fire return intervals that don't allow time for shrubs to mature and accumulate enough seeds in the soil seed bank to replace killed shrubs. The high level of habitat conversion and fragmentation at lower elevations of the species' range creates a considerable barrier to dispersal and gene flow that could negatively affect the adaptive capacity and ability of the species to respond to changing conditions. Riordan and Rundel (2014) caution that human land use may compound projected climate-driven losses in suitable habitat in southern California shrublands.</p>
<b>C. SDM caveat (concerns)</b>	<p>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, population dynamics and 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.</p>
<b>VI. GROWTH, REPRODUCTION, AND DISPERSAL</b>	
<b>A. Seedling emergence relevant to general ecology</b>	<p>Seedlings of this obligate seeder emerge after fire and large colonies are often formed within a few years (McMinn 1939a). Seedlings have toothed leaves (McMinn 1939a). Seed germination also occurred after mastication treatments in northern California in the absence of fire (Wilkin et al. 2017), likely due to soil heating after plant canopy removal. Shrub density and cover were greatest after fall mastication (compared to prescribed fire or spring mastication treatments).</p>
<b>B. Growth pattern (phenology)</b>	<p>Seedlings emerge predominantly in the first winter to spring following fire (Keeley et al. 2006). In central California, Schultz et al. (1955) noted <i>C. cuneatus</i> seedlings emerged mostly mid-March to mid-April in the foothills of the Sierra Nevada in central California and that this varied depending on rainfall patterns and weather. Plants begin to reach reproductive maturity in about 5 years (Sawyer et al. 2009), but it can take multiple years for seeds to accumulate in the soil. Flowering occurs February to May (CCH 2016), with later flowering at the higher elevations. Fruit maturation occurs in April to June, with seeds mostly dispersed by June. While some leaves remain all year, a major portion of them can be lost during the dry summer months (Baker et al. 1982). The timing of these events may vary year to year depending on temperature and precipitation patterns.</p>
<b>C. Vegetative propagation</b>	<p><i>Ceanothus cuneatus</i> has been observed to produce sprouts occasionally from exposed roots (Conrad 1987). However, there are no specialized structures for vegetative spread.</p>
<b>D. Regeneration after fire or other disturbance</b>	<p>This shrub is killed by fire and is considered to be an obligate seeder after fire (Keeley et al. 2006). After fire, seedlings had higher survival to the second year in plots that had dead wood added to canopies before the fire, compared to plots with clipped canopies or no canopy (Schwilk 2003). Keeley et al. (2006) examined recruitment for five years after fire at three sites in southern California and found 97% of the many thousands of seedlings emerged in the first spring after fire. The remaining 3% emerged the second year. Two flushes of seedlings of approximately equal magnitude were noted after a March (spring) prescribed fire, one the year of the fire and the other a year later (Beyers &amp; Wakeman 2000), suggesting that cold stratification requirements might not have been met for all the seeds the first growing season. Florence &amp; Florence (1988) suggest that late wet-season prescribed burns could have lower <i>C. cuneatus</i> seedling survival.</p>

<b>E. Pollination</b>	The small, unspecialized flowers of all <i>Ceanothus</i> species are visited by a variety of insects that can pollinate their flowers. Twenty species of bees were recorded on <i>C. cuneatus</i> in one study in California (Kremen et al. 2002). Of these, 9 species were found to also visit crop plants. In a different study, 18 species were recorded toward the end of the flowering season at Pinnacles National Monument (Messinger & Greiswold 2002). Moldenke & Neff (1974) recorded many species of bees (large and small) as well as flies and beetles. Bee genera included: <i>Andrena</i> , <i>Bombus</i> (including <i>B. vosnesenskii</i> and <i>B. edwardsii</i> ), <i>Evylaeus</i> , <i>Hylaeus</i> , <i>Chelostomopsis</i> , and <i>Panurginus</i> . Most species of <i>Ceanothus</i> are visited by a variety of insects, including small flies, bees, and occasionally butterflies (Moldenke 1976, Fross & Wilken 2006). <i>Ceanothus</i> is an important pollen plant for bumble bees ( <i>Bombus</i> species) (Thorp et al. 2002).
<b>F. Seed dispersal</b>	When capsules dehisce, the ovary pops off and seeds are explosively ejected. Seeds are secondarily dispersed by animals and dispersed downslope by gravity. Seed casting distances were measured in <i>C. cuneatus</i> (Evans et al. 1987). Most seeds were cast in the middle of the day (when temperature highest and relative humidity lowest); 32% of the seeds fell beneath shrubs, 42% at the edges, decreasing outward to 1.9% at 9 m.
<b>G. Breeding system, mating system</b>	Likely self-incompatible and outcrossing, but reports have been mixed. Nobs (1963) found some taxa in the <i>Cerastes</i> group to be self-incompatible, but some were "partially" self-fertile. <i>Ceanothus cuneatus</i> was not among the taxa stated to be self-incompatible. Moldenke (1976) reports <i>Ceanothus</i> as self-incompatible, but Fross & Wilken (2006) concluded from the early studies of McMinn (1944) and Nobs (1963) that most <i>Ceanothus</i> are self-compatible. In studies that focused on interspecific crosses, Burge et al. (2013) did not obtain seeds from self or cross pollination of <i>C. cuneatus</i> from a single population; however, crosses with another taxon did produce some seeds (see VI. H. Hybridization potential).
<b>H. Hybridization potential</b>	In areas where <i>C. cuneatus</i> overlaps with other species in the <i>Cerastes</i> group, there is potential for hybridization, and various botanists have suspected hybridization based on morphological intermediates between species (Nobs 1963). In a greenhouse and garden setting, Nobs (1963) conducted crosses among taxa of the <i>Cerastes</i> group and also attempted crosses between <i>Cerastes</i> and subgenus <i>Ceanothus</i> taxa. All interspecific hybrids within <i>Cerastes</i> were fertile and produced highly fertile pollen, normal seed set, and viable F1 progeny, including <i>C. cuneatus</i> crosses with <i>C. rigidus</i> , <i>C. jepsonii</i> var. <i>albiflorus</i> , <i>C. purpureus</i> , <i>C. masonii</i> , and <i>C. gloriosus</i> var. <i>porrectus</i> . However, hybridization between taxa from different subgenera nearly always failed indicating genetic barriers to hybridization. In contrast, Burg et al. (2013) found pre-zygotic sterility barriers interfere with success of crosses with <i>C. roderickii</i> , of the <i>Cerastes</i> group. There was also postzygotic failure of F1 seedlings associated with the different soils to which the plants are adapted. Molecular (ALFP) studies showed very little gene exchange across different soil types occupied by the parental species. Results suggest very little potential for gene exchange between these two species. Also, Hardig et al. (2002) examined the genetics of putative hybrid taxa resulting from past hybridization between <i>C. c.</i> var. <i>cuneatus</i> and other taxa. Their results were consistent with some expectations based on past hybridization events, but also with expectations of evolutionary diversification in an increasingly heterogeneous environment. However, Burg et al. (2015) have documented hybridization between <i>C. cuneatus</i> and <i>C. prostratus</i> where populations come into contact.
<b>I. Inbreeding and outbreeding effects</b>	Data not sufficient.
<b>VII. BIOLOGICAL INTERACTIONS</b>	
<b>A. Competitiveness</b>	<i>Ceanothus cuneatus</i> seedlings grow fairly quickly, putting down a tap root below the depth of herbaceous plant roots in the first growing season under favorable conditions (League 2005). However, when growing in stands of non-native ryegrass ( <i>Festuca perennis</i> , aka <i>Lolium multiflorum</i> ), root growth was found to be stunted compared to when growing alone (Schultz et al. 1955). In contrast, at low elevations in the Sierra Nevada, they may occur in low densities interspersed among the foothill trees (R. B. Pratt pers. com.). The species is more resistant to drought-induced xylem cavitation than a co-occurring sprouting <i>Ceanothus</i> species, <i>C. oliganthus</i> , in the Santa Monica Mountains, suggesting it could have a competitive advantage in dry years (Davis et al. 1999). McMinn (1939a) mentions plants often grow in dense thickets that can exclude other species.
<b>B. Herbivory, seed predation, disease</b>	Mice and birds feed on the seeds of this species, along with some insects (League 2005). Deveny and Fox (2006) found that seed predation by rodents (especially deer mice) was inversely related to the intensity of browsing in the closely related <i>C. rigidus</i> in central California. Exit holes from insects are often found in seeds. Chalcids in the genus <i>Eurytoma</i> are known to parasitize seeds of <i>Ceanothus</i> species (Huffman 2002). Plants may suffer branch dieback during severe drought years. <i>Ceanothus cuneatus</i> var. <i>ramulosus</i> and the closely related <i>C. crassifolius</i> were shown to be susceptible to infection by <i>Botryosphaeria dothidea</i> (Brooks & Ferrin 1994) which causes lesions. Diverse taxa of chaparral shrubs were also susceptible, which suggests the same for all <i>C. cuneatus</i> infrataxa.

<b>C. Palatability, attractiveness to animals, response to grazing</b>	Deer, goats and sheep browse the leaves and cattle use it sparingly (Sampson & Jespersen 1963). Leaves have higher total crude protein than the average evergreen shrub, and deer digest the leaves similarly to hay.
<b>D. Mycorrhizal? Nitrogen fixing nodules?</b>	Actinorhizal. Develops symbiotic association with an endophytic, filamentous N-fixing bacteria in the genus <i>Frankia</i> (Murry et al. 1997, Oakley et al. 2004). <i>Frankia</i> forms nodules on the roots and nodulation can occur in young seedlings; low water availability appears to limit nodulation (Pratt et al. 1997). Nodules on seedlings were lacking in open, postfire soils until irrigated. Pratt et al. (2012) also found nodule formation in seedlings was inhibited in the shade, suggesting lack of shade tolerance. White (1969) found that nitrogen-fixing nodules rarely formed in serpentine soil but were nearly always present in non-serpentine soils. <i>Ceanothus cuneatus</i> also forms associations with arbuscular mycorrhizal (Rose 1980, He et al. 2006) and possibly also ectomycorrhizal fungi. Most actinorhizal plants also form mycorrhizae (Rose 1980, Chaia et al. 2011).
<b>E. Insect pollinators</b>	Several of the bee genera that visit <i>C. cuneatus</i> (see VI. C. Pollination) are known to have species that forage over large distances, which may facilitate intermediate to long-distance pollen movement among flowers. Several species of <i>Bombus</i> were found to fly distances of 1,000 to 10,000 m, and several species of <i>Andrena</i> , <i>Lassioglossum</i> , and <i>Hylaeus</i> were found to forage over hundreds of meters and some to over 1000 m (Zurbuchen et al. 2010). However, the way different species of bees travel across fragmented habitat or respond to the spatial scale of urbanization varies (Schochet et al. 2016). The butterflies, small flies, and beetles visitors to flowers tend to move pollen short distances and are less likely than the bees to move pollen among plants.
<b>VIII. ECOLOGICAL GENETICS</b>	
<b>A. Ploidy</b>	$2n = 24$ (Nobs 1963). This is common to the many <i>Ceanothus</i> taxa counted as of 1963.
<b>B. Plasticity</b>	The broad distribution of <i>C. c. var. cuneatus</i> and its occurrence on many types of soil (see III. A. General distribution) suggests broad habitat tolerances. This could involve a combination of plastic response and genetic differences over its range.
<b>C. Geographic variation (morphological and physiological traits)</b>	<i>Ceanothus c. var. cuneatus</i> was included in a UPGMA analysis of genetic identity with four potentially hybridizing taxa in northern California, but no geographic patterns were detected (Hardig et al. 2002). Fross and Wilken (2006) note that there is a lot of morphological variation but few obvious geographic patterns within var. <i>cuneatus</i> . Low growing, mounding plants less than 1 m tall occur in the Klamath Mountain region, and prostrate forms have been reported. The most obvious geographic variants have been described as different varieties. Jacobsen et al. (2014) examined vulnerability to cavitation, a measure of dehydration tolerance, in plants from contrasting environments in southern California. Plants from the colder, higher precipitation San Gabriel Mountains were more vulnerable to cavitation than plants from the coastal Santa Monica Mountains. It is not known if the differences reflect a plastic response owing to plants having developed under different environmental conditions, genetic differences in traits associated with cavitation resistance, or a combination of effects. Results from common garden experiments are needed to help disentangle potential underlying controls.
<b>D. Genetic variation and population structure</b>	In a study of seven populations of <i>C. c. var. cuneatus</i> from northern California, Hardig et al. (2002) found the percent of polymorphic loci ranged from 14.3% to 57.1% with a mean of 34.7%. The average alleles/locus ranged from 1.4 to 2.4, with a mean of 1.8 alleles. Burge & Manos (2011) sampled soil and genomic DNA from 33 populations of <i>C. c. var. cuneatus</i> from across the taxon's range (except for southern Washington). Looking at this larger geographic scale, they found geographic clustering of NIA isolates for the Sierra Nevada of California and Cascade Ranges of Oregon. There was also a genetic split between populations from the region comprising the Klamath-Siskiyou and Coast Ranges and those from the region comprising the Cascades, Sierra Nevada, Peninsular Ranges, and Transverse Ranges.
<b>E. Phenotypic or genotypic variation in interactions with other organisms</b>	No information found.
<b>F. Local adaptation</b>	In a reciprocal transplant experiment of <i>C. cuneatus</i> seedlings from serpentine versus sandstone soils and north versus southern slope aspects, Bieger et al. (2014) found no evidence for local adaptation at the level of microsites. After two years, survival and growth was less on serpentine soil no matter the soil of the parent (source) population, and seedlings from the different source soils performed similarly in both recipient soil types. They also found no significant differences in growth on north and south facing slope aspects. The two populations tested appeared to have broad tolerances at a local geographic scale.

<b>G. Translocation risks</b>	Work by Bieger et al. (2014) suggests that careful matching of soil type or slope aspect may not be important in this species (see VIII. F. Local adaptation). There are no studies examining how populations from very different latitudes, elevations, or geographic regions perform relative to one another at different locations. Given the large geographic range of <i>C. c. var. cuneatus</i> and evidence of a genetic split between two major geographic clusters of regions (see VII. D. Genetic variation and population structure), it would be prudent to move plants only within the geographic areas represented by the split. Many studies of other widely distributed species have shown differences in adaptation over a species' range.
<b>IX. SEEDS</b>	<p>Seed image by John Macdonald (RSA Seeds 2016).</p> <p>Note exit holes in parasitized seeds in photo on right.</p> <div style="text-align: center;">  </div> <div style="text-align: center; margin-top: 10px;">  </div>
<b>A. General</b>	Seeds of this obligate seeding species are expected to live a long time in storage and in the soil seed bank. Normally, heat scarification occurs when fire burns over the soil. Seed availability is listed as variable (Stover Seed Company 2019).
<b>B. Seed longevity</b>	Long-lived. When not eaten, seeds are assumed to have considerable longevity in the soil (Sawyer et al. 2009). Keeley et al. (2005) found significant seedling recruitment in chaparral stands that hadn't burned in well over 100 years in the Sierra Nevada. Seedlings emerge from long-unburned forest stands after high severity fire, suggesting good long-term survival there as well (van Wagtenonk et al. 2018). Seeds are expected to last many years under dry storage. Everett (2012) found that seeds collected from 14-year old herbarium specimens germinated after providing dormancy breaking treatment. Quick & Quick (1961) got 98% germination of a 17. 4 year-old seed lot after dormancy-breaking treatment.
<b>C. Seed dormancy</b>	Seeds of <i>C. cuneatus</i> have both physical and physiological dormancy (Baskin & Baskin 1998). The tough seed coat is typically broken by fire, but may also occur from other types of mechanical scarification or exposure to hot solarization (Conard & Reed 2008). Keeley (1987) found that heat and light increased germination of <i>C. cuneatus</i> seeds in a laboratory experiment; charate treatment increased germination rate in darkness above that of heat treatment alone, but had no effect when seeds were exposed to light. After a spring (March) prescribed fire in the Santa Ynez mountains, seedlings appeared late spring in the year of fire and additional germinations occurred the following year (Beyers & Wakeman 2000), possibly because of insufficient cold stratification of some seeds the first year. See IX. H. Seed germination for treatment details. In some <i>Ceanothus</i> species, the need for cold stratification may differ for populations from different elevations, with shorter times for the lowest elevations (Conard & Reed 2008).
<b>D. Seed maturation</b>	Fruits mature in late spring, and seeds are usually all dispersed by June or July (Baker et al. 1982, CCH 2016).
<b>E. Seed collecting and harvesting</b>	Fruits dehisce explosively, casting seeds away from the parent plant. Thus they need to be collected just as they are ripening (but not too soon), or branch tips can be enclosed in cloth or mesh bags to capture seeds on maturity (Conard & Reed 2008, DeSiervo 2011). Almost-mature fruits should be stored in a paper bag to dry, shatter, and release seeds. Seeds are best collected from single-species stands to decrease the probability that the seeds are the result of hybridization with other related species of <i>Ceanothus</i> (Conard & Reed 2008).
<b>F. Seed processing</b>	Processing is difficult unless capsules are collected just before they pop or collected by bagging as described in IX. E. Seed collecting and harvesting, above. For one collection, seeds were cleaned to 99% purity by breaking dry capsules open by hand followed by air-screened using a Clipper with a #10 tiangle and top and bottom screens at high speed (Barner 2009). Alternatively, processing can be done same as for other species of <i>Ceanothus</i> . For mature capsules collected before they pop, the dried capsules can be crushed or passed through a mill then screened if they do not shatter during drying. Rub fruits over medium screens, then use seed blower to remove fruit parts from seeds. Higher blower speeds can be used to separate hollow seeds (from seed predators or seed abortion), or hollow seeds can be floated off in water (Wall & Macdonald 2009).
<b>G. Seed storage</b>	Dry, cool storage (around 4.5 °C) is recommended (Conard & Reed 2008).



<b>H. Seed germination</b>	<p>Seeds require heat treatment to break the physical dormancy (Keeley 1987, Emery 1988) and cold treatment to break the physiological dormancy (see IX. C. Seed dormancy). Ten minutes dry heat in an oven at 100 °C works to break dormancy for many species of <i>Ceanothus</i>. Keeley (1987) and Wilkin et al. (2013) had some success with 100 °C for 5 min (52% and 6.7%, respectively). In the later, germination rose to 17% when heat was combined with liquid smoke treatment. Emery (1988) recommends hot water treatment and 3 months cold stratification to stimulate germination. The hot water treatment involves placing the seeds in hot water and allowing them to sit in the water until cooled, often until the next day. Quick (1935) found the highest germination for <i>C. cuneatus</i> with water at 70 °C. He also found that 3 months of cold stratification at 2.5 °C improved results over no stratification. Quick &amp; Quick (1961) got 98% germination of one 17.5 year old seed lot of <i>C. cuneatus</i> after boiling seeds for 10 seconds, cooling them, and stratifying them for 90 days (boiling too long kills the seeds (Quick 1935)). Everett (2012) planted seeds after providing a 20 to 24 hour hot water treatment and no stratification. Seedlings of wild-collected seeds emerged in 12 to 60 days and seedlings from seed retrieved from 14-year old herbarium specimens emerged in 23 to 47 days. He noted that seedlings took longer to emerge from the most recently collected seeds. Others have boiled seeds for 1 min for heat scarification, followed by treatment with 400 ppm GA (gibberelic acid) for 13 hours, air dried 4 days, then treated with 3% thiourea for 5 min in lieu of a cold treatment (Emery 1988).</p>
<b>I. Seeds/lb</b>	<p>Conard &amp; Reed (2008) report a range of 36,000-56,000 seeds/lb and an average of 49,000 seeds/lb. Values were for clean seed and, though not stated, the values appear to be for live seeds per bulk pound. Seed from different collections may differ in seed weight, especially if different percentages have been parasitized. For one seed lot from San Benito Co., California, Barner (2009) recorded 87,900 seeds/lb for a lot that had 81% filled seeds and 99% pure seed. This seed lot with a PLS of 80.2% would have 70,487 live seeds/lb. Stover Seed Co. (2019) reports 80,250 seeds per pound, with purity around 90% and germination around 65%; this translates to 46,946 live seeds per bulk pound. S&amp;S Seeds (2019) list commercial seed lots as averaging 33,750 live seeds per bulk pound (S&amp;S Seeds 2019).</p>
<b>J. Planting</b>	<p>In a greenhouse trial, seeds were planted at 0, 1, 1.5, 2, and 2.5 inches deep in sun and shade. Seeds planted at depths 1 and 1.5 inches were most successful under both sun and shade (Adams 1962). Planting heat-treated seeds (see IX. C. Seed dormancy, H. Seed germination, above) in the fall will provide a natural vernalization (cold treatment) to break the physiological dormancy.</p>
<b>K. Seed increase activities or potential</b>	<p>Seeds can be collected from native stands with proper permits from land management agencies. Unknown if any seed increase has been done. Seed orchards would take a lot of space and may not be feasible.</p>
<b>X. USES</b>	
<b>A. Revegetation and erosion control</b>	<p><i>Ceanothus cuneatus</i> should be suitable for revegetation or habitat restoration. League (2005) reports that it has been successfully used for this purpose in the southwestern U.S. Newton &amp; Claassen (2003) list <i>C. cuneatus</i> as a commonly used in the Northwestern, Cascade Range, Sierra Nevada, Central Western, and Southwestern Regions of California.</p>
<b>B. Habitat restoration</b>	<p>As shrubs are lost during type conversion from chaparral to non-native grassland in areas with overly frequent fire or mortality following lengthy and extreme drought combined with fire (Jacobsen &amp; Pratt 2018), there will likely be an increasing demand for this species to restore lower elevation chaparral habitats.</p>
<b>C. Horticulture or agriculture</b>	<div style="display: flex;"> <div style="flex: 1;">  </div> <div style="flex: 2; padding-left: 10px;"> <p><i>C. cuneatus</i> is used in horticulture and several ornamental cultivars are available from native plant nurseries from time to time. Most cultivars are derived from varieties other than var. <i>cuneatus</i>. Fross &amp; Wilken (2006) mention <i>C. cuneatus</i> 'Mount Madonna' was selected from a population in the Santa Cruz Mountains while <i>C. cuneatus</i> var. <i>ramulosus</i> 'Rodeo Lagoon' and <i>C. cuneatus</i> var. <i>ramulosus</i> 'Rodeo Marin' are prostrate forms selected from the wind-swept central coast. They also mentioned <i>C. cuneatus</i> var. <i>rigidus</i> 'Snowball', which is now classified as <i>C. rigidus</i> 'Snowball'.</p> <p>A valuable plant for use in hedgerows (DeSiervo 2011) and an important plant for honey bees and honey production (Goltz 1987). It has been in cultivation since 1848 (USDA Forest Service 1948). <i>C. cuneatus</i> tend to accumulate over 60% dead biomass over time, adding to fuel loads and increasing flammability of vegetation (Cowan &amp; Ackerly 2010).</p> <p>For vegetative propagation of species in subgenus <i>Cerastes</i>, Smith (1986) provides recommendations for rooting <i>Ceanothus</i> cuttings and growing plants from seeds. He reports using strong rooting hormones (e.g., 0.5% IBA/NAA) for hard cuttings from the wild and long bench times without misting. For propagation from seeds, he uses a fast-draining seedling mix.</p> </div> </div> <div style="border: 1px solid black; padding: 5px; margin-top: 10px; text-align: center;">       Seedlings grew to about 7 cm tall in germination flats in shadehouse within 8 months. Photo by Kate Kramer © 2019.     </div>
<b>D. Wildlife value</b>	<p>This species is important deer browse and provides protective cover for a number of species, including deer and a variety of chaparral rodents (summarized in League 2005). Seeds are eaten by birds, rodents, and occasionally coyotes. The high protein content of leaves makes good forage and is likely linked to the plant's nitrogen-fixing capabilities (R. B. Pratt pers. com.).</p>

<b>E. Plant material releases by NRCS and cooperators</b>	There are no conservator cultivars listed on the California Plant Materials Center website and none are mentioned in the NRCS Plant Guide (DeSiervo 2011).
<b>F. Ethnobotanical</b>	Roots have been used in a tincture to treat lymphatic tissue congestion and a number of other ailments; also used to stop bleeding (Moore 1989). DeSiervo (2011) describes uses by California tribes including for firewood, woody material to create fish dams, twigs for shafts for two-piece arrows, wood for traditional tools (e.g., needles, digging sticks, seed beaters), and the young shoots for basketry.
<b>XI. ACKNOWLEDGMENTS</b>	Partial funding for production of this plant profile was provided by the U.S. Department of Agriculture, Forest Service, Pacific Southwest Region Native Plant Materials Program and the Riverside-Corona Resource Conservation District. We thank R. Brandon Pratt and Kate Kramer for providing photos of seedlings and R. Brandon Pratt who provided comments that improved the manuscript.
<b>XII. CITATION</b>	Montalvo, A. M., E. C. Riordan, and J. L. Beyers. 2020. Plant Profile for <i>Ceanothus cuneatus</i> . 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: <a href="https://www.rccrd.org/plant-profiles">https://www.rccrd.org/plant-profiles</a>
<b>XIII. LINKS TO REVIEWED DATABASES &amp; PLANT PROFILES</b>	
Fire Effects and Information System (FEIS)	<a href="https://www.fs.fed.us/database/feis/plants/shrub/ceacun/all.html">https://www.fs.fed.us/database/feis/plants/shrub/ceacun/all.html</a>
Calflora	<a href="https://www.calflora.org/cgi-bin/species_query.cgi?where-calreclnum=1771">https://www.calflora.org/cgi-bin/species_query.cgi?where-calreclnum=1771</a>
Jepson Interchange	<a href="https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?18434">https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?18434</a>
Jepson eFlora (JepsonOnline, 2nd ed.)	<a href="https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=18434">https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=18434</a>
Jepson eFlora (JepsonOnline, 2nd ed.)	<a href="https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=75440">https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=75440</a>
USDA PLANTS	<a href="https://plants.usda.gov/core/profile?symbol=CECU">https://plants.usda.gov/core/profile?symbol=CECU</a>
USDA Plant Guide	<a href="https://plants.usda.gov/plantguide/pdf/cs_cecu.pdf">https://plants.usda.gov/plantguide/pdf/cs_cecu.pdf</a>
Native Plant Network Propagation Protocol Database (NPNDP)	<a href="https://nnp.rngr.net/propagation/protocols">https://nnp.rngr.net/propagation/protocols</a>
Native Plants Journal	<a href="https://nnp.rngr.net/journal">https://nnp.rngr.net/journal</a>
Native Seed Network (NSN)	<a href="http://www.nativeseednetwork.org/">http://www.nativeseednetwork.org/</a>
GRIN (provides links to many resources)	<a href="https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx">https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx</a>
Flora of North America (FNA) (online version)	<a href="http://www.efloras.org/florataxon.aspx?flora_id=1&amp;taxon_id=250101433">http://www.efloras.org/florataxon.aspx?flora_id=1&amp;taxon_id=250101433</a>
Ethnobotanical	<a href="http://naeb.brit.org/">http://naeb.brit.org/</a>
Woody Plant Seed Manual	<a href="https://rng.net/publications/wpsm">https://rng.net/publications/wpsm</a>
Rancho Santa Ana Botanic Garden Seed Program, seed photos	<a href="http://www.hazmac.biz/seedhome.html">http://www.hazmac.biz/seedhome.html</a>
<b>XIV. IMAGES</b>	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. Seedling photos by R. Brandon Pratt and Kate Kramer (copyright 2019). All other images by Arlee Montalvo (copyright 2019) unless otherwise indicated with rights reserved by the Riverside-Corona Resource Conservation District (RCCRD). 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.

## Bibliography for *Ceanothus cuneatus*

- Adams, L. 1962. Planting depths for seeds of three species of *Ceanothus*. Research Note No. 194. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.
- Baker, G. A., P. W. Rundel, and D. J. Parsons. 1982. Comparative phenology and growth in three chaparral shrubs. *Botanical Gazette* **143**:94-100.
- Barner, J. 2009. Propagation protocol for production of propagules (seeds, cuttings, poles, etc.): *Ceanothus cuneatus* (Hook.) Nutt. seeds USDA FS – R6 Bend Seed Extractory, Bend Oregon. In Native Plant Network. <https://nnp.rngr.net/propagation/protocols>. [Accessed 19 June 2019].
- Baskin, C. C., and J. M. Baskin. 1998. Seeds: Ecology, biogeography and evolution of dormancy and germination. Academic Press, San Diego, CA.
- Beyers, J. L., and C. D. Wakeman. 2000. Season of burn effects in southern California chaparral. Pages 45-55 in J. E. Keeley, M. Baer-Keeley, and C. J. Fotheringham, editors. 2nd interface between ecology and land development in California: U.S. geological survey open-file report 00-62. US Geological Survey, Sacramento, CA.
- Bieger, A., N. Rajakaruna, and S. Harrison. 2014. Little evidence for local adaptation to soils or microclimate in the post-fire recruitment of three Californian shrubs. *Plant Ecology & Diversity* **7**:411-420.
- Brooks, F., and D. Ferrin. 1994. Branch dieback of southern California chaparral vegetation caused by *Botryosphaeria dothidea*. *Phytopathology* **84**:78-83.
- Burge, D. O., D. M. Erwin, M. B. Islam, J. Kellermann, S. W. Kembel, D. H. Wilken, and P. S. Manos. 2011. Diversification of *Ceanothus* (Rhamnaceae) in the California Floristic Province. *International Journal of Plant Sciences* **172**:1137-1164.
- Burge, D. O., R. Hopkins, Y.-H. E. Tsai, and P. S. Manos. 2013. Limited hybridization across an edaphic disjunction between the gabbro-endemic shrub *Ceanothus roderickii* (Rhamnaceae) and the soil-generalist *Ceanothus cuneatus*. *American Journal of Botany* **100**:1883-1895.
- Burge, D. O., and P. S. Manos. 2011. Edaphic ecology and genetics of the gabbro-endemic shrub *Ceanothus roderickii* (Rhamnaceae). *Madroño* **58**:1-21.
- Burge, D. O., K. Zhukovsky, and D. H. Wilken. 2015. A taxonomic conspectus of *Ceanothus* subgenus *Cerastes* (Rhamnaceae). *Systematic Botany* **40**:950-961.
- Calflora. 2016. The Calflora Database. Information on California plants for education, research and conservation, based on data contributed by the Consortium of Calif. Herbaria and dozens of other public and private institutions and individuals. Berkeley, CA: [a non-profit organization]. Available: <http://www.calflora.org/>. [Accessed 12 February 2016].
- CCH Consortium of California Herbaria. 2016. Regents of the University of California, Berkeley, California. Available: <http://ucjeps.berkeley.edu/consortium/>. [Accessed 20 July 2016].
- Chaia, E. E., L. G. Wall, and K. Huss-Danell. 2011. Life in soil by the actinorhizal root nodule endophyte *Frankia*. A review. *Symbiosis* **51**:201-226.
- Cleland, D. T. F., J.A.; Keys, J.E.; Nowacki, G.J.; Carpenter, C.A.; McNab, W.H. 2007. Ecological Subregions: Sections and Subsections for the conterminous United States. Gen. Tech. Report WO-76D [Map on CD-ROM] (A.M. Sloan, cartographer). U.S. Department of Agriculture, Forest Service, Washington, DC.

- Conard, S. G., and M. J. Reed. 2008. *Ceanothus* L. Pages 348-356, in Bonner, F. T., and R. P. Karrfalt, editors, The Woody Plant Seed Manual. USDA Forest Service Agricultural Handbook 727.
- Conard, S. G., A. E. Jaramillo, J. Kermit Cromack, and S. Rose, compilers. 1985. The Role of the Genus *Ceanothus* in Western Forest Ecosystems. General Technical Report PNW-182. U.S. Department of Agriculture Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR, Portland, OR. 72 p.
- Conrad, C. E. 1987. Common Shrubs of Chaparral and Associated Ecosystems of Southern California. General Technical Report PSW-99. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. 86 p.
- Cowan, P. D., and D. D. Ackerly. 2010. Post-fire regeneration strategies and flammability traits of California chaparral shrubs. *International Journal of Wildland Fire* **19**:984-989.
- Curtis, J. D. 1952. Effect of pregermination treatments on the viability of *Ceanothus* seeds. *Ecology* **33**:577-578.
- Davis, S. D., F. W. Ewers, J. S. Sperry, K. A. Portwood, M. C. Crocker, and G. C. Adams. 2002. Shoot dieback during prolonged drought in *Ceanothus* (Rhamnaceae) chaparral of California: a possible case of hydraulic failure. *American Journal of Botany* **89**:820-828.
- Davis, S. D., F. W. Ewers, J. Wood, J. J. Reeves, and K. J. Kolb. 1999. Differential susceptibility to xylem cavitation among three pairs of *Ceanothus* species in the Transverse Mountain Ranges of southern California. *Ecoscience* **6**:180-186.
- Davis, S. D., A. M. Helms, M. S. Heffner, A. R. Shaver, A. C. Deroulet, N. L. Stasiak, S. M. Vaughan, C. B. Leake, H. D. Lee, and E. T. Sayegh. 2007a. Chaparral zonation in the Santa Monica Mountains: the influence of freezing temperatures. *Fremontia* **35**:12-15.
- Davis, S. D., R. B. Pratt, F. W. Ewers, and A. L. Jacobsen. 2007b. Freezing tolerance impacts chaparral species distribution in the Santa Monica Mountains. Pages 159-172 in Knapp, D. A. (editor), *Flora and Ecology of the Santa Monica Mountains*. Southern California Botanists, Fullerton, California.
- Department of Forester and Fire Warden. 1985. Emergency revegetation in Los Angeles County 1919-1984. County of Los Angeles, Fire Department, Los Angeles, California.
- DeSiervo, M. 2011. Plant Guide for Buckbrush (*Ceanothus cuneatus*). USDA-Natural Resources Conservation Service, Lockeford Plant Materials Center, Lockeford, CA 95237.
- Deveny, A. J. and L. R. Fox. 2006. Indirect interactions between browsers and seed predators affect the seed bank dynamics of a chaparral shrub. *Oecologia* **150**:69-77.
- Dobson, H. E. M. 1993. Bee fauna associated with shrubs in two California chaparral communities. *Pan-Pacific Entomologist* **69**:77-94.
- Emery, D. E. 1988. Seed Propagation of Native California Plants. Santa Barbara Botanical Garden, Santa Barbara, California.
- Epling, C., and H. Lewis. 1942. The centers of distribution of the chaparral and coastal sage associations. *The American Midland Naturalist* **27**:445-462.
- Evans, R. A., H. H. Biswell, and D. E. Palmquist. 1987. Seed dispersal in *Ceanothus cuneatus* and *C. leucodermis* in a Sierran oak-woodland savanna. *Madroño* **34**:283-293.
- Everett, P. C. 2012. A Second Summary of the Horticulture and Propagation of California Native Plants at the Rancho Santa Ana Botanic Garden, 1950-1970. Edited by Bart C. O'Brien., Rancho Santa Ana Botanic Garden, Claremont, CA.

- Florence, S. F. and M. A. Florence. 1988. Prescribed burning effects in central California chaparral. *Rangelands* **10(3)**:138-140.
- Franklin, J. 1998. Predicting the distribution of shrub species in southern California from climate and terrain-derived variables. *Journal of Vegetation Science* **9**:733-748.
- Franklin, J. 2002. Enhancing a regional vegetation map with predictive models of dominant plant species in chaparral. *Applied Vegetation Science* **5**:135-146.
- Frazer, J. M., and S. D. Davis. 1988. Differential survival of chaparral seedlings during the first summer drought after wildfire. *Oecologia* **76**:215-221.
- Fross, D., and D. Wilken. 2006. *Ceanothus*. Timber Press, Inc., Portland, OR.
- Goltz, L. 1987. Honey and pollen plants. part V. North American shrubby plants. *American Bee Journal* **127**:576-580.
- Goudey, C. B., and D. W. Smith. 1994. Ecological units of California: Subsections (map). San Francisco, CA: U.S. Department of Agriculture, Forest Service. Pacific Southwest Region. Scale 1:1,000,000; colored.
- Gordon, H., and T. C. White. 1994. Ecological Guide to Southern California Chaparral Plant Series: Transverse and Peninsular Ranges: Angeles, Cleveland, and San Bernardino National Forests. R5-ECOL-TP-005. USDA Forest Service, Pacific Southwest Region, San Diego, CA.
- Hacke, U. G., A. L. Jacobsen, and R. B. Pratt. 2009. Xylem function of arid-land shrubs from California, USA: an ecological and evolutionary analysis. *Plant, Cell & Environment* **32**:1324-1333.
- Hanes, T. L. 1971. Succession after fire in the chaparral of southern California. *Ecological Monographs* **41**:27-52.
- Hardig, T. M., P. S. Soltis, and D. E. Soltis. 2000. Diversification of the North American shrub genus *Ceanothus* (Rhamnaceae): conflicting phylogenies from nuclear ribosomal DNA and chloroplast DNA. *American Journal of Botany* **87**:108-123.
- Hardig, T. M., P. S. Soltis, D. E. Soltis, and R. B. Hudson. 2002. Morphological and molecular analysis of putative hybrid speciation in *Ceanothus* (Rhamnaceae). *Systematic Botany* **27**:734-746.
- He, X., C. S. Bledsoe, R. J. Zasoski, D. Southworth, and W. R. Horwath. 2006. Rapid nitrogen transfer from ectomycorrhizal pines to adjacent ectomycorrhizal and arbuscular mycorrhizal plants in a California oak woodland. *New Phytologist* **151**: 143-170.
- Hellmers, H., J. S. Horton, G. Juhren, and J. O'Keefe. 1955. Root systems of some chaparral plants in southern California. *Ecology* **36**:667-678.
- Holland, R. F. 1986. Preliminary Descriptions of the Terrestrial Natural Communities of California. State of California Department of Fish and Game, Nongame Heritage Program, Sacramento, CA.
- Huffman, D. W. 2002. A seed chalcid (*Eurytoma squamosa* Bugbee) parasitizes buckbrush (*Ceanothus fendleri* Gray) seeds in a ponderosa pine forest of Arizona. *Western North American Naturalist* **62**:474-478.
- Jacobsen, A. L., and R. B. Pratt. 2018. Extensive drought-associated plant mortality as an agent of type-conversion in chaparral shrublands. *New Phytologist* **219**:498-504.
- Jacobsen, A. L., R. B. Pratt, F. W. Ewers, and S. D. Davis. 2007. Cavitation resistance among 26 chaparral species of southern California. *Ecological Monographs* **77**:99-115.

- Jacobsen, A. L., R. B. Pratt, S. D. Davis, and F. W. Ewers. 2008. Comparative community physiology: nonconvergence in water relations among three semi-arid shrub communities. *New Phytologist* **180**:100-113.
- Jacobsen, A. L., R. B. Pratt, S. D. Davis, and M. F. Tobin. 2014. Geographic and seasonal variation in chaparral vulnerability to cavitation. *Madroño* **61**:317-327.
- Jeong, S. C., A. Liston, and D. D. Myrold. 1997. Molecular phylogeny of the genus *Ceanothus* (Rhamnaceae) using *rbcL* and *ndhF* sequences. *Theoretical Applied Genetics* **94**:852-857.
- Keator, G. 1994. Complete Garden Guide to the Native Shrubs of California. Chronicle Books, San Francisco, CA.
- Keeley, J. E. 1975. Longevity of nonsprouting *Ceanothus*. *The American Midland Naturalist* **93**:504-507.
- Keeley, J. E. 1977. Seed production, seed populations in soil, and seedling production after fire for two congeneric pairs of sprouting and nonsprouting chaparral shrubs. *Ecology* **58**:820-829.
- Keeley, J. E. 1987. Role of fire in seed germination of woody taxa in California chaparral. *Ecology* **68**:434-443.
- Keeley, J. E. 1991. Seed germination and life history syndromes in the California chaparral. *The Botanical Review* **57**:81-116.
- Keeley, J. E. 1992. Demographic structure of California chaparral in the long-term absence of fire. *Journal of Vegetation Science* **3**:79-90.
- Keeley, J. E. 1992. Recruitment of seedlings and vegetative sprouts in unburned chaparral. *Ecology* **73**:1194-1208.
- Keeley, J. E. 1993. Utility of growth rings in the age determination of chaparral shrubs. *Madroño* **40**:1-14.
- Keeley, J. E. 1998. Postfire ecosystem recovery and management: The October 1993 large fire episode in California. Pages 69-90 in J. M. Moreno, editor. *Large Forest Fires*. Backhuys Publishers, Leiden, The Netherlands.
- Keeley, J.E. and Brennan, T.J. 2012. Fire-driven alien invasion in a fire-adapted ecosystem. *Oecologia* **169**:1043-1052.
- Keeley, J. E., and C. J. Fotheringham. 2000. Role of fire in regeneration from seed. Pages 311-330 in M. Fenner, editor. *Seeds: The ecology of regeneration in plant communities*. CAB International, New York.
- Keeley, J. E., C. J. Fotheringham, and M. Baer-Keeley. 2006. Demographic patterns of postfire regeneration in Mediterranean-climate shrublands of California. *Ecological Monographs* **76**:235-255.
- Keeley, J. E., and S. C. Keeley. 1981. Post-fire regeneration of southern California chaparral. *American Journal of Botany* **68**:524-530.
- Keeley, J. E., A. H. Pfaff, and H. D. Safford. 2005. Fire suppression impacts on postfire recovery of Sierra Nevada shrublands. *International Journal of Wildland Fire* **14**:255-265.
- Keeley, J. E., and T. J. Soderstrom. 1986. Postfire recovery of chaparral along an elevational gradient in southern California. *The Southwestern Naturalist* **31**:177-184.
- Keeley, J. E., and A. D. Syphard. 2016. Climate change and future fire regimes: examples from California. *Geosciences* **6**:37.
- Keeley, J. E., and P. H. Zedler. 1978. Reproduction of chaparral shrubs after fire: a comparison of sprouting and seeding strategies. *The American Midland Naturalist* **99**:142-161.

- Kolb, K. J., and S. D. Davis. 1994. Drought tolerance and xylem embolism in co-occurring species of coastal sage and chaparral. *Ecology* **75**:648-659.
- Kremen, C., R. L. Bugg, N. Nicola, S. A. Smith, R. W. Thorp, and N. M. Williams. 2002. Native bees, native plants, and crop pollination in California. *Fremontia* **30 (3-4)**:41-49.
- Lawson, D. M., H. M. Regan, P. H. Zedler, and J. Franklin. 2010. Cumulative effects of land use, altered fire regime and climate change on persistence of *Ceanothus verrucosus*, a rare, fire-dependent plant species. *Global Change Biology* **16**:2518-2529.
- League, Kevin R. 2005. *Ceanothus cuneatus*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: <http://www.fs.fed.us/database/feis/plants/shrub/ceacun/all.html> [2017, November 17].
- Le Fer, D., and V. Parker. 2005. The effect of seasonality of burn on seed germination in chaparral: the role of soil moisture. *Madroño* **52**:166-174.
- Malanson, G. P., and J. F. O'Leary. 1985. Effects of fire and habitat on post-fire regeneration in Mediterranean-type ecosystems: *Ceanothus spinosus* chaparral and Californian coastal sage scrub. *Acta Oecologica Oecologia Plantarum* **6**:169-181.
- Malanson, G. P., and J. F. O'Leary. 1995. The coastal sage scrub-chaparral boundary and response to global climatic change. Pages 203-224 in J. M. Moreno and W. C. Oechel, editors. *Global Change and Mediterranean-type Ecosystems*. Springer-Verlag New York, Inc., New York.
- Martin, B. D. 1982. Vegetation responses to prescribed burning in Cuyamaca Rancho State Park, California. Page 617 in Conrad, C. E. and W. C. Oechel, technical coordinators. *Dynamics and Management of Mediterranean-type Ecosystems*. General Technical Report PSW-58. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.
- McMinn, H. E. 1930. A geographic and taxonomic study of the California species of the genus *Ceanothus*. Stanford University Press.
- McMinn, H. E. 1939a. An Illustrated Manual of California Shrubs. Gillick Press, Berkeley, CA.
- McMinn, H. E. 1939b. Notes on the genus *Ceanothus* in California. *Madroño* **5**:13-15.
- McMinn, H. E. 1944. The importance of field hybrids in determining species in the genus *Ceanothus*. *Proceedings of the California Academy of Sciences* **25**:323-356.
- McPherson, J. K., and C. H. Muller. 1967. Light competition between *Ceanothus* and *Salvia* shrubs. *Bulletin of the Torrey Botanical Club* **94**:41-55.
- Messinger, O., and T. Griswold. 2002. A pinnacle of bees. *Fremontia* **30**:32-40.
- Meyer, E., and B. Sale. 2014. Horticultural Guidelines for Species Commonly Used for Restoration Projects in Southern California Chaparral. Report prepared for USDA Forest Service Region 5, Rancho Santa Ana Botanic Garden, Claremont, CA.
- Miller, P. C., and E. Ng. 1977. Root: shoot biomass ratios in shrubs in southern California and central Chile. *Madroño* **24**:215-223.
- Mills, J. N. 1983. Herbivory and seedling establishment in post-fire southern California chaparral. *Oecologia* **60**:267-270.
- Mills, J. N. 1986. Herbivores and early postfire succession in southern California chaparral. *Ecology* **67**:1637-1649.

- Mirov, N. T. 1940. Additional data on collecting and propagating the seeds of California wild plants. Research Note 21. U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station, Berkeley, CA.
- Moldenke, A. R. 1976. California pollination ecology and vegetation types. *Phytologia* **34**:305-361.
- Moldenke, A. R., and J. L. Neff. 1974. Studies on pollination ecology and species diversity of natural California plant communities, III. Technical Report 74-14, International Biological Programme, Origin and Structure of Ecosystems, 233 pp.
- Moore, M. 1989. Medicinal Plants of the Desert and Canyon West. Museum of New Mexico Press, Santa Fe, NM.
- Moreno, J. M., and W. C. Oechel. 1991. Fire intensity effects on germination of shrubs and herbs in southern California chaparral. *Ecology* **72**:1993-2004.
- Muller, C. H., and R. del Moral. 1971. Role of animals in suppression of herbs by shrubs. *Science* **173**:462-463.
- Munz, P. A., and D. D. Keck. 1968. A California Flora with Supplement. University of California Press, Berkeley, CA.
- Murry, M. A., A. S. Konopka, S. D. Pratt, and T. L. Vandergon. 1997. The use of PCR-based typing methods to assess the diversity of *Frankia* nodule endophytes of the actinorhizal shrub *Ceanothus*. *Physiologia Plantarum* **99**:714-721.
- Nobs, M. A. 1963. Experimental Studies on Species Relationships in *Ceanothus*. Carnegie Institution of Washington Publication 623, Washington, D. C.
- Oakley, B., M. North, J. F. Franklin, B. P. Hedlund, and J. T. Staley. 2004. Diversity and distribution of *Frankia* strains symbiotic with *Ceanothus* in California. *Applied and Environmental Microbiology* **70**:6444-6452.
- O'Neil, S. E., and V. T. Parker. 2005. Factors contributing to the soil seed bank size of two obligate seeding *Ceanothus* species in northern California. *Madroño* **52**:182-190.
- Odion, D. C. 2000. Seed banks of long-unburned stands of maritime chaparral: composition, germination behavior, and survival with fire. *Madroño* **47**:195-203.
- Odion, D. C., and F. W. Davis. 2000. Fire, soil heating and the formation of vegetation patterns in chaparral. *Ecological Monographs* **70**:149-169.
- Painter, E. 2012. Common (vernacular) names applied to California vascular plants. University of California Jepson Herbarium, Online database: [http://herbaria4.herb.berkeley.edu/cgi-bin/getpainter\\_common.pl?56082](http://herbaria4.herb.berkeley.edu/cgi-bin/getpainter_common.pl?56082). Last accessed 7/31/16.
- Poole, D. K., and P. C. Miller. 1975. Water relations of selected species of chaparral and coastal sage communities. *Ecology* **56**:1118-1128.
- Pratt, R. B., A. L. Jacobsen, K. A. Golgotiu, J. S. Sperry, F. W. Ewers, and S. D. Davis. 2007. Life history type and water stress tolerance in nine California chaparral species (Rhamnaceae). *Ecological Monographs* **77**:239-253.
- Pratt, R. B., A. L. Jacobsen, J. Hernandez, F. W. Ewers, G. B. North, and S. D. Davis. 2012. Allocation tradeoffs among chaparral shrub seedlings with different life history types (Rhamnaceae). *American Journal of Botany* **99**:1464-1476.
- Pratt, R. B., A. L. Jacobsen, R. Mohla, F. W. Ewers, and S. D. Davis. 2008. Linkage between water stress tolerance and life history type in seedlings of nine chaparral species (Rhamnaceae). *Journal of Ecology* **96**:1265.



- Pratt, R. B., A. L. Jacobsen, A. R. Ramirez, A. M. Helms, C. A. Traugh, M. F. Tobin, M. S. Heffner, and S. D. Davis. 2014. Mortality of resprouting chaparral shrubs after a fire and during a record drought: physiological mechanisms and demographic consequences. *Global Change Biology* **20**:893-907.
- Pratt, R. B., E. D. MacKinnon, M. D. Venturas, C. J. Crous, and A. L. Jacobsen. 2015. Root resistance to cavitation is accurately measured using a centrifuge technique. *Tree Physiology* **35**:185-196.
- Pratt, S. D., A. S. Konopka, M. A. Murry, F. W. Ewers, and S. D. Davis. 1997. Influence of soil moisture on the nodulation of post fire seedlings of *Ceanothus* spp. growing in the Santa Monica Mountains of Southern California. *Physiologia Plantarum* **99**:673-679.
- Principe, Z., J. B. MacKenzie, B. Cohen, J. M. Randall, W. Tippetts, T. Smith, and S. A. Morrison. 2013. 50-Year Climate Scenarios and Plant Species Distribution Forecasts for Setting Conservation Priorities in Southwestern California v.1. The Nature Conservancy of California, San Francisco, CA. 36 pages + Appendices.
- Quick, C. R. 1935. Notes on the germination of *Ceanothus* seeds. *Madroño* **3**:135-140.
- Quick, C. R., and A. S. Quick. 1961. Germination of *Ceanothus* seeds. *Madroño* **16**:23-30.
- Rice, S. K. 1993. Vegetation establishment in post-fire *Adenostoma* chaparral in relation to fine-scale pattern in fire intensity and soil nutrients. *Journal of Vegetation Science* **4**:115-124.
- Riordan, E.C, A.M. Montalvo, and J. L. Beyers. 2018. Using Species Distribution Models with Climate Change Scenarios to Aid Ecological Restoration Decisionmaking for Southern California Shrublands. Research Paper PSW-RP-270. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA. 130 p.  
[https://www.fs.fed.us/psw/publications/documents/psw\\_rp270/](https://www.fs.fed.us/psw/publications/documents/psw_rp270/). [Accessed 6 September 2018].
- Riordan, E. C., and P. W. Rundel. 2014. Land use compounds habitat losses under projected climate change in a threatened California ecosystem. *PLoS One* **9**:e86487.
- Ritchie, N. J., and D. D. Myrold. 1999. Geographic distribution and genetic diversity of *Ceanothus*-infective *Frankia* strains. *Applied and Environmental Microbiology* **65**:1378-1383.
- Rose, S. L. 1980. Mycorrhizal associations of some actinomycete nodulated nitrogen-fixing plants. *Canadian Journal of Botany* **58**:1449-1454.
- Rowe, P. B., and L. F. Riemann. 1961. Water use by brush, grass, and grass-forb vegetation. *Journal of Forestry* **59**:175-181.
- RSA Seeds. 2016. Rancho Santa Ana Botanic Garden Seed Program, photos by John Macdonald: <http://www.hazmac.biz/seedphotoslistgenus.html/>. [Accessed 31 August 2016].
- Sampson, A. W., and B. S. Jespersen. 1963. California Range Brushlands and Browse Plants. University of California Division of Agricultural Sciences, Berkeley, CA.
- Saruwatari, M. W., and S. D. Davis. 1989. Tissue water relations of three chaparral shrub species after wildfire. *Oecologia* **80**:303-308.
- Sawyer, J. O., T. Keeler-Wolf, and J. M. Evens. 2009. A Manual of California Vegetation. 2nd edition. California Native Plant Society Press, Sacramento, CA.
- Schmidt, M., N. Smith, S. P. Edwards, J. Lutsko, R, and W. Roderick. 1990. Native Plants for Your Garden. California Native Plant Society.
- Schopmeyer, C. S. 1974. Seeds of Woody Plants in the United States. USDA Forest Service, Washington, D.C.

- Schwilk, D. 2003. Flammability is a niche construction trait: canopy architecture affects fire intensity. *The American Naturalist* **162**:725-733.
- Schwilk, D. W., and D. D. Ackerly. 2005. Is there a cost to resprouting? Seedling growth rate and drought tolerance in sprouting and nonsprouting *Ceanothus* (Rhamnaceae). *American Journal of Botany* **92**:404-410.
- Schultz, A. M., J. L. Launchbaugh, and H. H. Biswell. 1955. Relationship between grass density and brush seedling survival. *Ecology* **36**:226-238.
- Smith, M. N. 1986. Propagating *Ceanothus*. *Proceedings of the International Plant Propagators' Society* **35**:301-305.
- S&S Seeds. 2019. S & S Seeds Inc. Plant database: <http://www.ssseeds.com/database/index.html>. [Accessed 11 June 2019].
- Stover Seed Company. 2019. Species list. <http://www.stoverseed.com/websearch/specieslist.cfm#P>. [Accessed 11 June 2019].
- Syphard, A. D., V. C. Radeloff, T. J. Hawbaker, and S. I. Stewart. 2009. Conservation threats due to human-caused increases in fire frequency in Mediterranean-climate ecosystems. *Conservation Biology* **23**:758-769.
- Thomas, C. M., and S. D. Davis. 1989. Recovery patterns of three chaparral shrub species after wildfire. *Oecologia* **80**:309-320.
- Thorp, R. W., P. C. Schroeder, and C. S. Ferguson. 2002. Bumble bees: boisterous pollinators of native California flowers. *Fremontia* **30**:26-31.
- USDA PLANTS. 2019. The PLANTS Database (<http://plants.usda.gov>). National Plant Data Team, Greensboro, NC 27401-4901 USA. [Accessed 20 June 2019]
- U.S. Department of Agriculture, Forest Service. 1948. Woody-plant Seed Manual. Miscellaneous Publication No. 654. U.S. Government Printing Office, Washington, D.C. 416 p.
- van Wageningen, J. W., J. A. Fites-Kaufman, H. D. Safford, M. P. North, and B. M. Collins. 2018. Chapter 14. Sierra Nevada bioregion. Pages 249-278 *in* van Wageningen, J. W., N. G. Sugihara, S. L. Stephens, A. E. Thode, K. E. Shaffer, and J. A. Fites-Kaufman, editors. *Fire in California's Ecosystems*. University of California Press, Oakland.
- Venturas, M. D., E. D. MacKinnon, H. L. Dario, A. L. Jacobsen, R. B. Pratt, and S. D. Davis. 2016. Chaparral shrub hydraulic traits, size, and life history types relate to species mortality during California's historic drought of 2014. *PLoS ONE* **11**(7): e0159145.
- Wall, M., and J. Macdonald. 2009. *Processing Seeds of California Native Plants for Conservation, Storage, and Restoration*. Rancho Santa Ana Botanic Garden Seed Program, Claremont, CA; available online: <http://www.hazmac.biz/seedhome.html>.
- White, C. D. 1967. Absence of nodule formation on *Ceanothus cuneatus* in serpentine soils. *Nature* **215**:875-875.
- Wilken, D.H., and D.O. Burge. 2016. *Ceanothus cuneatus*, in Jepson Flora Project (eds.) *Jepson eFlora*, Revision 4, [https://ucjeps.berkeley.edu/eflora/eflora\\_display.php?tid=18434](https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=18434). [Accessed 19 June 2019].
- Wilkin, K. M., V. L. Holland, D. Keil, and A. Schaffner. 2013. Mimicking fire for successful chaparral restoration. *Madroño* **60**:165-172.
- Wilkin, K. M., L.C. Ponisio, D. L. Fry, C. L. Tubbesing, J. B. Potts, and S. L. Stephens. 2017. Decade-long plant community responses to shrubland fuel hazard reduction. *Fire Ecology* **13**:105-136.