








I. SPECIES	<i>Rhamnus crocea</i> Nutt. and <i>Rhamnus ilicifolia</i> Kellogg	
NRCS CODE: 1. RHCR 2. RHIL	Family: Rhamnaceae Order: Rhamnales Subclass: Rosidae Class: Magnoliopsida	
		 <p data-bbox="651 667 1040 741"><i>Rhamnus crocea</i>, San Bernardino Co., 5 June 2015, A. Montalvo</p>
		 <p data-bbox="175 1629 509 1692"><i>Rhamnus ilicifolia</i>, Riverside Co., 10 June 2015, A. Montalvo</p> <p data-bbox="808 1629 1354 1703"><i>Rhamnus ilicifolia</i>, Riverside Co. Note the finely serrulate leaf margins. 7 March 2008, A. Montalvo</p>
A. Subspecific taxa 1. RHCR 2. RHIL	<p data-bbox="467 1717 1430 1772">1. None recognized by Sawyer (2012b) or in 2019 Jepson e-Flora whereas <i>R. pilosa</i> is recognized as <i>R. c.</i> Nutt. subsp. <i>pilosa</i> (Trel.) C.B. Wolf in the PLANTS database (USDA PLANTS 2018).</p> <p data-bbox="467 1772 542 1797">2. None</p>	
B. Synonyms 1. RHCR 2. RHIL	<p data-bbox="467 1843 1003 1873">1. <i>Rhamnus croceus</i> (spelling variant noted by FNA 2018)</p> <p data-bbox="467 1873 1446 1927">2. <i>Rhamnus crocea</i> Nutt. subsp. <i>ilicifolia</i> (Kellogg) C.B. Wolf; <i>R. c.</i> Nutt. var. <i>ilicifolia</i> (Kellogg) Greene (USDA PLANTS 2018)</p>	

C. Common name 1. RHCR 2. RHIL	The name red-berry, redberry, redberry buckthorn, California red-berry, evergreen buckthorn, spiny buckthorn, and hollyleaf buckthorn have been used for multiple taxa of <i>Rhamnus</i> (Painter 2016 a,b) 1. Spiny redberry (Sawyer 2012a); also little-leaved redberry (Painter 2016a) 2. Hollyleaf redberry (Sawyer 2012b); also holly-leaf buckthorn, holly-leaf coffeeberry (Painter 2016b)
D. Taxonomic relationships	There are about 150 species of <i>Rhamnus</i> worldwide and 14 in North America, 6 of which were introduced from other continents (Nesom & Sawyer 2018, FNA). This is after splitting the genus into <i>Rhamnus</i> (buckthorns and redberries) and <i>Frangula</i> (coffeeberries) based on a combination of fruit, leaf venation, and flower traits (Johnston 1975, FNA). The species of both genera are woody shrubs or trees, but <i>Rhamnus</i> generally have unisexual flowers, 2–4 styles, longitudinally dehiscent stones within the fleshy drupes, and leaf blades with arching secondary veins, while <i>Frangula</i> have bisexual flowers, a single style, indehiscent stones (or only open at base), and leaf blades with secondary veins nearly straight and parallel. <i>R. crocea</i> and <i>R. ilicifolia</i> are part of the <i>Rhamnus crocea</i> complex of species that also includes <i>R. pirifolia</i> Greene of the Channel Islands and Baja California and <i>R. pilosa</i> (Trelease ex Curran) Abrams of San Diego and extreme southwestern Riverside County (Nesom & Sawyer 2018). Plants in this complex have persistent leaves and fleshy, bright red drupes with two stones.
E. Related taxa in region	<i>R. crocea</i> and <i>R. ilicifolia</i> overlap over much of their distribution within California and both overlap with the narrowly distributed <i>R. pilosa</i> in western San Diego Co. <i>R. pilosa</i> , known as hairy-leaf redberry, differs in having flexible branches and leaf blades with hairs on both surfaces. None of these three taxa overlap with <i>R. pirifolia</i> of the Channel Islands. In California, the more distantly related, deciduous, northerly, and very widespread <i>R. alnifolia</i> L'Héritier occurs in wet habitats in the northern high Sierra Nevada outside the range of the <i>R. crocea</i> complex (Jepson eFlora 2018).
F. Taxonomic issues	Several closely related species of <i>Rhamnus</i> , including <i>R. ilicifolia</i> , were included as infrataxa of <i>R. crocea</i> in older floras (McMinn 1939, Munz & Keck 1968), but now all are commonly recognized as distinct species (Munz 1974, Hickman 1993, Sawyer 2012a,b, FNA 2018). The USDA PLANTS (2018) database treats <i>Rhamnus pilosa</i> as a subspecies of <i>R. crocea</i> . This is likely owing to the existence of intermediates between the two taxa, especially in San Diego Co. (Sawyer 2012a). <i>R. crocea</i> and <i>R. ilicifolia</i> are the most widespread of the related taxa and intermediates have been noted from Marin Co. south to Mexico (Wolf 1983 in Nesom & Sawyer 2018, Sawyer 2012a). Intermediates have also been noted between <i>R. ilicifolia</i> and <i>R. insula</i> (Kellogg) in Baja California (Sawyer 2012b). We are treating <i>R. crocea</i> and <i>R. ilicifolia</i> together in a single profile to cross reference their similarities and differences.
G. Other	Modern molecular techniques at the population and species level need to be applied to the study of the <i>Rhamnus crocea</i> group of <i>Rhamnus</i> to better illuminate the taxonomy. Work is especially needed in areas with potential hybrid zones and where populations appear to intergrade.
II. ECOLOGICAL & EVOLUTIONARY CONSIDERATIONS FOR RESTORATION	
A. Attribute summary list (based on referenced responses in full table)	For both taxa unless noted otherwise: Taxonomic stability - intermediate Longevity - long-lived Parity - polycarpic Flowering age - 5+ yr Stress tolerance - moderate to high Environmental tolerance - broad in adults Reproduction after fire - obligate sprouter Fragmentation history - historical and recent Habitat fragmentation - high at low elevations (<i>R. crocea</i>), moderate (<i>R. ilicifolia</i>) Distribution - wide in both species Seeds - dormant, medium longevity Seed dispersal distance - near to far Pollen dispersal - near to far Breeding system - highly outcrossed Population structure - likely low in absence of strong, local selection Adaptive trait variation - unknown Chromosome number - diploid Genetic marker polymorphism - no data Average total heterozygosity - likely high Hybridization potential - high where the two taxa overlap SDM projected midcentury suitable habitat - <i>R. crocea</i> 2–99 % stable; <i>R. ilicifolia</i> : 32–99 % stable SDM projected midcentury habitat gain - <i>R. crocea</i> : loss < gain (assuming unlimited dispersal) in 3 of 5 models; <i>R. ilicifolia</i> loss > gain in 3 of 5 future scenarios (assuming unlimited dispersal).
B. Implications for seed transfer (summary based on referenced responses in full table)	Based on reproductive and dispersal traits associated with high levels of gene flow and heterozygosity, seed movement to appropriate habitats within ecological sections and among adjacent subsections is not likely to result in lower fitness in either species of redberry. However, there is no evidence in support of movement across larger geographic scales, such as between divergent ecological sections. Owing to different habitat affinities and suspected hybridization among <i>R. ilicifolia</i> , <i>R. crocea</i> , and closely related species, matching species to known habitat within their current distributions would likely ensure success. When restoring populations of <i>R. crocea</i> to support rare butterflies, using seed from within the historical range of the butterfly may insure genetically determined differences in plant chemistry, phenology or other traits of host value are preserved. When considering seed movements to ameliorate habitat fragmentation or projected changes in suitable habitat, restoring populations in potential dispersal corridors with seeds from the same or adjacent ecological subsections could increase the adaptive potential of populations.

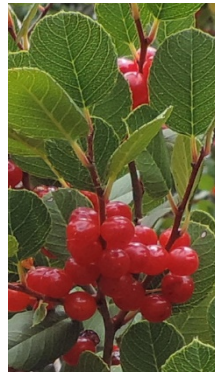
D. Distinguishing traits



Arlee Montalvo, *R. crocea*



Arlee Montalvo, *R. ilicifolia*



Spiny redberry is a rigid-stemmed, evergreen, spreading, greyish green shrub, 1–2 m tall that is complexly branched with many small ridged branchlets. The alternate, often fasciated, coriaceous leaves are obovate to nearly round, 10–15 mm long, with short, 1–4 mm long petioles. Blades are shiny and glabrous above, with indistinct secondary veins and finely serrate margins. The small, greenish-yellow, unisexual flowers, are usually 4-parted, lack petals, and occur in small clusters. Fruit is a 5–6 mm long, luminous, red, berry-like drupe containing two approximately 4 mm long seeds. (Munz 1974, Nesom & Sawyer 2018)

Hollyleaf redberry is a spreading, tall evergreen shrub, 1.5 – 4 m high. It differs from spiny redberry in often being taller, branching primarily from the base with less branching above, more flexible stems, and more obviously alternate, larger oval to roundish leaves, 20–40 mm long, with 2–10 mm long petioles. The leaf tips can be rounded to notched. Leaf blades are also glabrous above but with more obvious secondary veins, and nearly entire to serrulate margins. As in spiny redberry, the flowers are small, greenish-yellow, unisexual, lacking petals, and usually 4-parted; however, the sepals tend to be longer and more narrow and flower clusters can have many flowers. The similar luminous, red berry-like fruits are about 8 mm long and also have two seeds, but the longer seeds are about 6 mm long. (Munz 1974, Nesom & Sawyer 2018).

E. Root system, rhizomes, stolons, etc.

No description of roots found.

F. Rooting depth

Indirect measures suggest plants have roots of medium depth. Based on differences in resistance to xylem cavitation and incidence of dieback, Pratt et al. (2007) estimate that roots of both *R. crocea* and *R. ilicifolia* grow deeper than those of obligate seeding species of *Ceanothus* that have higher resistance to water stress yet experience dieback during drought. Because the redberries did not suffer branch dieback during severe drought they hypothesized that roots accessed deep soil moisture that was unavailable to shallow-rooted species. However, based on seasonal dehydration of redberries, their roots do not appear to grow as deep as *Heteromeles arbutifolia*, *Quercus berberidifolia*, or *Malosma laurina* (R.B. Pratt personal communication). Venturas et al. (2016) found moderate levels of mortality in *R. ilicifolia* after a severe drought, and Jacobsen & Pratt (2018) classified it as intermediate in rooting depth in part based on those data.

IV. HABITAT

A. Vegetation alliances, associations

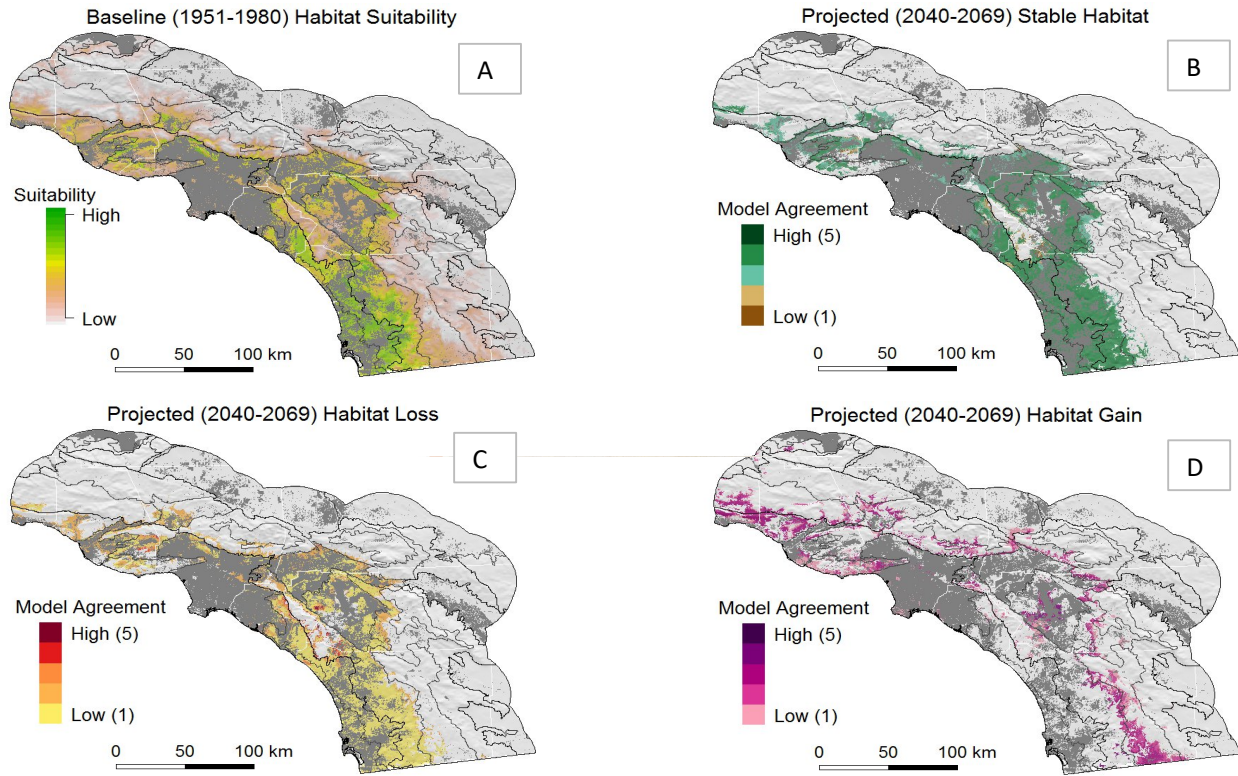
Differences between the species in habitat affinity (see IV. B. Habitat affinity) were made clear from a study of 979 plots of coastal sage scrub and chaparral in the Los Padres National Forest by Borchert et al. (2004). Although the two taxa occurred together in some plant communities, they found that *R. crocea* obtained significant cover (here reported as >10%) primarily below 2000 ft within coastal sage scrub alliances where *Artemisia californica*, *Salvia mellifera*, or *Hesperoyucca whipplei* were dominant. In contrast *R. ilicifolia* obtained significant cover where *Eriogonum fasciculatum*, *Salvia leucophylla*, or *Hesperoyucca whipplei* were dominant. Furthermore, *R. crocea* was only occasional in the chaparral alliances whereas *R. ilicifolia* was a significant component of mid-elevation (1500–3500 ft) xeric chaparral alliances dominated by *Arctostaphylos glandulosa*, *Ceanothus crassifolius*, *C. cuneatus*, *C. megacarpus*, *Adenostoma fasciculatum*-*A. sparsifolium*, *Adenostoma fasciculatum*-*Arctostaphylos glandulosa*, or *Adenostoma fasciculatum*-*Salvia mellifera*. *Rhamnus ilicifolia* was also significant at the mid-elevation with lower solar insolation and evapotranspiration values in what is called mesic chaparral dominated by *Ceanothus sparsiflorus*, *Prunus ilicifolia*, *Quercus berberidifolia*, *Cercocarpus betuloides*-*Prunus ilicifolia*, *Quercus berberidifolia*-*Adenostoma fasciculatum*, *Ceanothus megacarpus*-*Prunus ilicifolia*, or *Heteromeles arbutifolia*-*Prunus ilicifolia*. Finally, only *R. ilicifolia* was significant at higher (3500–6000 ft) montane chaparral alliances including those dominated by *Cercocarpus betuloides*, *Quercus john-tuckeri*, *Q. wislizenii*, or *Q. wislizenii*-*Cercocarpus betuloides*.

Spiny redberry is represented in the group Californian xeric chaparral primarily within the *Adenostoma fasciculatum*-*Salvia mellifera* shrubland alliance (Sawyer et al. 2009). In the Transverse and Peninsular Ranges of southern California, *R. crocea* was not recorded as a significant component of chaparral sample plots, likely owing to its distribution being primarily lower and outside the boundaries of the

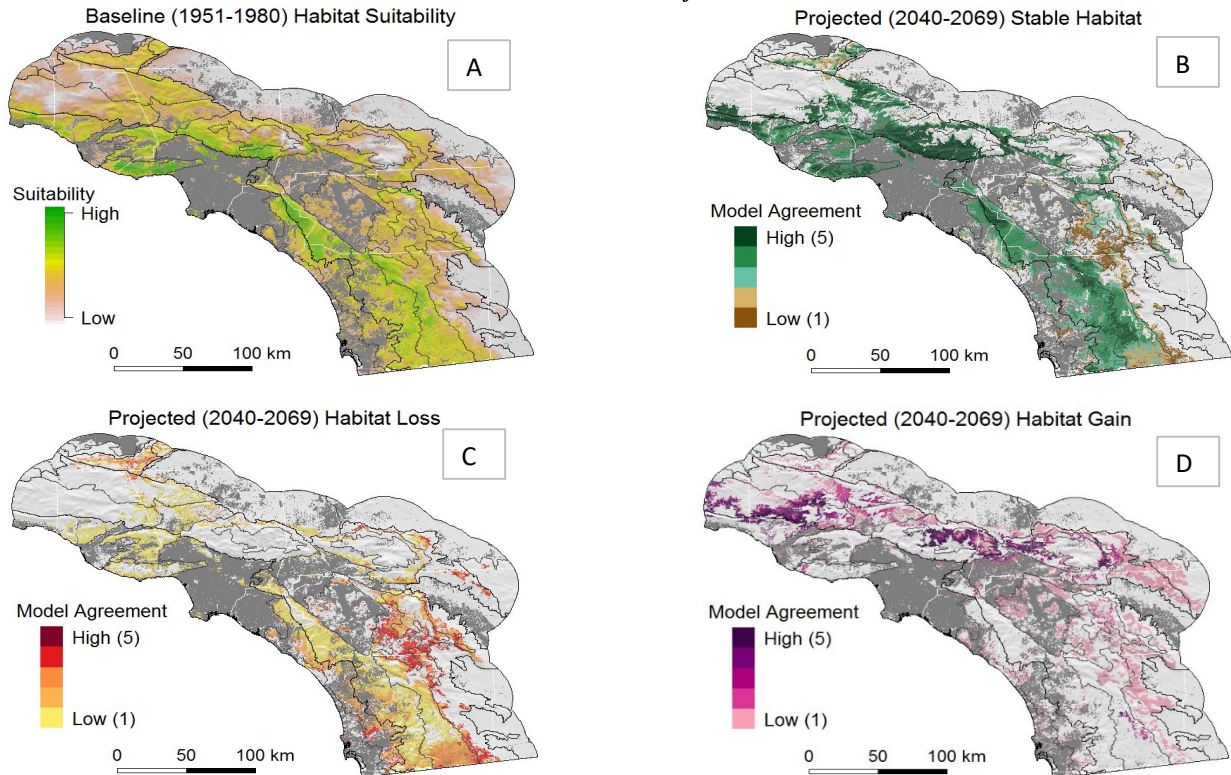
A. Vegetation alliances, associations (.....continued)	<p>National Forests where most studies occurred. However, <i>R. ilicifolia</i> was recorded with usually low cover, but common in the following xeric chaparral alliances: <i>Adenostoma fasciculatum-Salvia apiana</i>, <i>Adenostoma sparsifolium</i>, and <i>Xylococcus bicolor</i>; mesic chaparral alliances: <i>Arctostaphylos glauca</i>, <i>Quercus berberidifolia</i>, <i>Q. berberidifolia-A. fasciculatum</i>, <i>Q. berberidifolia-Ceanothus oliganthus-Heteromeles arbutifolia</i>, <i>Prunus ilicifolia-Heteromeles arbutifolia-Ceanothus spinosus</i>, and <i>Q. berberidifolia-Cercocarpus betuloides</i>; California pre-montane chaparral alliances: <i>Arctostaphylos pungens-Arctostaphylos pringlei</i> and <i>Q. wislizenii-Q. chrysolepis</i>; in Vancouverian coastal deciduous scrub in the <i>Toxicodendron diversiloba</i> alliance; and in Californian maritime chaparral in the <i>Malosma laurina</i> alliance (Gordon & White 1994, Sawyer et al. 2009). They also noted hollyleaf redberry in Californian evergreen coniferous forest and woodland in the <i>Pinus sabiniana</i> alliance and in the Californian broadleaf forest and woodland <i>Quercus chrysolepis</i> and <i>Q. engelmannii</i> alliances.</p>
B. Habitat affinity and breadth of habitat	<p><i>R. crocea</i> occurs in dry washes, gravel flood plains, alluvial fans, coastal dunes, and on steep granitic or sedimentary slopes within alluvial scrub, chaparral, coastal sage scrub, and woodlands (Munz 1974, Nesom & Sawyer 2018). <i>R. ilicifolia</i> usually occurs in cooler more mesic conditions than <i>R. crocea</i> on canyon slopes and bottoms, rock faces, open hillsides, sandstone ridges, serpentine slopes, stream benches and riparian edges in coastal sage scrub, chaparral, chaparral/desert scrub transition, woodlands, and montane forests (Nesom & Sawyer 2018). In a study in southern California, <i>R. ilicifolia</i> was found equally on north and south-facing slopes of at least 16° (Kirkpatrick & Hutchinson 1980).</p>
C. Elevation range	<p><i>R. crocea</i>: 50–1200 m (roughly 150–4000 ft), mostly below 1000 m (~3200 ft) (FNA, Jepson eFlora). <i>R. ilicifolia</i>: 100–2200 m, (roughly 300–7200 ft), mostly below 2000 m (~6500 ft) rarely higher (FNA, Jepson eFlora).</p>
D. Soil: texture, chemicals, depth	<p>Spiny redberry is found to be adaptable to a variety of soil textures in gardens (Bornstein et al. 2005, Theodore Payne Foundation 2018). It occurs in xeric chaparral and coastal sage scrub communities on relatively shallow loamy sand or sandy loam. Hollyleaf redberry is thought to require well-drained soils (Calscape 2018, Theodore Payne Foundation 2018), and it appears to be associated with non-granitic, unconsolidated soils (Kirkpatrick & Hutchinson 1980). It is also noted as occurring on gabbro soils (Alexander 2011). Both species occur in serpentine soils (Sánchez-Mata & Rodríguez-Rojo 2016) and in the coarse sandy loams of young alluvial deposits along streams as well as in the finer textured soils of older alluvial fans and in soil derived from sedimentary rocks.</p>
E. Precipitation	<p>Both species occur in the Mediterranean climate zone with cool to cold moist winters and warm to hot dry summers, but <i>R. ilicifolia</i> is also common further inland within the Mojave Desert and Sierra Nevada. In regions where the species overlap the most, annual normal precipitation ranges as follows: from 10 to 40 in (250 to 1,020 mm) in the Southern California Mountains and Valleys (M262B); from 10 to 25 in (250 to 640 mm) in the Southern California Coast (261B); and from 12 to 60 in (304 to 1,524 mm) in the Central California Coast (261A). In those regions, <i>R. ilicifolia</i> tends to occur in the more mesic zones and <i>R. crocea</i> in the lower precipitation zones. <i>R. ilicifolia</i> also occurs throughout much of the Sierra Nevada Foothills (M261F) where precipitation ranges from 8 to 40 in (203 to 1,016 mm), in areas of the Sierra Nevada (M261) that range from 12 to 60 in, and in the higher rainfall locations of the Mojave Desert which has a range of 4 to 10 in (101 to 254 mm).</p>
F. Drought tolerance	<p>Detached stems and roots of <i>R. crocea</i> and <i>R. ilicifolia</i> were found to be more inclined to xylem cavitation than those of obligate seeding species of <i>Ceanothus</i>, suggesting that <i>R. crocea</i> and <i>R. ilicifolia</i> are less resistant to drought stress and instead rely on moderately deep roots accessing soil moisture during the long dry season to prevent excessive water loss (Pratt et al. 2007). Jacobsen & Pratt (2018) classified <i>R. ilicifolia</i> as having intermediate rooting depth (see III. F. Rooting depth), and Venturas et al. (2016) found intermediate mortality levels after a severe, multi-year drought compared to co-occurring chaparral species. <i>Rhamnus crocea</i> appears to be a bit more drought resistant than <i>R. ilicifolia</i> based on its smaller leaves and distribution in drier, more open habitats. In addition, <i>R. crocea</i> seedlings suffered somewhat lower mortality than <i>R. ilicifolia</i> in a study of water stress tolerance (Pratt et al. 2008).</p>
G. Flooding or high water tolerance	<p>Both <i>R. crocea</i> and <i>R. ilicifolia</i> can be found in alluvial scrub sites that flood occasionally and where the flood waters typically evacuate quickly (A. Montalvo personal observation). In alluvial scrub, Smith (1980) and Hanes et al. (1989) also found <i>R. crocea</i> on higher, more mature floodplain terraces and alluvial islands rather than in the lower more flood-prone zones. Neither species would survive prolonged inundation.</p>
H. Wetland indicator status for California	<p>None.</p>
I. Shade tolerance	<p>Both redberries tolerate full sun to partial shade (Calscape 2018, Theodore Payne Foundation 2018), and <i>R. ilicifolia</i> may be the more shade tolerant. It often grows in the shade of coast live oaks and western sycamores in southern California (A. Montalvo personal observation). Seedlings of both redberries may emerge in the shade in periods between fire (Keeley 1992a,b; Pratt et al. 2007, Rundel 2018).</p>

V. CLIMATE CHANGE AND PROJECTED FUTURE SUITABLE HABITAT

Rhamnus crocea



Rhamnus ilicifolia



A. Species Distribution Models (SDM forecasts from Riordan et al. 2018) Map descriptions

Modeled habitat suitability under (A) baseline (1951–1980) and (B–D) projected midcentury (2040–2069) climate conditions. Projected future habitat suitability maps show agreement across five different climate model scenarios: (B) stable = suitable under both baseline and future conditions; (C) loss = suitable under baseline but unsuitable under future conditions; (D) gain = unsuitable under baseline and becoming suitable under future conditions. In all maps, land area that has already been converted to urban and agriculture land uses is masked in dark gray (FRAP 2015 Assessment; <https://map.dfg.ca.gov/metadata/ds1327.html>).

B. SDM summary

The two redberries differ in the results of species distribution modeling and there was variation in the projections of future suitable habitat among the five General Circulation Models (GCMs) examined. For *R. crocea*, four of the five GCMs projected a range of 68–99 % of the current suitable habitat would remain suitable to mid-century with a 2–60 % gain, whereas the fifth model, the one that predicts the wettest future (CNRM), predicted retention of only 2% suitable habitat and no gain. In contrast, for *R. ilicifolia*, four of the five models projected between 72–99 % of the current suitable habitat would remain suitable with a 15–45 % gain; but the fifth model, the one predicting the driest future (MIROC), predicted retention of 32% of suitable habitat and a modest 15% gain. These results make sense biologically given the differences between the redberries in their habitat affinities (see IV.B. Habitat affinity). *Rhamnus crocea* tends to occur in drier, warmer, and lower elevation sites than *R. ilicifolia*. Principe et al. (2013) also predicted higher losses in climatically suitable habitat for *R. crocea* relative to *R. ilicifolia* by mid-century.

Land use, altered fire regimes, invasive species, and their interaction with climate change could exacerbate loss of suitable habitat, even if projected loss in suitable habitat from climate change alone is relatively low. In southern California human activity is the primary driver of fire (Keeley & Syphard 2016) with fire ignitions and fire frequency increasing with human population growth (Syphard et al. 2009). In areas with high levels of habitat conversion and fragmentation - which is generally higher for *R. crocea* owing to its occupation of lower elevations than *R. ilicifolia* - there may be considerable barriers to dispersal and gene flow that could negatively impact the adaptive capacity and ability of populations to respond to changing conditions. Much of the currently suitable habitat of *R. crocea* in southern California has been developed. Riordan and Rundel (2014) caution that human land use may compound projected climate-driven losses in habitat suitability in southern California shrublands.

C. SDM caveat (concerns)

The five GCMs used to predict future habitat suitability assume a ‘business-as-usual’ scenario of high greenhouse gas emissions that tracks our current trajectory (IPCC scenario RCP 8.5). They show how climate may change in southern California and highlight some of the uncertainty in these changes. The true conditions at mid-21st century, however, may not be encompassed in these five models. Predictions of current and future habitat suitability should be interpreted with caution and are best applied in concert with knowledge about the biology, ecology, and population dynamics/demographics of the species. They are best interpreted as estimates of exposure to projected climate change. Our models characterize habitat suitability with respect to climate and parent geology but do not include other factors, such as biotic interactions or disturbance regimes, that may also influence species distributions. Additionally, they do not include the adaptive capacity of a species, which will affect its sensitivity to changes in climate. See Riordan et al. (2018) for more information on SDM caveats.

VI. GROWTH, REPRODUCTION, AND DISPERSAL

A. Seedling emergence relevant to general ecology

Juvenile plants of equal age in common garden study. Photos by Stephen Davis © 2019.



Most recruitment from seeds is during long intervals between fire events in leaf litter in the shade of existing vegetation (Keeley 1992a,b; Pratt et al. 2007). The seedlings of redberries are sensitive to drought and may need the cover of mature shrubs and thick duff to withstand the summer drought during establishment (Keeley et al. 2006). Seedlings of *R. ilicifolia* were observed in several areas that had remained unburned for long periods by Patric & Hanes (1964). In a study of chaparral stands that had not burned for at least 50 years, seedling recruitment of *R. ilicifolia* was abundant and appeared to be continuous over years since the last fire rather than episodic (Keeley 1992a,b). (Note: Keeley 1992b cites *R. crocea* var. *ilicifolia* at one point; we assume Keeley 1992a is also reporting on *R. crocea* var. *ilicifolia*.)



R. crocea



R. ilicifolia

<p>B. Growth pattern (phenology)</p>	<p>Seedlings of both species emerge in the rainy season during the winter months at low elevations followed by most shoot elongation and leaf production during the rainy season. Everett (2012) noted flowering and fruiting for the first time on three-year old plants of <i>R. crocea</i> in cultivation, but this may take longer in natural populations; he noted collecting seeds for the first time from a nine-year old <i>R. ilicifolia</i>. <i>Rhamnus crocea</i> flowers primarily from January through April whereas <i>R. ilicifolia</i> flowers primarily from March through June, with later flowering at the higher elevations (Jepson eFlora 2018). At low elevations of Riverside Co., both <i>R. crocea</i> and <i>R. ilicifolia</i> can be found flowering in late February to early March, with fruits maturing in early June (A. Montalvo pers. obs.). Leaf desiccation can occur in the summer drought after fruits disperse. In the more xeric sites, many leaves of <i>R. crocea</i> may desiccate and drop during the late summer.</p> <p>Minnich (1985) recorded plastic growth response of <i>R. crocea</i> to an intense August storm in the Santa Monica Mountains (see VIII. b. Plasticity). Plants responded with shoot elongation and flowered from September to early October, maturing fruits the second week of October.</p>
<p>C. Vegetative propagation</p>	<p>The plants lack rhizomes or other specialized structures for vegetation reproduction. Everett (2012) does not report vegetation propagation of <i>Rhamnus crocea</i> or <i>R. ilicifolia</i>. Both species have lignotubers that aid in resprouting (Pratt et al. 2008, R.B. Pratt personal communication).</p>
<p>D. Regeneration after fire or other disturbance</p>	<p>Keeley (1991) considers the plants to be "fire-resisting" but their seeds to be "non-refractory." Plants in this syndrome readily resprout after fire, often have fleshy fruits specialized for animal dispersal, require safe mesic sites for seed germination in periods between fires, do not germinate in response to fire, and do not accumulate a long-lived seed bank. Plants persist and resprout readily from underground structures after fire (Keeley 1992; Pratt et al. 2007, 2008; Rundel 2018). Resprouting success in <i>R. crocea</i> was found to be unrelated to fire severity in a study of 250 post-fire sample sites in southern California (Keeley et al. 2008). Plants of <i>R. crocea</i> that resprouted after one fire all successfully resprouted again after a second fire one year later (Zedler et al. 1983), unlike some other species followed in the study. For <i>R. ilicifolia</i>, 100% of post-fire tagged resprouts survived a severe drought (Pratt et al. 2014).</p> <p>Some seedling recruitment of <i>R. crocea</i> (included <i>R. ilicifolia</i> in surveys) was found in a study of 90 post-fire sites in years 1, 3, 4, and 5 after fire, but 80% of all seedlings found were in the 5th year (Keeley et al. 2006). This suggests seedlings were from seeds that dispersed from resprouts or nearby plants.</p>
<p>Resprouting <i>R. ilicifolia</i> after the Holy Jim fire, Santa Ana Mountains, 2,000 ft, 20 January 2019 (left), 10 March 2019 (right).</p> <div style="display: flex; justify-content: space-around;">   </div>	
<p>E. Pollination</p>	<p>Pollination is needed for fruit production, and a variety of small bee species visit the flowers of both redberries. At a Descanso Calif. chaparral site in San Diego Co., Moldenke & Neff (1974) found the following floral visitors and potential pollinators on <i>R. ilicifolia</i>: bees in the genera <i>Perdita</i>, <i>Lassioglossum</i>, <i>Hylaeus</i>, <i>Evylaeus</i>, and <i>Andrena</i>. On <i>R. crocea</i>, they found two species of <i>Perdita</i>, one species of <i>Dialictus</i>, and five species of <i>Andrena</i>. The flowers of <i>R. crocea</i> are also visited by the blue orchard bee, <i>Osmia lignaria</i> (Bosch & Kemp 2002). The similar flowers of <i>Rhamnus californica</i> (= <i>Frangula c.</i>) produce nectar and also attract a variety of bee taxa in the genera <i>Andrena</i>, <i>Nomada</i>, <i>Bombus</i>, <i>Hylaeus</i>, <i>Dialictus</i>, <i>Evylaeus</i>, as well as the non-native honeybee, <i>Apis mellifera</i> (Dobson 1993).</p>

F. Seed dispersal

The fruits of both redberries are eaten by a variety of birds and mammals who can disperse the seeds upon defecation or regurgitation. Bornstein et al. (2005) note the fruits are favored by birds, including western blue birds. Clarke et al. (2007) describe a two-stage seed dispersal mechanism where passerine birds first digest the flesh of the drupe and regurgitate the endocarp containing the seeds. Then the endocarp dries out and pops open, throwing the seeds. Birds can disperse seeds long distances.

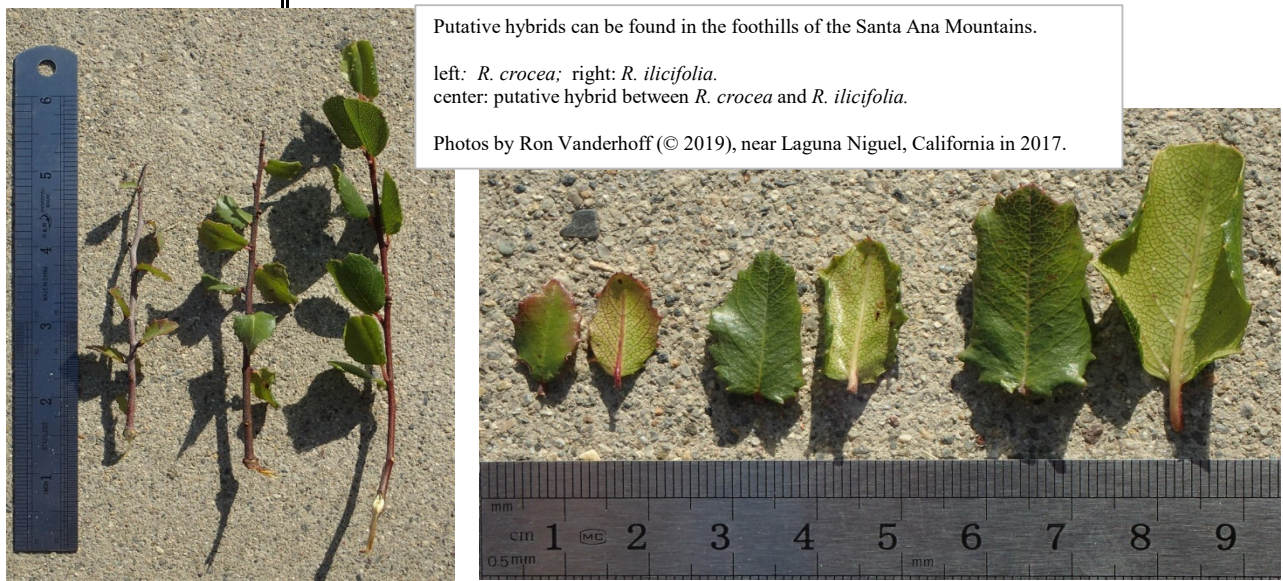
Wilson & Thomas (1999) collected seeds of *R. ilicifolia* and other chaparral plants from the scat of the grey fox (*Urocyon cinereoargenteus*) and tested their germination compared to uneaten controls. Native fruits occurred in 70% of grey fox scats. The hollyleaf redberry seeds were retrieved from scat from June to November and the seeds germinated at a significantly faster rate than fresh seeds. Seeds from scat germinated in an average of 52 +/- 8.2 days compared to 68.9 +/- 15.2 days for fresh seeds. Carnivores such as the grey fox and coyotes have large home ranges and are long-distance agents of seed dispersal.

G. Breeding system, mating system

Most *Rhamnus* have unisexual flowers. Some species are dioecious, whereas others are monoecious or have mixtures of monoecious and dioecious plants, however monoecious individuals are rare (Rottenberg 1998, 2000). In the dioecious *R. legionensis*, the ratio of male to female plants in two Spanish populations was found to be about fifty-fifty (Guitian 1995), but male plants produced more than twice as many flowers. The small flowers of *R. crocea* and *R. ilicifolia* are also reported to be unisexual (Munz & Keck 1968, Allen & Roberts 2013, Nesom & Sawyer 2018), but there may be some plants with both male and female flowers, or female and bisexual flowers (A. Montalvo, personal observation). Everett (2012) noted that there were differences between male and female plants growing at Rancho Santa Ana Botanic Gardens in Claremont California. No studies were found on the ratios of dioecious vs monoecious plants, or male vs female plants in either species. If populations are primarily dioecious, that condition would enforce high outcrossing rates. Moldenke (1976) noted *Rhamnus* as being self-incompatible and nearly always outcrossed, likely owing to its unisexual flowers.

H. Hybridization potential

The flowering times of these two redberries overlap as do the floral visitors. The two taxa tend to grow in different habitats, but when growing together, this creates the potential to hybridize. Some authors have commented that populations of redberries intergrade, which may be in part from hybridization events (Nesom & Sawyer 2018). Study is needed to reveal if variation and intergradation are influenced by hybridization.




I. Inbreeding and outbreeding effects


No information found.


VII. BIOLOGICAL INTERACTIONS

A. Competitiveness

Seedlings of both redberries may emerge in the shade in periods between fire (Keeley 1992, Pratt et al. 2007, Rundel 2018), suggesting that at least competition for light is not initially an issue. After fire, rapidly resprouting plants have little competition from other plants when they first begin to resprout (see photo in VI. D. Regeneration after fire). Later in the season, small resprouts may have some competition for shallow soil moisture from a profusion of post-fire annuals (R.B. Pratt personal communication).

<p>B. Herbivory, seed predation, disease</p> 	<p>Herbivory: Spiny redberry in San Diego County is the only larval host of the rare Hermes copper butterfly, <i>Lycaena hermes</i> (Marschalek & Deutschman 2008, 2009; Marschalek & Klein 2010). The adults of the Hermes copper emerge in May and oviposit on spiny redberry in May through July in coastal sage scrub where there is also <i>Eriogonum fasciculatum</i>, the butterfly's primary nectar host. They oviposit at the base of leaves or axil of new branches, the eggs then overwinter on the plants, and larvae emerge and feed on the leaves of redberry from mid-March to into May. The butterfly is found only in habitat with <i>R. crocea</i> in San Diego County south into northern Baja California. It is not known why the butterfly does not occur in other parts of the range of <i>R. crocea</i>. Saving this butterfly from extinction will require preservation of <i>R. crocea</i>.</p> <p>2003 photo of the Hermes copper (<i>Lycaena hermes</i>) in Descanso, California. By Greg Ballmer © 2019.</p>
<p>C. Palatability, attractiveness to animals, response to grazing</p>	<p><i>R. ilicifolia</i> was noted to intergrade with <i>R. crocea</i> and to be highly palatable to deer and goats, but less so to cattle and sheep (Sampson & Jespersen 1963). Birds and mammals eat the fruits (see section VI. F. Seed dispersal).</p>
<p>D. Mycorrhizal? Nitrogen fixing nodules?</p>	<p>Both species are likely to be mycorrhizal. Other species of <i>Rhamnus</i> are known to form arbuscular mycorrhizae (Caravaca et al. 2003, Wang & Qiu 2006).</p>
<p>E. Insect pollinators</p>	<p>Several species of <i>Andrena</i> and <i>Lassioglossum</i> were found to forage over hundreds of meters and some to over 1000 m, and <i>Osmia lignaria</i> was found to forage over about 600 m (Zurbuchen et al. 2010); however, some of the small bees that visit the redberreries, such <i>Perdita</i> and <i>Dialictus</i>, are likely to forage and disperse pollen over much shorter distances (Danforth 1989, Greenleaf et al. 2007). The way different species of bees travel across fragmented habitat or respond to the spatial scale of urbanization varies (Schochet et al. 2016), but in an experimental study with unrelated plant species, bees and butterflies were found to transfer pollen through dispersal corridors between habitat fragments (Townsend & Levey 2005).</p>
<p>F. Variation in interactions</p>	<p>Sampson & Jespersen (1963) noted that use and preference of hollyleaf redberry by deer, sheep, and goats differed among localities. They suspected the differences may have been owing to habitat differences and co-occurring shrubs.</p>
<p>VIII. ECOLOGICAL GENETICS</p>	
<p>A. Ploidy</p>	<p><i>R. crocea</i>: no counts reported. <i>R. ilicifolia</i>: 2n = 12 pairs (Raven et al. 1965) In the genus <i>Rhamnus</i>, the base number of chromosomes ranges from 10 to 13 and polyploidy appears to be uncommon, although few species have been studied (Holmgren & Oxelman 2004).</p>
<p>B. Plasticity</p>	<p>Shoot elongation, initiation of flowering, and fruit maturity may shift with rainfall patterns and elevation in <i>R. crocea</i> (Minnich 1985). Minnich (1985) noted differences in flowering time in southern Baja California (February - June) compared to Arizona (March-May, October), regions that normally experience summer rainfall. <i>R. crocea</i> in southern California which normally has dry summers tends to flower early in rainy season and mature its fruits in June. However, plants can respond to unusual, deep summer rainfall events with stem elongation and summer flowering (see VI. B. Growth Pattern).</p>
<p>C. Geographic variation (morphological and physiological traits)</p>	<p>Populations of both species of <i>Rhamnus</i> live under a range of environmental conditions, especially those associated with latitude, but <i>R. ilicifolia</i> occurs in more ecological sections and subsections, and over a larger range in elevation. We expect that plants from different regions and elevations may differ in physiological responses to environmental factors and stressors. For example, Everett (2012), also see section IX. H. Seed germination, noted that wild collections of <i>R. ilicifolia</i> seeds from different places differed in how much cold stratification was needed before seeds would germinate. Also, Jacobsen et al. (2014) found differences in cavitation vulnerability in a number of chaparral shrubs, including <i>R. ilicifolia</i>, for plants from the coastal Santa Monica Mountains compared to the more inland, San Gabriel Mountains. Such differences could be from acclimation, differences in heritable traits, or a combination.</p>
<p>D. Genetic variation and population structure</p>	<p>No studies found.</p>
<p>E. Phenotypic or genotypic variation in interactions with other organisms</p>	<p>No studies found.</p>
<p>F. Local adaptation</p>	<p>No studies found.</p>

<p>G. Translocation risks</p>	<p>There are no reciprocal common garden studies or provenance trials reported for redberries to evaluate the importance of adaptive differences over different geographic scales. It is also unknown if hybrids between related taxa of redberries suffer fitness declines. Although hybrids between some plant species sometimes do well in intermediate habitats or exhibit hybrid vigor, hybrids between parents with different environmental affinities often suffer in either parental habitat (Rogers & Montalvo 2004). Based on reproductive and dispersal traits associated with high levels genetic variation and gene flow, adaptive differences at small, spatial scales such as within and between adjacent ecological subsections are less likely than in species with low levels of gene flow and genetic variation. There appear to be adaptive differences between <i>R. ilicifolia</i>, <i>R. crocea</i>, and other closely related species, so matching species to habitats would lower translocation risk.</p>
<p>IX. SEEDS</p>	<p>Rancho Santa Ana Botanic Garden Seed Program images by John Mcdonald left: http://www.hazmac.biz/030714/030714RhamnusCrocea.html (seeds 3.5 – 3.5 mm long) right: http://www.hazmac.biz/050808/050808RhamnusIlicifolia.html (seeds 3.5 – 5.5 mm long)</p> 
<p>A. General</p>	<p>Each fruit produces two seeds and it is easy to clean seeds to a high level of purity (see IX. F. Seed processing). Average seed mass calculated from a random sample of 100 seeds drawn from many individuals was 12.1 mg for <i>R. ilicifolia</i> and 6.22 mg for <i>R. crocea</i> (Pratt et al. 2007). Keeley (1991) considers the seeds to be "non-refractory" in that they do not require fire-related cues (smoke, heat) to germinate (see VI. D. Response to fire).</p>
<p>B. Seed longevity</p>	<p>Tests of seed lots of both species stored under warehouse storage under ambient conditions in Carpinteria, California, revealed that the percentage of pure live seed (PLS) can drop somewhat after about 3 years and substantially after 5 years (Jody Miller, S&S Seeds, unpublished data provided June 2019). Seeds are expected to last longer under cool, dry storage conditions (Youngblood 2008). Seeds are not expected to accumulate a long-lived seed bank (Keeley 1991).</p>
<p>C. Seed dormancy</p>	<p>Baskin & Baskin (1987) classify <i>R. crocea</i> seeds as having "physical dormancy" which is consistent with Emery (1988) reporting that <i>R. crocea</i> may benefit from 2.5 months of cold stratification. Some collections of <i>Rhamnus ilicifolia</i> need no treatment for fresh seed, but may enter dormancy in storage. Study is needed to understand if there is variation among populations of <i>R. ilicifolia</i> and <i>R. crocea</i> in physiological dormancy and how dormancy is affected by seed age (see IX. H. Seed germination).</p>
<p>D. Seed maturation</p>	<p>For both taxa, fruits undergo development and expansion from late March to June in southern California at the lower elevations. Fruits tend to ripen in June, but maturation can be expected to extend into the summer at the higher elevations of the species range and at more northern latitudes.</p>
<p>E. Seed collecting and harvesting</p>	<p>Collection protocols are the same for both species. It is best to collect when fruits are bright red and ripe, often from early to late June in southern California. Young (2001) reports collection of <i>R. crocea</i> fruits between June 1st and October 1st in Marin Co., Calif. Collect by hand-picking and shaking into small tubs or plastic bags. For the genus <i>Rhamnus</i>, Youngblood (2008) suggests doing fruit collection about 2 weeks before fully ripe to limit losses to birds.</p>

<p>F. Seed processing</p>	<p>Both spiny redberry and hollyleaf redberry can be processed the same way (A. Montalvo personal observation). Soon after collection, ripe fruits can be run through a macerator (Youngblood 2008) or in small batches through a blender with blades covered with plastic tubing or other softening material. Then wash the pulp from the crushed fruits away from the seeds over a screen. As the seeds air dry, the papery endocarp that pops off of the seeds or remaining pulp can be removed by winnowing or with a mechanical seed blower (see Wall & Macdonald 2009). For the related <i>R. pirifolia</i>, Serrill et al. (2006) dried fruits in paper bags in a warm dry room, then ran them through a blender with modified blades to extract the seeds from the pulp. The materials was then sieved, then blown for 3 min to remove debris.</p> <p>Seeds can be disinfected in a Physan (quaternary amonium) solution for 5 to 10 min, or a 5% dilution of household bleach for 3 to 5 min. and rinsed before testing, sowing, or stratifying (Serrill et al. 2006).</p> <div data-bbox="159 478 1451 905">  <p data-bbox="441 716 915 814">Seeds of <i>R. ilicifolia</i> after pulp washed away, seeds air dried, and seeds popped out of endocarp. The endocarp shells are empty and yellow.</p> </div>
<p>G. Seed storage</p>	<p>Store processed seeds dry in a cold room or refrigerator (Young 2001).</p>
<p>H. Seed germination</p>	<p>Keeley (1991) considered the seeds of <i>Rhamnus</i> to be non-refractory; they don't increase germination after intense heat shock as happens with <i>Ceanothus</i>. Keeley (1987) found that seeds of <i>R. crocea</i> were inhibited by dark, but germinated at the same percentages in dark or light when treated with charate (leachate from charred stems of chamise). For seeds in light at 23 °C without charate, significantly fewer germinated when previously exposed to 70 °C for 1 hr, 100°C or 120 °C for 5 min compared to unheated controls. However, when seeds from different heat treatments were also treated with charate, the unheated controls and those exposed to 70 °C germinated at similar rates while those exposed to 100 °C germinated at nearly twice the rate. Germination was significantly lower for seeds exposed to 120 °C under all treatments. Seeds were stratified for one month at 5 °C before treatment. Keeley (1987) noted that germination was slow and improved under a second cold stratification period, a finding suggestive of physiological dormancy.</p> <p>For a collection of <i>R. ilicifolia</i> from the foothills of the Santa Ana Mountains, CA, 95% of 22-month old seeds placed in moist perlite in a dark cold room at 41–46 °F germinated within 47 days of initiating stratification (A. Montalvo pers. obs). The clean seeds had been stored under cool, dry conditions. Everett (2012) found seeds collected from cultivated plants germinated during cold stratification and that untreated seeds started to germinate in 18 days. He noted differences in the need for cold stratification and in time to germination for wild-collected seeds from different source populations.</p> <p>For a collection of <i>R. crocea</i> from San Timoteo Cn, CA, freshly cleaned seeds were stratified at 34 °F in moist perlite for 4.5 mo (but perlite became dry), then sown in December to 1/4 to 1/2 in deep. Seedlings began to emerge under ambient conditions in 29 days; 52% of the seeds produced seedlings within 3 months. Everett (2012) noted that untreated seeds started to germinate in 14 to 19 days, and after 18 days after stored for four years.</p>
<p>I. Seeds/lb</p>	<p><i>R. crocea</i>. Average live seeds/bulk lb = 20,000 (S&S Seeds 2018). Average seeds/lb = 70,000 (Stover Seed Company 2019) Keeley (1987) reported 105 seeds/g (= 47,600 seeds/lb) based on pure seed. The low number of seeds/g suggests that the seeds may have been <i>R. ilicifolia</i>. More data is needed.</p> <p><i>R. ilicifolia</i>. Average live seeds/bulk lb = 17,000 (S&S Seeds 2018) Montalvo (pers. obs) found 133 filled seeds per gram (= 60,328 seeds/lb) for a population at the base of the Santa Ana Mountains in Riverside Co.</p>

J. Planting	No information was found for direct seeding at natural sites. The following is for <i>R. crocea</i> but also works for <i>R. ilicifolia</i> (A. Montalvo pers. obs.). For container production, plant seeds in the early fall for natural vernalization or soak seeds and cold stratify for about 60 days (shorter times may work for low elevation populations, see IX. Seed germination, above) before planting in late winter (Young 2001, A. Montalvo pers. obs.). Plant seeds about 1/4 inch deep (about twice the diameter of the seed) in a well-drained mix in flats or tubes. Keep moist until seedling emerge. Avoid overwatering once emerged.
K. Seed increase activities or potential	These redberries are unlikely candidates for production of seed in seed orchards. Plants are used in low numbers relative to more dominant taxa and seeds can be readily collected from wild populations. A seed orchard would need to be large to accommodate the large plant size and need for both male and female plants.
X. USES	
A. Revegetation and erosion control	Both species are used for erosion control and land rehabilitation. Newton & Claassen (2003) note the use of <i>R. ilicifolia</i> seeds (no treatment needed) and containers as good for dry banks in chaparral and montane forests in the following geographic regions: Northwestern California, Sierra Nevada, Central Western California, and Southwestern California. They also note <i>R. crocea</i> as good for dry washes in coastal sage scrub, chaparral, and woodlands where there is good drainage in the following regions: Central Western California and Southwestern California.
B. Habitat restoration	Neither species is commonly found on restoration plant palettes for southern California, but both would be welcome additions to a variety of habitats. Hollyleaf redberry is appropriate at low density in a number of oak woodland and chaparral sites. Spiny redberry would be good for a number of alluvial scrub sites. Both species would support a variety of bees, birds, deer, and other wildlife (see X. D. Wildlife value). Once established, these species might survive the shorter fire return intervals becoming increasing common in parts of southern California. On Catalina Island, the related <i>R. pirifolia</i> was successfully seeded into experimental plots and in a drought year, several water additions more than doubled the survivorship (Stratton 2004). Untreated seeds of <i>R. ilicifolia</i> were planted into shrub shelters in a chaparral restoration experiment in the western San Gabriel Mountains; by October of the planting year with no additional water, 26% of shelters had at least one germinated seedling surviving (J. Beyers unpubl. data). If seeded, both <i>R. crocea</i> and <i>R. ilicifolia</i> may benefit from some shade from an overstory during seedling establishment (see IV. Shade tolerance).
C. Horticulture or agriculture	Both species are planted in gardens. Theodore Payne introduced redberries into cultivated gardens (Theodore Payne Foundation 2018). Both redberries are easy to start from seeds (A. Montalvo pers. obs.). In studies of leaf thickness and flammability as measured by the time it took for detached mature leaves to ignite, <i>R. crocea</i> and <i>R. ilicifolia</i> were very similar in response ranking number 12 and 13 of 34 taxa studied (Montgomery & Cheo 1971). Both ignited faster than <i>Arctostaphylos densiflora</i> , <i>Heteromeles arbutifolia</i> , and <i>Rhus ovata</i> (among the slowest native plants to ignite), but ignited significantly slower than the natives <i>Atriplex lentiformis</i> and <i>Salvia mellifera</i> , as well as non-native <i>Eucalyptus globosus</i> , <i>Lagerstroemia indica</i> , and four species of <i>Cistus</i> . There are no official cultivars, but it may be possible to propagate especially fruitful plants from cuttings. Sharma & Graves (2005) successfully rooted cuttings of the distantly related <i>R. alnifolia</i> and <i>R. lanceolata</i> . Of the methods studied, terminal softwood stem cuttings dipped in indole-3-butyric acid (IBA) in talc (8000 ppm) and stuck in vermiculite alone yielded the most callus and roots.
D. Wildlife value	<i>R. crocea</i> is the larval host of <i>Lycaena hermes</i> , the rare Hermes copper butterfly (Jennings 2008, see section VII. B. Herbivory, seed predation, disease). Calscape (2018) reports both <i>R. crocea</i> and <i>R. ilicifolia</i> as potential hosts for a variety of other lepidopterans. <i>R. crocea</i> and <i>R. ilicifolia</i> are preferred browse plants of deer (Sampson & Jespersen 1963, Conrad 1987) and intense deer browsing can limit the height of hollyleaf redberry (R.B. Pratt personal communication). The fruits of both redberries are eaten by a variety of birds, insects and mammals (Allen & Roberts 2013). The densely branched plants provide cover for a variety of wildlife in gardens and natural habitats (e.g. Bornstein et al. 2005). Small amounts of <i>R. ilicifolia</i> were found the nests of wood rat (Horton & Wright 1944).
E. Plant material releases by NRCS and cooperators	None.

F. Ethnobotanical	<p>The red berries of <i>Rhamnus crocea</i> were reported to be available for food for the Cahuilla people from August to October (Bean & Saubel 1972). Berries were also noted to be used as food by the Apache (likely was <i>R. ilicifolia</i>) who mixed the berries with animal substances, turning the mixture red (Hedrick 1972). The red color was said to be absorbed into the circulation, then tinging the skin red. We have found no record of the berries being safe to eat in quantity. The bright and juicy red berries, though tempting, have been reported as not edible by others (Theodore Payne Foundation 2018). It was also pointed out by Bean & Saubel (1972) that in Europe, people have been poisoned by eating berries of other <i>Rhamnus</i> species. Fruits of the related <i>Frangula californica</i> contain laxative properties (Bean & Saubel 1972) and have also been used to induce vomiting (Garcia & Adams 2008).</p> <p>Various decoctions of <i>Rhamnus ilicifolia</i> were used by the Kawaiisu people of California for analgesic, antirheumatic, and other medicinal purposes (NAE 2018). For example, decoctions made from the roots were said to be used as a stimulant, laxative, diuretic, and to treat gonorrhea. Plant parts were also smoked as an analgesic or anitirheumatic (Mohagheghzadeh et al. 2006). Garcia & Adams (2008) cite the preparations from roots and bark for laxative effects as the primary use. They caution that although it is probably safe to use the plant for occasional constipation, gut damage may occur from long-term use and suggest the chemical properties may be similar to that of other <i>Rhamnus</i> (some now <i>Frangula</i>). They say short-term use for stomach ailments and as an analgesic is likely safe. The related, widespread <i>R. alnifolia</i> has been reported to have many medicinal uses as well (NAE 2018).</p> <p>In a review of the chemistry of medicinal plants, Gurib-Fakim (2006) noted that in the family Rhamnaceae, plants are known to accumulate anthraquinones and may possess alkaloids of the benzylisoquinoline type and cyclo-peptide type. It appears most work has been on the <i>Frangula</i> group. Carranza et al. (2015) found that extracts of <i>Frangula californica</i> leaves and bark showed antimicrobial activity against MRSA (methicillin-resistant <i>Stapylococcus aureus</i>) and other some other Gram-positive bacteria which justifies some of the traditional medicinal uses of the plant.</p>
XI. ACKNOWLEDGMENTS	<p>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 Ron Vanderhoff and R. Brandon Pratt for sharing their photos and R. Brandon Pratt for providing comments that improved the manuscript.</p>
XII. CITATION	<p>Montalvo, A. M., E. C. Riordan, and J. L. Beyers. 2020. Plant Profile for <i>Rhamnus crocea</i> and <i>Rhamnus ilicifolia</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: https://www.rccrd.org/plant-profiles</p>
XIII. LINKS TO REVIEWED DATABASES & PLANT PROFILES	
Fire Effects and Information System (FEIS)	Not available: http://www.feis-crs.org/feis/
Calflora (RHCR)	https://www.calflora.org/cgi-bin/species_query.cgi?where-taxon=Rhamnus+crocea
Calflora (RHIL)	https://www.calflora.org/cgi-bin/species_query.cgi?where-taxon=Rhamnus+ilicifolia
Jepson Interchange (RHCR)	https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?41069
Jepson Interchange (RHIL)	https://ucjeps.berkeley.edu/cgi-bin/get_cpn.pl?41070
Jepson eFlora (JepsonOnline, 2nd ed.)	https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=41069
Jepson eFlora (JepsonOnline, 2nd ed.)	https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=41070
USDA PLANTS	https://plants.usda.gov/core/profile?symbol=RHCR
USDA PLANTS	https://www.plants.usda.gov/core/profile?symbol=RHIL
Native Plant Network Propagation Protocol Database (NPNPP)	https://nnp.rngr.net/propagation
Native Plants Journal	https://nnp.rngr.net/journal

Native Seed Network (NSN)	https://nativeseednetwork.org/
GRIN (provides links to many resources)	https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearch.aspx
GRIN (provides links to many resources)	https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?31034
Flora of North America (FNA) (online version)	http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=128246
Flora of North America (FNA) (families covered)	http://floranorthamerica.org/families
Native American Ethnobotany (NAE)	http://naeb.brit.org/
Woody Plant Seed Manual	https://www.fs.usda.gov/nsi/nsi_wpsm.html
Rancho Santa Ana Botanic Garden Seed Program, seed photos	http://www.hazmac.biz/seedhome.html
XIV. IMAGES	<p>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.</p> <p>Closeup images of <i>R. crocea</i> flowers by Keir Morse have a Creative Commons- Attribution-NonCommercial-ShareAlike 3.0 Unported designation (https://creativecommons.org/licenses/by-nc-sa/3.0/) and may be used freely for non-commercial purposes as outlined on the website. Images by Stephen Davis (copyright 2019), Ron Vanderhoff (copyright 2019), and Greg Ballmer (copyright 2019) are included with their permission. All other images by Arlee Montalvo (copyright 2019) unless otherwise indicated with rights reserved by the Riverside-Corona Resource Conservation District (RCRCD). Photos may be used freely for non-commercial and not-for-profit use if credit is provided. All other uses require permission of the authors, photographers, and the Riverside-Corona Resource Conservation District.</p>

Bibliography for *Rhamnus crocea* and *Rhamnus ilicifolia*

- Allen, R. L., and F. M. Roberts, Jr. 2013. Wildflowers of Orange County and the Santa Ana Mountains. Laguna Wilderness Press, Laguna, CA.
- Alexander, E. B. 2011. Gabbro soils and plant distributions on them. *Madroño* **58**:113-122.
- Baskin, C. C., and J. M. Baskin. 1998. Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination. Academic Press, San Diego, CA. 666 pages.
- Bean, J. L., and K. S. Saubel. 1972. Temalpakh: Cahuilla Indian Knowledge and Usage of Plants. Malki Museum Press, Morongo Indian Reservation, CA.
- Borchert, M., A. Lopez, C. Bauer, and T. Knowd. 2004. Field Guide to Coastal Sage Scrub & Chaparral Alliances of Los Padres National Forest. Technical Report R5-TP-019. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Vallejo, CA.
- Bosch, J., and W. P. Kemp. 2002. How to Manage the Blue Orchard Bee. Sustainable Agriculture Network Handbook Series 5. National Agricultural Library, Beltsville, MD. 88 pages.
- Bornstein, C., D. Fross, and B. O'Brien. 2005. California Native Plants for the Garden. Cachuma Press, Los Olivos, CA.
- Calflora. 2016. Information on California plants for education, research and conservation [web application]. The Calflora Database [a non-profit organization], Berkeley, California. Available: <http://www.calflora.org/> [Accessed 6 April 2016]
- Caravaca, F., D. Figueroa, A. Roldán, and C. Azcón-Aguilar. 2003. Alteration in rhizosphere soil properties of afforested *Rhamnus lycioides* seedlings in short-term response to mycorrhizal inoculation with *Glomus intraradices* and organic amendment. *Environmental Management* **31**:0412-0420.
- Carranza, M. G., M. B. Seigny, D. Banerjee, and L. Fox-Cubley. 2015. Antibacterial activity of native California medicinal plant extracts isolated from *Rhamnus californica* and *Umbellularia californica*. *Annals of Clinical Microbiology and Antimicrobials* **14**:29.
- CCH. 2016. Consortium of California Herbaria. Regents of the University of California, Berkeley, California. Available: <http://ucjeps.berkeley.edu/consortium/>. [Accessed 20 July 2016].
- Clarke, O. F., D. Svehla, G. Ballmer, and A. Montalvo. 2007. Flora of the Santa Ana River and Environs with References to World Botany. Heyday Books, Berkeley, CA. 495 p.
- Cleland, D. T. F., J. A. Freeouf, J. E. Keys, G.J. Nowacki, C. A. Carpenter, W. H. McNab. 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.
- Conrad, C. E. 1987. Common Shrubs of Chaparral and Associated Ecosystems of Southern California. General Technical Report PSW-99, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA, 86 p.
- Danforth, B. N. 1989. Nesting behavior of four species of *Perdita* (Hymenoptera: Andrenidae). *Journal of the Kansas Entomological Society* **62**:59-79.
- Dobson, H. E. M. 1993. Bee fauna associated with shrubs in two California chaparral communities. *Pan-Pacific Entomologist* **69**:77-94.

- 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.
- FNA 2018. Volume 12. 1. *Rhamnus* Linnaeus. Flora of North America North of Mexico. New York and Oxford. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=128246. [Accessed 26 June 2018].
- U.S. Department of Agriculture, Forest Service. 1948. Woody-plant Seed Manual. Miscellaneous Publication No. 654. Government Printing Office, Washington, D.C.
- Garcia, C., and J. D. Adams, Jr. 2009. Healing with Medicinal Plants of the West: Cultural and Scientific Basis for their Use. 2nd edition. Abedus Press, La Crescentia, CA.
- 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. Technical Report R5-ECOL-TP-005. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, San Diego, CA.
- 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.
- Greenleaf, S. S., N. M. Williams, R. Winfree, and C. Kremen. 2007. Bee foraging ranges and their relationship to body size. *Oecologia* **153**:589-596.
- Guitian, J. 1995. Sex ratio, reproductive investment and flowering phenology in dioecious *Rhamnus alaternus* (Rhamnaceae). *Nordic Journal of Botany* **15**:139-143.
- Gurib-Fakim, A. 2006. Medicinal plants: Traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine* **27**:1-93.
- Hanes, T., R. Friesen, and K. Keane. 1989. Alluvial scrub vegetation in coastal southern California. Pages 187-193 in D. L. Abell, technical coordinator. Proceedings of the California Riparian Systems Conference: Protection, Management, and Restoration for the 1990s: September 22-24, 1988; Davis, CA. General Technical Report PSW-110. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.
- Hedrick, U. P., editor. 1972. Sturtevant's Edible Plants of the World. Dover Publications, Inc., New York.
- Hickman, J. C., editor. 1993. The Jepson Manual: Higher Plants of California. University of California Press, Berkeley, CA.
- Holmgren, K., and B. Oxelman. 2004. Generic limits in *Rhamnus* L. s.l. (Rhamnaceae) inferred from nuclear and chloroplast DNA sequence phylogenies. *Taxon* **53**:383-390.
- Horton, J. S., and J. T. C. Wright. 1944. The wood rat as an ecological factor in southern California watersheds. *Ecology* **25**:341-351.
- Jacobsen, A. L., and R. B. Pratt. 2018. Extensive drought-associated plant mortality as an agent of type-conversion in chaparral shrublands. *Tansley insight. New Phytologist* **219**:498-504.
- 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.
- 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., M. F. Tobin, H. S. Toschi, M. I. Percolla, and R. B. Pratt. 2016. Structural determinants of increased susceptibility to dehydration-induced cavitation in post-fire resprouting chaparral shrubs. *Plant, Cell & Environment* **39**:2473-2485.
- Jennings, M. K. 2018. Faunal diversity in chaparral ecosystems. Page 53-77 in E. C. Underwood, H. D. Safford, N. A. Molinari, and J. E. Keeley, editors. *Valuing Chaparral: Ecological, Socio-Economic, and Management Perspectives*. Springer, Cham.
- Jha, S., L. E. V. Stefanovich, and C. Kremen. 2013. Bumble bee pollen use and preference across spatial scales in human-altered landscapes. *Ecological Entomology* **38**:570-579.
- Johnston, L. A. 1975. Revision of the *Rhamnus serrata* complex. *Sida* **6**: 67-79.
- 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. 1992a. Demographic structure of California chaparral in the long-term absence of fire. *Journal of Vegetation Science* **3**:79-90.
- Keeley, J. E. 1992b. Recruitment of seedlings and vegetative sprouts in unburned chaparral. *Ecology* **73**:1194-1208.
- Keeley, J. E., T. Brennan, and A. H. Pfaff. 2008. Fire severity and ecosystem responses following crown fires in California shrublands. *Ecological Applications* **18**:1530-1546.
- 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 A. Syphard. 2016. Climate change and future fire regimes: Examples from California. *Geosciences* **6**:37.
- Kirkpatrick, J. B., and C. F. Hutchinson. 1980. The environmental relationships of California coastal sage scrub and some of its component communities and species. *Journal of Biogeography* **7**:23-28.
- Marschalek, D. A., and D. H. Deutschman. 2008. Hermes copper (*Lycaena hermelycaena hermes*: Lycaenidae): life history and population estimation of a rare butterfly. *Journal of Insect Conservation* **12**:97-105.
- Marschalek, D. A., and D. H. Deutschman. 2009. Larvae and oviposition of Hermes copper (Lepidoptera: Lycaenidae). *Journal of Entomological Science* **44**:400-401.
- Marschalek, D. A., and M. W. Klein. 2010. Distribution, ecology, and conservation of Hermes copper (Lycaenidae: *Lycaena [Hermelycaena] hermes*). *Journal of Insect Conservation* **14**:721-730.
- McMinn, H. E. 1939. *An Illustrated Manual of California Shrubs*. J. W. Stacey, Inc., San Francisco, CA.
- Minnich, R. A. 1985. Evolutionary convergence or phenotypic plasticity? Responses to summer rain by California chaparral. *Physical Geography* **6**:272-287.
- Mohagheghzadeh, A., P. Faridi, M. Shams-Ardakani, and Y. Ghasemi. 2006. Medicinal smokes. *Journal of Ethnopharmacology* **108**:161-184.
- 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.

- Montgomery, K. R., and P. Cheo. 1971. Notes: Effect of leaf thickness on ignitibility. *Forest Science* **17**:475-478.
- Munz, P. A. 1974. *A Flora of Southern California*. University of California Press, Berkeley, CA.
- Munz, P. A., and D. D. Keck. 1968. *A California Flora with Supplement*. University of California Press, Berkeley, CA.
- Nesom, G. and J. Sawyer. 2018. *Rhamnus*. In *Flora of North America Editorial Committee*, eds. 1993+. *Flora of North America North of Mexico*. 20+ vols. New York and Oxford. Vol. 12. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=128246. [Accessed 29 November 2018]
- Newton, G. A., and V. Claassen. 2003. *Rehabilitation of Disturbed Lands in California: A Manual for Decision-Making*. California Department of Conservation, California Geological Survey, Sacramento, CA.
- Painter, E. 2016a. Common (vernacular) names applied to California vascular plants. *Rhamnus crocea*. University of California Jepson Herbarium, Online database: https://ucjeps.berkeley.edu/cgi-bin/getPainter_common.pl?41069. [Accessed 4 February 2020]
- Painter, E. 2016b. Common (vernacular) names applied to California vascular plants. *Rhamnus ilicifolia*. University of California Jepson Herbarium, Online database: https://ucjeps.berkeley.edu/cgi-bin/getPainter_common.pl?41070. [Accessed 4 March 2020]
- Patric, J. H., and T. L. Hanes. 1964. Chaparral succession in a San Gabriel Mountain area of southern California. *Ecology* **45**:353-360.
- Pausas, J. G., R. B. Pratt, J. E. Keeley, A. L. Jacobsen, A. R. Ramirez, A. Vilagrosa, S. Paula, I. N. Kaneakua-Pia, and S. D. Davis. 2016. Towards understanding resprouting at the global scale. *New Phytologist* **209**:945-954.
- Pivovarovoff, A. L. 2015. *Examining California Chaparral and Coastal Sage Scrub Responses to Environmental Change: A Hydraulics Approach*. Dissertation. University of California Riverside, Riverside, CA.
- 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, 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.
- 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.
- Raven, P. H., D. W. Kyhos, and A. J. Hill. 1965. Chromosome numbers of spermatophytes, mostly Californian. *Aliso* **6**:105-113.

- 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/. [Accessed 29 November 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.
- Rogers, D. L., and A. M. Montalvo. 2004. Genetically appropriate choices for plant materials to maintain biological diversity. University of California. Report to the USDA Forest Service, Rocky Mountain Region, Lakewood, CO. Online:
https://www.researchgate.net/publication/228494807_Genetically_appropriate_choices_for_plant_materials_to_maintain_biological_diversity. [Accessed 4 February 2020]
- Rottenberg, A. 1998. Sex ratio and gender stability of the dioecious plants of Israel. *Botanical Journal of the Linnean Society* **128**:137-148
- Rottenberg, A. 2000. Fertility of exceptional bisexual individuals in four dioecious plant species. *Sexual Plant Reproduction* **12**:219-221.
- Rundel, P. W. 2018. California chaparral and its global significance. Pages 1-27 *in* E. C. Underwood, H. D. Safford, N. A. Molinari, and J. E. Keeley, editors. *Valuing Chaparral: Ecological, Socio-Economic, and Management Perspectives*. Springer International Publishing, Cham.
- S&S Seeds. 2019. S & S Seeds Inc. Plant database: <http://www.ssseeds.com/database/index.html>. [Accessed 11 June 2019].
- Sampson, A. W., and B. S. Jespersen. 1963. California Range Brushlands and Browse Plants. University of California, California Agricultural Experiment Station Manual 33.
- Sánchez-Mata, D., and M. P. Rodríguez-Rojo. 2016. Mediterranean ultramafic (serpentine) chaparrals of California (USA): a geobotanical overview. Pages 285-312 *in* E. O. Box, editor. *Vegetation Structure and Function at Multiple Spatial, Temporal and Conceptual Scales*. Springer International Publishing, Cham.
- Sawyer, J. O., Jr. 2012a. *Rhamnus crocea*, *In* Jepson Flora Project (eds.) Jepson eFlora, https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=41069. [Accessed 4 February 2020]
- Sawyer, J. O., Jr. 2012b. *Rhamnus ilicifolia*, *In* Jepson Flora Project (eds.) Jepson eFlora, https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=41070. [Accessed 4 February 2020]
- 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.
- Serrill, D., M. Herrera, and J. Takara. 2006. Propagation protocol for production of container (plug) *Rhamnus pirifolia* Greene plants #1 Treepot (173 cubic inches); Catalina Island Conservancy Avalon, California. *In*: Native Plant Network.
<https://nnp.rngr.net/propagation/protocols> [Accessed 29 November 2018]. US Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources.
- Sharma, J., and W. R. Graves. 2005. Propagation of *Rhamnus alnifolia* and *Rhamnus lanceolata* by seeds and cuttings. *Journal of Environmental Horticulture* **23**:86-90
- Smith, R. L. 1980. Alluvial scrub vegetation of the San Gabriel River floodplain, California. *Madroño* **27**:126-138.

- Stover Seed Company. 2019. Species List. Online database:
<http://www.stoverseed.com/websearch/specieslist.cfm>. [Last accessed 7 June 2019].
- Stratton, L. C. 2004. Santa Catalina Island experimental restoration trials: Developing appropriate techniques. Pages 213-227 *in* Proceedings of the Sixth Channel Islands Symposium, December 1-3, 2003, Ventura, CA. Available online: http://iws.org/publications_proceedings_6th.html.
- 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.
- Theodore Payne Foundation. 2018. *Rhamnus ilicifolia*. Online:
http://theodorepayne.org/nativeplantdatabase/index.php?title=Rhamnus_ilicifolia. [Accessed 19 June 2019].
- Townsend, P. A., and D. J. Levey. 2005. An experimental test of whether habitat corridors affect pollen transfer. *Ecology* **86**:466-475.
- USDA PLANTS. 2018. The PLANTS Database (<https://plants.usda.gov>). National Plant Data Team, Greensboro, NC 27401-4901 USA. [Accessed 25 October 2018]
- 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>.
- Wang, B., and Y.-L. Qiu. 2006. Phylogenetic distribution and evolution of mycorrhizas in land plants. *Mycorrhiza* **16**:299-363.
- Wilson, J. A., and B. Thomas. 1999. Diet and seed dispersal efficiency of the gray fox (*Urocyon cinereoargenteus*) in chaparral. *Bulletin of the Southern California Academy of Sciences* **98**:119-126.
- Wolf, C. B. 1938. The North American Species of *Rhamnus*. Rancho Santa Ana Bot. Gard. Monogr., Bot. Ser. 1.
- Young, B. 2001. Propagation protocol for production of container (plug) *Rhamnus crocea* Nutt. plants Deepot 40; San Francisco, California. *In* Native Plant Network: <https://nnp.nmgr.net/propagation>. [Accessed 26 October 2018]. US Department of Agriculture, Forest Service, National Center for Reforestation, Nurseries, and Genetic Resources.
- Youngblood, A. 2008. *Rhamnus* L. Pages 939-942 *in* F. T. Bonner, and R. P. Karrfalt, editors. The Woody Plant Seed Manual. Agriculture Handbook 727. U.S. Department of Agriculture, Forest Service, Washington, DC.
- Zedler, P. H., C. R. Gautier, and G. S. McMaster. 1983. Vegetation change in response to extreme events: The effect of a short interval between fires in California chaparral and coastal scrub. *Ecology* **64**:809-818.
- Zurbuchen, A., L. Landert, J. Klaiber, A. Müller, S. Hein, and S. Dorn. 2010. Maximum foraging ranges in solitary bees: Only few individuals have the capability to cover long foraging distances. *Biological Conservation* **143**:669-676.