Fremontodendron californicum, California flannelbush 2021

Figure 1—California flannelbush in Los Angeles County, California. Image courtesy of Marisa Persaud © 2020 (CC BY-NC 4.0).

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ABSTRACT

California flannelbush, *Fremontodendron californicum,* is a shrub or small tree that occurs in California, central Arizona, and northern Baja California, Mexico. It is most common on dry sites in mountainous areas and is commonly associated with nutrient poor, rocky, or coarse soils. California flannelbush occurs mainly in chaparral and woodland communities and may be dominant in desert chaparral.

California flannelbush reproduces by seed and by root sprouting, and it can sprout from roots and root crowns after top-kill from fire or other disturbances. Seeds may be produced on plants as young as 2 years old. Seeds fall from capsules and are likely dispersed by ants over short distances. Seeds are dormant and must be scarified in order to germinate. High temperatures stimulate germination. No information on California flannelbush seed banks was available; however, observations of seedling establishment after fire indicate that seeds persist in the soil for at least short periods.

California flannelbush is adapted to survive, regenerate, and establish from seed after fire in chaparral and woodland environments. It is considered "fire dependent" and a "fire-recruiter" because seedling establishment is largely restricted to the first rainy season after fire and because it sprouts after it is top-killed by fire. California flannelbush is typically most abundant in early postfire environments in both chaparral and pinyon-juniper woodlands. While it can persist in late-successional chaparral (~100 years after fire), it is rarely observed in late postfire succession (>80 years after fire) in singleleaf pinyon (*Pinus monophyla*) woodlands.

Fire regimes in California chaparral are typically characterized by intense, stand-replacing crown fires. Historical fire intervals vary depending on location, but typically range from about 35 to 115 years. Fires have become more frequent in the late 20th and early 21st centuries on some southern California sites, resulting in conversions from native chaparral to communities dominated by nonnative, annual forbs and grasses. Repeated fires at short intervals may reduce California flannelbush occurrence in favor of herbaceous species; however, its response to frequent fires has not been studied.

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INTRODUCTION

FEIS ABBREVIATION
frecal

COMMON NAME
California flannelbush
flannelbush
California fremontia
fremontia

TAXONOMY
The scientific name of California flannelbush is *Fremontodendron californicum* (Torr.) Coville (Malvaceae) [4, 17]. Across its range, morphologically distinct populations of California flannelbush have been treated as subspecies or varieties (e.g., [10, 17, 86]); however, these infrataxa are no longer recognized [17, 41].

California flannelbush is one of three species in its genus along with Pine Hill flannelbush (*F. decumbens*) and Mexican flannelbush (*F. mexicanum*) [4, 17]. Pine Hill flannelbush is called *Fremontodendron californicum* subsp. *decumbens* in some publications (e.g., [10, 86]). It differs from California flannelbush primarily in growth form (i.e., Pine Hill flannelbush is decumbent; California flannelbush is erect [41]), flower color, and pedicel length [17]. Genetic and morphological relationships among flannelbush species are described by Kelman and others (1991, 2006) [41, 42]. In this review "flannelbush" is used to indicate genus-level information.

A hybrid ('California Glory') of California flannelbush and Mexican flannelbush was developed for horticultural use [49]. Hyland (1990) describes 'California Glory' as a "natural hybrid" occurring in California [29], but it is not described in floras (e.g., [4, 17]).

See table A1 for a complete list of common and scientific names of plant species mentioned in this Species Review and links to other FEIS Species Reviews.

SYNONYMS
None

LIFE FORM
Shrub-tree

DISTRIBUTION AND PLANT COMMUNITIES

GENERAL DISTRIBUTION

California flannelbush occurs in California, central Arizona, and northern Baja California, Mexico (fig. 2) [4, 17, 30, 48, 57, 85]. It is most common in California, where it occurs in the northern [26] and southern Coast Ranges and Sierra Nevada foothills (fig. 3) [35, 79]. It is uncommon and occurs only in a few areas in central Arizona [46, 48] and Baja California [53, 55, 85]. The densest populations of "flannelbush" occur in the Transverse Ranges and the southern Sierra Nevada [41]; most of these populations are California flannelbush.

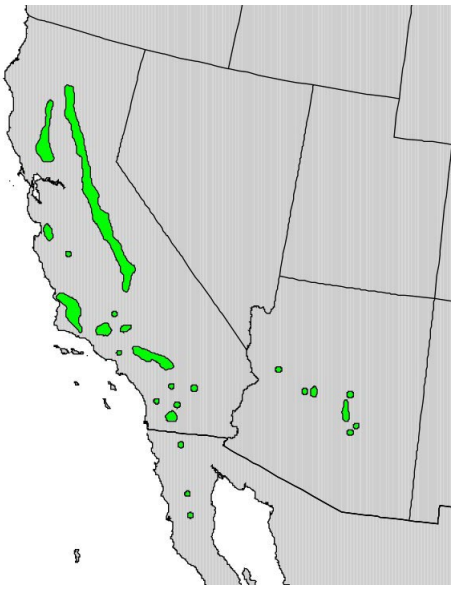

Figure 2—Distribution of California flannelbush
Map from Little (1976) [47] and digitized by Thompson and others (1999) [74].

States and Provinces:
United States: AZ, CA.
Mexico

Most sources describe the United States distribution of California flannelbush in California and Arizona only (e.g., [4, 17, 30]); however, USDA Plants also maps it in Oregon [77].

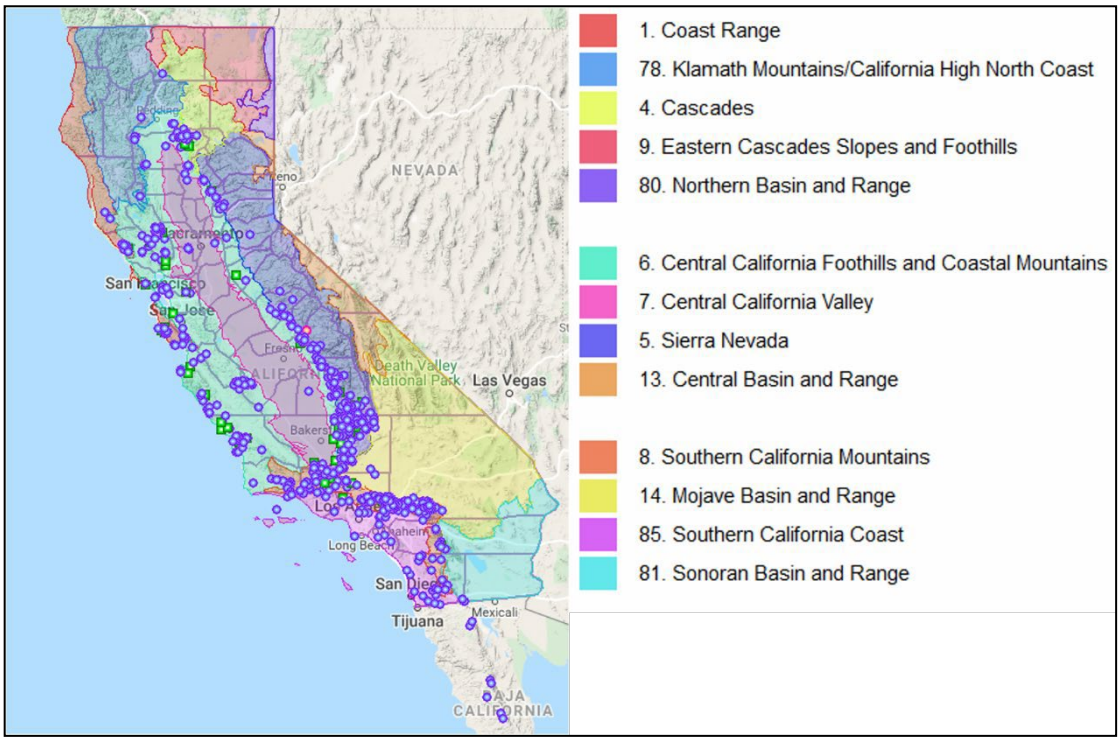

Figure 3—Observations of California flannelbush by EPA Ecoregion III [76] in California. Map created using Calflora Observation Search maps [12].

Site Characteristics

California flannelbush is most common on dry sites [31, 40] in mountainous areas on slopes and in canyons [31, 57, 62, 85]. It is commonly associated with nutrient poor, rocky, coarse [7, 57], and shallow soils [12], and it often grows in rocky crevices [1]. It also occurs in serpentine soils [26, 59], where it can be dominant [59]. California flannelbush root samples from populations in California and Arizona showed varied rates of mycorrhizal colonization [62].

California flannelbush grows in areas that have a mediterranean climate of hot, dry summers and cool, wet winters [5, 51]. Based on statewide distribution and climate map layers in California, California flannelbush can grow in areas with 13 to 69 inches (33 to 175 cm) mean annual precipitation that have a 3- to 8-month wet season and a 2- to 11-month growing season. It tolerates average minimum temperatures in December of 22 °F (-6 °C) and average maximum temperatures in July of 95 °F (35 °C) [12].

Habitat suitability models suggest that in central Arizona, California flannelbush is most common on sites with Inceptisols, 40% to 60% slopes, 30 to 32 inches (76-81 cm) mean annual precipitation, and at 5,250 to 7,220 feet (1,600-2,200 m) elevation [62].

Across its distribution, California flannelbush occurs from about 590 to 7,610 feet (180-2,320 m) in elevation [4]. Elevation ranges at some locations where California flannelbush occurs are shown in table 1.

Table 1—Elevation range of California flannelbush at some locations.

Location	Elevation range
AZ: Central	3,200-6,500 feet (970-1,980 m) [46]; 3,500-6,000 feet (1,070-1,830 m) [31]
CA: San Bernardino Mountains	4,265-6,560 feet (1,300-2,000 m) [51, 84]
CA: San Diego County north to Shasta and Kern Counties	3,000-6,000 feet (900-1,800 m) [15]
CA: Southern Sierra Nevada, Tulare County, South Fork Tule River	2,400-3,510 feet (730-1,070 m) [60]

Plant Communities

California flannelbush occurs mainly in chaparral and woodland communities, and it may be dominant or codominant in desert chaparral [50, 52] and semi-desert chaparral [78]. In southern California, it often occurs in desert chaparral on the lee side or desert-facing slopes of the San Bernardino and San Gabriel Mountains [23, 50, 75] and in pinyon-juniper woodlands [75]. The California Native Plant Society describes California flannelbush as occurring in six alliances. Plant communities other than those described below are listed in table 2.

Plant communities and associated species where California flannelbush most commonly occurs include:

Chaparral

California dry-mesic chaparral (northern and central California): California flannelbush is an associated species in some dry-mesic chaparral communities. This community includes chaparral typically located inland from maritime chaparral up to 4,550 feet (1,500 m) elevation in central and northern California. It includes extensive areas on coarse-grained soils with annual precipitation up to 29.5 inches (74.9 cm) that occurs as rain, but not snow. Other characteristic species include chamise, buckbrush, manzanita species, Mendocino bushmallow, tree poppy, and chaparral pea. Scattered and young trees may occur, such as ponderosa pine, gray pine, coast Douglas-fir, and interior live oak [56].

Xeric serpentine chaparral: California flannelbush is a common associate and sometimes dominant in serpentine chaparral (e.g., [26, 59]). This plant community occurs on thin, rocky, ultramafic soils with very low Ca:Mg ratios and is highly variable and spotty in distribution [56]. Shrubs are dwarfed and compact and widely spaced. Interspaces may be occupied by perennial bunchgrasses, subshrubs, and annual herbs [59]. Other shrubs in this community commonly include chamise, manzanita, ceanothus, chaparral silktassel, leather oak and other oaks, and toyon. Scattered trees may include gray pine, California laurel, coast Douglas-fir, and oaks [26, 56, 59].

Desert chaparral (southern California): California flannelbush may be dominant or codominant in some areas of desert chaparral such as on the eastern side of Transverse Ranges in southern California (i.e., San Bernardino and San Gabriel Mountains) [27, 50, 52]. Desert chaparral occurs above the western boundary of the Mojave Desert ecosystem and mixes with pinyon-juniper woodlands at its upper elevations [32]. It is more open than other California chaparral types [24,

32] because it is drier. Associated species include manzanita, desert ceanothus, oaks, alderleaf mountain-mahogany, California buckthorn, and hollyleaf cherry [51, 52].

Woodlands

Pinyon-juniper woodlands (southern California): California flannelbush occurs in the understory of pinyon-juniper woodlands below 6,560 feet (2,000 m) in the San Bernardino Mountains [51, 84]. Singleleaf pinyon is the dominant tree and often forms monotypic stands but is sometimes mixed with California juniper. Associated understory species include desert chaparral shrubs such as desert ceanothus, interior live oak, bigberry manzanita, and alderleaf mountain-mahogany. Herbaceous cover is sparse [84].

Table 2—Plant communities where California flannelbush occurs other than those described above.

Location	Plant communities
AZ: Central	Chaparral, mainly associated with Arizona cypress [46]
CA: Coastal	Scrub oak chaparral [61]
CA: Coastal (Central and Southern)	Scrub oak, mixed chaparral, and coastal transition chaparral [18]
CA: Lassen National Forest (Indian Creek RNA)	Interior live oak woodland-scrub at elevations where coastal sage scrub oak replaces interior live oak [13]
CA: San Bernadino National Forest (Cleghorn Canyon RNA)	Chamise-hoaryleaf ceanothus chaparral [13]
CA: Sequoia National Forest	Chamise chaparral, mixed chaparral, and lowland live oak woodlands [82, 83]
CA: Sequoia National Forest (Long Canyon cRNA)	Desert chaparral, annual grassland, foothill pine woodland, Havard oak brush, and Paiute cypress forest [13]
CA: Sequoia National Forest and Giant Sequoia National Monument, Kings River Basin	Mixed ponderosa pine–oak–chaparral [35]
CA: Southern Cascades bioregion	Blue oak woodlands [67]
CA: Southwestern Mojave Desert, San Gabriel Mountains	Joshua tree woodland and pinyon-juniper woodland ecotone [73]
CA: Southern Sierra Nevada, Tulare County, South Fork Tule River	Canyon walls of foothill woodland, chaparral, and Sierran mixed hardwood forests [60]

BOTANICAL AND ECOLOGICAL CHARACTERISTICS

GENERAL BOTANICAL CHARACTERISTICS

Botanical Description

This description covers characteristics that may be relevant to fire ecology and is not meant for identification. Identification keys (e.g., [4]) and detailed descriptions of the genus [41] are available.

California flannelbush is a loosely branched, erect shrub or small tree. It generally grows about 5 to 16.5 feet (1.5 to 5 m) tall and branches near the ground [4, 17, 65]. Sudworth (1908) describes it as a small tree from 10 to 20 feet (3-6 m) tall with a short trunk from 3 to 6 inches (8-15 cm) wide and an open crown of wide-spreading limbs. "Very often, however, it is a much branched shrub, from 4 to 6 feet high, forming dense thickets with other foothills brush" [70]. Its bark can be rough, deeply fissured and scaly [46, 70], and its inner bark is mucilaginous [4, 46, 71]. California flannelbush is evergreen [4, 17], but "somewhat drought deciduous" [15, 29] with soft to leathery leaves [4] that generally persist for 2 years [5]. Leaves are typically palmately lobed but degree of lobing and leaf size vary substantially by habitat; mean leaf lengths are 0.8 ± 0.6 inch (2.1 ± 1.4 cm) long, and mean widths are 0.7 ± 0.5 inch (1.9 ± 1.3 cm) wide [5]. The yellow flowers are comprised of sepals only and are generally 0.9 to 3 inches (2.3 to 7.6 cm) wide [4, 17]. The fruit is a bristly, 5-valved capsule, about 1 to 1.5 inches (2.5-3.8 cm) long [4, 29, 46] that contains 2 to 3 seeds per valve (fig. 4). Seeds are about 3.5 to 5.5 mm long and have elaiosomes [4, 41].

Little information was available about California flannelbush roots or underground structures. Graves (1932) describes "running roots" with sprouts as far as 5 feet (1.5 m) from the parent plant [21]. The Missouri Botanical Garden describes shallow, wide-spreading roots, in the hybrid 'California Glory' [54].

Figure 4—California flannelbush flower (left) and fruit (right).
Images courtesy of Diane Etchison 2019 © (*CC* BY-*NC 4.0*) (left) and John Ruter, University of Georgia, Bugwood.org (right).

Raunkiaer Life Form [63]
Phanerophyte
Geophyte

SEASONAL DEVELOPMENT
California flannelbush typically flowers from April through July in California and Baja California [4, 58, 85]. In central Arizona, it usually flowers in May [31]. The flowering period for an individual plant is usually about 1 to 3 weeks long [85]. Fruits ripen from August to September and seeds disperse "in summer" [33] or September and October [58]. "Flannelbush" seeds are retained in capsules for about a month after ripening [58].

REGENERATION PROCESSES
California flannelbush reproduces sexually from seeds and asexually from root sprouts. It also sprouts from the base (likely the root crown) or from roots after top-kill. Little information has been published about regeneration processes for California flannelbush; however, information about other flannelbush species may provide insights regarding California flannelbush regeneration.

Pollination and Breeding System
No published information about California flannelbush pollination or breeding system was available as of this writing (2020), but it is likely pollinated by bees [8].

Seed Production and Mortality
"Flannelbush" plants may reach sexual maturity during their second growing season [58]. While no studies quantify California flannelbush seed production, Sudworth (1908) describes California flannelbush as "usually an abundant seeder" [70], and NatureServe states that it produces abundant seeds [57]. However, a 2-year study of Pine Hill flannelbush describes high mortality of flower buds (80.5%), flowers (51%), and fruits (81%) mostly from insect predation. Pine Hill flannelbush shrubs produced an estimated average of 32.6 fruits/shrub and 99 seeds/shrub during 1 sampling year. After seeds dispersed, 90% of seeds were predated, and rodents were more important seed predators than birds [11]. Because studies are lacking for California flannelbush, it is unknown if similar seed production and mortality rates can be inferred for California flannelbush.

Seed Dispersal
"Flannelbush" seeds fall from capsules and are dispersed by ants. California flannelbush and Pine Hill flannelbush seeds have eleiosomes, which are fatty appendages that may be eaten by ants without harming the seed [34]. Pine Hill flannelbush seeds were often found on ant middens that occurred within 26.2 feet (8 m) of parent plants, and the farthest seed found on an ant midden was 39.4 feet (12 m) from the nearest parent plant [9]. Seed dispersal has not been studied for California flannelbush.

Germination and Seed Banking
"Flannelbush" seeds are dormant and must be scarified and possibly stratified in order to germinate. Seeds may be scarified mechanically or by heat [49, 58]. "Complete germination" of California flannelbush seeds occurred after they were soaked in hot water for 1 to 5 minutes and stratified for 12 to 16 weeks at 35 °F (1.6 °C) [58]. California flannelbush seeds stored for almost 2 years in sealed containers at 41 °F (5 °C) retained viability [58].

High temperatures stimulate germination of California flannelbush seeds [33, 37]. In one study, freshly collected California flannelbush seeds were either stored for 6 months at room temperature or stored for approximately 1 year in soil. Seeds were exposed to one of five heat treatments or one of three

dilutions of liquid smoke. Seeds had higher germination rates after most heat treatments than untreated controls ($P < 0.05$). However, heat treatments at or greater than 284 °F (140 °C) for 5 minutes were lethal (table 3). Liquid smoke treatments did not affect germination rates [37]. Exposure to heat and charred wood may act synergistically to stimulate germination. Although results varied, California flannelbush seeds exposed to heat and/or charate (powdered charred wood) generally had higher germination rates than untreated controls, and germination rates were similar in light and dark. Germination rates were compared among 16 treatment combinations (table 4) [33].

Table 3—Germination rates of California flannelbush seeds.
Data approximated from figures 1 and 2 in Keeley and others (2005) [37].

Heat treatment	Germination rate of room temperature-stored seed (%)	Germination rate of soil-stored seed (%)
80 °C for 60 minutes	50*	75*
100 °C for 5 minutes	60*	55*
110 °C for 5 minutes	45*	35
130 °C for 5 minutes	40*	Not tested
140 °C for 5 minutes	3	Not tested

*Indicates treatments significantly higher than controls at $P < 0.05$.

Table 4—Germination rates of California flannelbush seeds with light, temperature, and charate treatments.
Data extracted from table 1 in Keeley (1987) [33].

Light treatment	Light				Dark			
Heat treatment	Control (%)	70 °C 1 hr (%)	100 °C 5 min (%)	120 °C 5 min (%)	Control (%)	70 °C 1 hr (%)	100 °C 5 min (%)	120 °C 5 min (%)
Non-charate	2[a]	0[a]	0[a]*	2[a]*	3	2[a]	0[a]	2[a]*
Charate	2[a]	3[a]	8[b]*	10[b]*	0[a]	3[a]	3[a]	8*

Temperature treatments with different superscript letters are significantly different from each other ($P < 0.05$). Light and dark treatments were considered separately. For a given temperature treatment, an asterisk (*) indicates charate treatments that are significantly different than each other ($P < 0.05$).

Although published information on California flannelbush seed bank dynamics is lacking, it is reasonable to infer and often stated (e.g., [36, 51, 52]) that California flannelbush establishes from a persistent soil seed bank. California flannelbush has dormant seeds that require scarification (likely by fire) and possibly stratification to germinate. This suggests that viable seeds can persist in the soil until these conditions are met, assuming that they escape predation. Field experiments with Pine Hill flannelbush found that >80% of seeds remained viable after 5.75 years buried under litter when protected from predation (i.e., enclosed in mesh sleeves) [11]. Given similar scarification requirements and heat-stimulated germination of Pine Hill flannelbush [11] and California flannelbush [33, 37] seeds, it is reasonable to assume that California flannelbush seeds also survive in the soil seed bank. Regarding California flannelbush seed banks, Keeley and others (2005) concluded, “we can infer their existence because they do not have propagules designed for long distance dispersal, and the time between fires and the first growing season is outside the season of seed dispersal” [37].

While seed banks were not directly measured, the authors of a chronosequence study of singleleaf pinyon woodlands in the San Bernardino Mountains infer that California flannelbush "establishes even-aged stands from seed banks immediately following fire" (see Plant Response to Fire) [84].

Seedling Establishment and Plant Growth

Although information about natural seedling establishment without fire is lacking and few studies quantified California flannelbush postfire seedling establishment [39, 84] (see Plant Response to Fire), several publications suggest that establishment is restricted to the early postfire environment [36], which typically has exposed mineral soil and abundant sunlight. Sudworth (1908) notes that "seedlings grow in exposed mineral soil where seed has been covered by wash" [70].

Field seeding and planting practices are described for California flannelbush [1, 25, 58]. Near Davis California, spot sowing yielded 34% emergence and 80% survival after 1 year. No further detail is provided [58]. California flannelbush is considered suitable for direct seeding, especially in fall after seeds are soaked in hot water [25].

Detailed information is lacking about California flannelbush seedling establishment. However, Pine Hill flannelbush seedlings failed to establish during experimental seedings at an unburned site in Eldorado County, California. Pine Hill flannelbush seeds were heat-treated and planted 0.4 to 0.8 inch (1-2 cm) deep in unprotected and protected (exclosed) plots in openings in the shrub canopy. Seedlings emerged beginning in December (2 months after planting) and continued through March. Emergence was 65% for exclosed plots and 59% for unprotected plots. Most of these seedlings were killed by rodent and insect predators, and those that escaped predation died from desiccation. Across the site, 12 unplanted seedlings were found, but they all died by June [11].

A few authors suggest that California flannelbush tends to grow rapidly [1, 49, 58]. Plants that established from seeds sown near Davis, California, grew to over 4 feet (1.2 m) tall and 5 feet (1.5 m) across by the end of the first growing season [58]. On the San Joaquin deer winter range in Madera County, California, California flannelbush sprouted "vigorously" and sprouts grew rapidly after it was bulldozed and then burned in early spring. When sprouts were protected from deer browsing, they grew 8 to 10 feet (2.4-3 m) tall by the end of the sixth growing season. Even with continuous deer browsing, sprouts grew out of reach of the deer by the end of the sixth growing season [20].

Vegetative Regeneration

California flannelbush spreads vegetatively via root sprouts [21, 41], and it sprouts after top-kill or damage from fire, browsing, or mechanical means. Studies and reviews of postfire response suggest that sprouts originate from roots [21] and from the stem base, presumably from the root crown [21, 36] or stumps [15]. Graves (1932) observed postfire root sprouts of California flannelbush as far as 5 feet (1.5 m) from the parent plant [21]. Root sprouting has also been observed where trails or erosion exposed roots at the soil surface [41]. Root sprouting differs from basal sprouting because root sprouts add a new ramet to the existing population; this may be an important reproductive strategy especially in the absence of fire [11]. The minimum and maximum ages that California flannelbush plants can sprout is not given in available literature.

In El Dorado County, California, excavations of small Pine Hill flannelbush shrubs found that they were sprouts from shallow (<12 inches (30 cm) deep) roots of nearby larger shrubs. Because Pine Hill flannelbush requires fire for seed scarification and germination, root sprouting is critical to population

persistence in the absence of fire. While the trigger for root sprouting is unknown, the authors speculate that it is associated with habitat disturbance [11].

All species of flannelbush can be propagated from stem cuttings [58].

SUCCESSIONAL STATUS

California flannelbush typically occurs early in postfire environments (see Plant Response to Fire); however, it can persist in chaparral that has not burned in about 100 years. For example, in Sequoia National Forest, California flannelbush density was greater in stands of chaparral that had not burned for over 90 years (164 stems/ha) than stands that had not burned in 50 to 60 years (102 stems/ha) (*P*=0.037) [38]. Sudworth notes that California flannelbush "appears capable of enduring considerable shade, but rarely subjected to it" [70].

California flannelbush occurs in the understory of pinyon-juniper woodlands [51, 84], but it is most abundant during the first 80 years after fire [84], when it may establish local thickets [52]. After fire in singleleaf pinyon woodlands in the San Bernardino Mountains, shrubs dominated for about 50 years and peaked at 40.5% and 47.7% cover on low (<6,560 ft (2,000 m)) and high (>6,560 ft (2,000 m)) elevation sites, respectively. A chronosequence of 38 burns found that at low elevation sites California flannelbush cover peaked at 6.5% in 9-year-old burns, and density peaked at 1,754 stems/ha in 33-year-old burns (table 5). Skeletons of California flannelbush occurred in burns more than 47 years old, but living stems were absent. At high elevation sites, California flannelbush occurred only in plots measured 47 and 78 years after fire. At low and high elevation sites, singleleaf pinyon established and density increased beginning at 33 and 47 years since fire, respectively, and total shrub cover and density declined, possibly due to increased shade. By postfire year 160, total shrub cover was 6.3% and 6.2% at low and high elevation sites, respectively [84].

Table 5—Estimated cover and density of California flannelbush from a chronosequence of 38 burns in singleleaf pinyon woodlands in the San Bernardino Mountains, California.
Dashes (-) indicate no data collected. Sample years between 90 and 160 years since fire are excluded because California flannelbush was absent. Table adapted from Wangler and Minnich (1996) [84].

Years since fire	1	5	8	9	13	14	18	32	33	35	38	43	47	78
Low elevation sites (<2,000 m)														
Mean cover (%)	0	-	2.1	6.5	3.3	-	3.2	-	3.5	-	1.1	-	3.2	-
Mean density (stems/ha)	0	-	556	1,026	422	-	484	-	1,754	-	508	-	1,022	-
High elevation sites (>2,000 m)														
Mean cover (%)	-	0	-	-	-	0	-	0	-	0	-	0	6.7	2.6
Mean density (stems/ha)	-	0	-	-	-	0	-	0	-	0	-	0	468	965

FIRE EFFECTS AND MANAGEMENT

FIRE EFFECTS

Immediate Fire Effects on Plant

California flannelbush is top-killed by fire [39, 79], but plants often sprout from the stem base (presumably the root crown) and from roots. Fire stimulates both seed production (i.e., a facultative seeder) and sprouting in California flannelbush [40]. Observations of postfire seedling establishment [39,

84] and heat treatment experiments [33, 37] suggest that fire scarifies California flannelbush seed and stimulates germination.

Postfire Regeneration Strategy
Tall shrub with a sprouting root crown
Geophyte
Ground residual colonizer (on site, initial community) [69]

FIRE ADAPTATIONS
California flannelbush is well-adapted to fire because fire stimulates sprouting [1, 13, 39, 40, 58, 64, 67, 84] and because seedling recruitment is largely restricted to the early postfire environment [36]. Sprouts originate at the stem base, presumably from the root crown [21, 36] or stumps [15], and from roots [21]. California flannelbush grows rapidly and likely reaches maturity relatively quickly, allowing it to thrive in early postfire environments (see Regeneration Processes).

Several publications classify California flannelbush as "fire dependent" and as a "fire-recruiter" because it is a facultative seeder with fire-stimulated seed production and sprouting, and because seedling establishment is largely restricted to the first rainy season after fire [22, 34, 36]

PLANT RESPONSE TO FIRE
While few studies quantify California flannelbush response to fire, observations and reports suggest that top-killed plants sprout (e.g., [1, 13, 39, 40, 64, 67, 84]) and seedlings establish soon after fire [39, 84]. California flannelbush may "establish local thickets in early postfire succession" in desert chaparral communities [52].

Chaparral: Two studies that describe early postfire plant community response in California chaparral indicate that California flannelbush sprouts and seedlings occur soon after fire [39, 64]. California flannelbush sprouts were observed in March, and seedlings were observed in June after a high-severity fire in southern California chaparral in November. Sprout density increased from 300 sprouts/ha in March to 2,000 sprouts/ha in June, and sprout areal cover increased from 2 m^2/ha in March to 171 m^2/ha in June. California flannelbush seedling density was 4,000/ha and areal cover was 9 m^2/ha in June. California flannelbush, chaparral whitethorn, and hairy yerba santa were considered dominant shrubs in this postfire environment [39]. In chamise chaparral in the foothills of Sequoia National Park, California flannelbush occurred at low frequency the summer following an October fire in plots that had burned at high and low intensities (2% and 1% frequency, respectively). Fire intensity was estimated by average minimum size of attached unburned twigs [64]. No information on long-term postfire response was available, although on the San Joaquin deer winter range in Madera County, California flannelbush plants were numerous and "tree-like" 22 years after bulldozing and burning [20].

Pinyon-juniper woodlands: In singleleaf pinyon woodlands of the San Bernardino Mountains, a chronosequence study of 38 burns resulting mostly from canopy fires, found that burns were populated by a mix of species that characterize Great Basin sage-scrub, and low elevation burns (<6,560 feet (2,000 m)) were also populated by species that characterize desert chaparral. At low elevations, burns less than 10 years old were dominated by sprouts of antelope bitterbrush and seedlings of several shrub species, including California flannelbush. In burns between 8 and 47 years old, California flannelbush cover estimates ranged from 1.1% to 6.5% and density estimates ranged from 422 to 1,754 stems/ha (table 5). In burns more than 47 years old, skeletons of California flannelbush were often present, but living California flannelbush were absent. Total shrub cover and density increased steadily with time-since-fire

and peaked at 40.5% cover and 11,339 stems/ha in burns 47 years old and then declined in older burns. Singleleaf pinyon was absent from all burns less than 18 years old, and its density gradually increased in burns beginning at 33 years old. Sites succeeded to mature woodland at about 100 to 150 years after fire. At high elevation sites (>6,560 feet (2,000 m)), California flannelbush occurred only in burns 47 and 78 years old. California flannelbush cover estimates were 6.7% and 2.6% and density estimates were 468 stems/ha and 965 stems/ha in burns 47 and 78 years old, respectively (table 5). At high elevations, total shrub cover and density peaked in 32- and 47-year-old burns, and singleleaf pinyon was absent in burns less than 47 years old. Singleleaf pinyon density increased on older burns, through 160 postfire years [84].

No information was available (as of 2020) on postfire response of California flannelbush populations in Arizona or in California xeric serpentine chaparral.

FUEL CHARACTERISTICS

As an evergreen shrub or small tree with branches near the ground [4, 17, 65] (see Botanical Description), California flannelbush may carry surface or crown fires; crown fires are more likely when it forms dense thickets with other shrubs [70]. However, in desert chaparral communities, California flannelbush may not contribute to fuel loads during later successional stages when fires are most likely to burn, because it does not persist beyond about 50 years after fire [52], and estimated fire intervals are longer than 50 years (reviewed in [78]).

Stand structure and fuel characteristics vary among plant communities where California flannelbush commonly occurs. For instance, many dry-mesic chaparral communities form dense and continuous stands of highly flammable shrubs [45] that support extensive, stand-replacing crown fires [14, 45, 56, 80], whereas desert chaparral and xeric serpentine chaparral tend to be more open [24, 27, 32, 56], with less fuel continuity, and therefore less conducive to extensive crown fires [27].

FIRE REGIMES

California flannelbush most commonly occurs in California chaparral communities with fire regimes characterized by stand-replacing crown fires, although fire characteristics may vary with differences in weather, topography, soil, species composition, and plant productivity [14, 40, 80, 81]. California flannelbush apparently establishes from soil-stored seed, and it persists by sprouting after top-kill. However, no information was available about the age at which California flannelbush produces seed or attains the ability to sprout after top-kill, therefore it is unclear how fire frequency affects California flannelbush. “Flannelbush” species can produce seeds at two years old [58], suggesting that California flannelbush populations may persist with a regime of short-interval fires, if postfire sprouts or newly established plants have sufficient time to produce seeds and replenish the soil seedbank prior to subsequent fire (but see Fire Management Considerations).

California flannelbush may also persist during long fire-free intervals in California chaparral (see Successional Status). Historical mean fire intervals in California chaparral varied with location [80], but estimates range from 35 to more than 100 years. The estimated mean fire interval for California chaparral (including mesic, xeric, and serpentine chaparral from northern to southern California) is 55 years (mean min-max: 35-115 years) and the estimated mean fire interval for semi-desert chaparral is 65 years (mean min-max: 50-115 years) (reviewed in [78]). LANDFIRE estimates of historical mean fire intervals in California chaparral range from 33 to 125 years [45].

While crown fires in chaparral typically have low spatial complexity (i.e., extensive, stand-replacing and homogeneous), patchy burns can occur under modest fire weather conditions [14]. Differences in fire size and complexity are not likely to affect established populations of California flannelbush.

Across California chaparral, fire season occurs from early spring through late fall. Most fires occur during summer; however, greater area is burned during Santa Ana winds in fall [40]. Timing of fires may influence postfire plant community response. For example, spring fires may burn with lower intensity than summer or fall fires, but they may be more likely to harm the underground structures and soil seed bank (reviewed in [14]). However, information comparing the effects of fires at different seasons on California flannelbush postfire response was not available (as of 2020).

California flannelbush also occurs in pinyon-juniper woodlands where fires are infrequent and succession to woodlands is slow (100-150 years). In these communities, California flannelbush abundance is likely to decrease during long fire intervals and be greater in early than late postfire succession. For example, California flannelbush cover and density peaked in burns between 9 and 33 years old, and living stems were absent 47 years after fire in a postfire chronosequence in singleleaf pinyon communities on low-elevation sites in the San Bernardino Mountains. Postfire succession may be slower, and California flannelbush may persist longer on high-elevation sites [84].

Likely due to human-caused ignitions, contemporary fires in California chaparral are more frequent than before Euro-American settlement on some southern California foothill sites, and native chaparral communities have converted to communities dominated by nonnative, annual forbs and grasses [40]. Contemporary fire intervals in southern California chaparral are estimated to range from 30 to 50 years (reviewed in [14]).

See these FEIS publications for further information on historical fire regimes in plant communities in which California flannelbush occurs:

- Fire regimes of California chaparral communities
- Fire regimes of California pinyon-juniper communities
- Fire regimes of southwestern pinyon-juniper communities
- Fire regimes of California oak woodlands
- Fire regimes of California coastal and valley hardwood communities
- Fire regimes of interior chaparral communities

FIRE MANAGEMENT CONSIDERATIONS

No information is available about fire management considerations specific to California flannelbush. It occurs in plant communities that generally have extensive, stand-replacing crown fires at moderate to long intervals (i.e., 35-115 years) [78, 80]. California flannelbush persists after these fires by sprouting and establishing from seed (see Fire Adaptations and Plant Response to Fire). California flannelbush may persist into late succession (~100 years) in California chaparral, but its abundance declines on sites where chaparral succeeds to woodlands after long fire-free intervals [84].

Some chaparral communities in southern California are converting to communities dominated by nonnative, annual plants due, in part, to increased fire frequency [40, 72]. For example, across San Diego County, woody cover in chaparral declined between 1953 and 2016. In 2016, woody cover had declined on 59% of plots that had >75% woody cover in 1953, with a mean loss of 22.5% woody cover. Of these

plots, 28% converted to communities with >50% herbaceous cover. The decline in woody cover and transition to herbaceous-dominated communities were driven by frequent fires (i.e., <15-year intervals), total number of fires, actual evapotranspiration, and elevation. While chaparral decline was substantial, only 16% of the initial plots with >75% woody cover had fully type-converted, suggesting that type change is a gradual process [72]. While California flannelbush regenerates soon after fire, repeated short interval fires may gradually reduce its occurrence in favor of herbaceous species, similar to other chaparral species during the type conversion process [87].

NONFIRE MANAGEMENT CONSIDERATIONS

FEDERAL LEGAL STATUS

None

OTHER STATUS

California flannelbush status is ranked by NatureServe as "Apparently Secure" overall but as "Imperiled" in Arizona [57]. Information on state- and province-level protection status of plants in the United States and Canada is available on the Plants Database.

IMPORTANCE TO WILDLIFE AND LIVESTOCK

Palatability and Nutritional Value

California flannelbush is browsed by deer and livestock [6, 15, 31, 65, 71]. Because it is evergreen, it is browsed throughout the year [65]. After fire, California flannelbush sprouts may be heavily browsed. For example, during the first 2 years after fire, domestic cattle, sheep, and goats "seldom leave more than a few inches of the more woody basal portions of young sprouts", and black-tailed deer tend to browse sprouts more than livestock [65]. After bulldozing and burning chaparral on the San Joaquin winter range, California flannelbush sprouted "vigorously" and was "highly preferred" by deer. Sprouts grew rapidly and were out of reach from deer at the end of the sixth growing season, even when continuously browsed. California flannelbush plants that were protected from deer browsing were 8 to 10 feet tall at the end of the sixth growing season [20].

California flannelbush browse is rated excellent for deer, good to fair for sheep and goats, fair to poor for cattle, and useless for horses [65].

Flannelbush seeds are dispersed by ants, which eat the elaiosome (a fatty appendage) without harming the seed [34]. Pine Hill flannelbush seeds are eaten by rodents and birds, and seedlings are eaten by rodents and insects [11]; the same is likely true of California flannelbush.

Cover Value

In singleleaf pinyon woodlands of the Tehachapi Mountains, California, California flannelbush is associated with pinyon mice habitat [66], and it may offer considerable cover for pinyon mice.

VALUE FOR RESTORATION OF DISTURBED SITES

California flannelbush is an attractive plant and is sometimes used for restoration, erosion control, and watershed protection [57, 58]. It offers protective cover to dry, rocky slopes [16, 70]. Because deer browsing can be substantial, some recommend planting it only where deer are not abundant [28]. Information about field seeding and nursery practices is available [49, 58].

OTHER USES

Traditional products derived from California flannelbush by American Indian tribes include cordage, arrows, bows, clothing, cooking tongs, digging sticks, games, granaries, harpoons, cradles, and storage bins [1-3]. In fall or winter, tribes in the Sierra Nevada burned individual shrubs or sites where the shrubs grew to induce rapid growth [1]. Young shoots were harvested and used to make cordage within the first 10 years after burning [2, 3]. The inner bark has been used in poultices to relieve irritation [43, 71].

"Flannelbushes" are used extensively for roadside and residential landscaping. They are becoming known as native garden plants [49].

OTHER MANAGEMENT CONSIDERATIONS

California flannelbush is subject to many diseases. It is not unusual to see large, apparently healthy individuals quickly decline and die [28].

APPENDIX

Table A1—Common and scientific names of plant species mentioned in this Species Review. Links go to FEIS Species Reviews.

Common name	Scientific name
Trees	
Arizona cypress	*Hesperocyparis arizonica*
blue oak	*Quercus douglasii*
California juniper	*Juniperus californica*
California laurel	*Umbellularia californica*
coast Douglas-fir	*Pseudotsuga menziesii var. menziesii*
gray pine	*Pinus sabiniana*
interior live oak	*Quercus wislizeni*
Joshua tree	*Yucca brevifolia*
oak	*Quercus* spp.
Paiute cypress	*Hesperocyparis nevadensis*
ponderosa pine	*Pinus ponderosa var. benthamiana; P. ponderosa* var. *ponderosa*
singleleaf pinyon	*Pinus monophylla*
Shrubs	
alderleaf mountain-mahogany	*Cercocarpus montanus*
antelope bitterbrush	*Purshia tridentata*
bigberry manzanita	*Arctostaphylos glauca*
buckbrush	*Ceanothus cuneatus*
California buckthorn	*Frangula californica*
ceanothus	*Ceanothus* spp.
chamise	*Adenostoma fasciculatum*
chaparral pea	*Pickeringia montana*
chaparral silktassel	*Garrya condonii*
chaparral whitethorn	*Ceanothus leucodermis*
coastal sage scrub oak	*Quercus dumosa*

desert ceanothus	*Ceanothus greggii*
flannelbush	*Fremontodendron* spp.
hairy yerba santa	*Eriodictyon trichocalyx*
Havard oak	*Quercus havardii*
hoaryleaf ceanothus	*Ceanothus crassifolius*
hollyleaf cherry	*Prunus ilicifolia*
leather oak	*Quercus durata*
manzanita	*Arctostaphylos* spp.
Mendocino bushmallow	*Malacothamnus fasciculatus*
Mexican flannelbush	*Fremontodendron mexicanum*
Pine Hill flannelbush	*Fremontodendron decumbens*
toyon	*Heteromeles arbutifolia*
tree poppy	*Dendromecon rigida*

Table A2—Ecosystems, Kuchler Associations, and Forest Cover Types where California flannelbush occurs.

Ecosystems [19]	
FRES21	Ponderosa pine
FRES34	Chaparral-mountain shrub
FRES35	Pinyon-juniper
Kuchler Plant Associations [44]	
K023	Juniper-pinyon woodland
K030	California oakwoods
K031	Oak-juniper woodlands
K033	Chaparral
SAF Forest Cover Types [68]	
237	Interior ponderosa pine
239	Pinyon-juniper
240	Arizona cypress
241	Western live oak
245	Pacific ponderosa pine

REFERENCES

1. Anderson, M. Kat; Roderick, Wayne. 2006. Plant guide: Flannelbush, Fremontodendron californicum. US Department of Agriculture, Natural Resources Conservation Service. 2 p. Available: https://plants.usda.gov/plantguide/pdf/cs_frca6.pdf. [94240]

2. Anderson, M. Kat; Rosenthal, Jeffrey. 2015. An ethnobiological approach to reconstructing indigenous fire regimes in the foothill chaparral of the western Sierra Nevada. Journal of Ethnobiology. 35(1): 4-36. [90396]

3. Anderson, Marion Kathleen. 1993. The experimental approach to assessment of the potential ecological effects of horticultural practices by indigenous peoples on California wildlands. Berkeley, CA: University of California. 211 p. Dissertation. [33081]

4. Baldwin, Bruce G.; Goldman, Douglas H.; Keil, David J.; Patterson, Robert; Rosatti, Thomas J.; Wilken, Dieter H., eds. 2012. The Jepson manual. Vascular plants of California, second edition. Berkeley, CA: University of California Press. 1568 p. [86254]

5. Bissing, Donald R. 1982. Evolution of leaf architecture in the chaparral species Fremontodendron californicum ssp. californicum (Sterculiaceae). American Journal of Botany. 69(6): 957-972. [21983]

6. Biswell, H. H. 1958. The use of fire in California chaparral for game habitat improvement. In: Proceedings: Society of American Foresters meeting; 1957 November 10-13; Syracuse. [12149]

7. Borchert, Mark L.; DeFalco, Lesley A. 2016. Yucca brevifolia fruit production, predispersal seed predation, and fruit removal by rodents during two years of contrasting reproduction. American Journal of Botany. 103(5): 830-836. [91266]

8. Boyd, Robert S. 1994. Pollination biology of the rare shrub Fremontodendron decumbens (sterculiaceae). Madrono. 14(4): 277-289. [94247]

9. Boyd, Robert S. 1996. Ant-mediated seed dispersal of the rare chaparral shrub Fremontodendron decumbens (sterculiaceae). Madrono. 43(2): 299-315. [94248]

10. Boyd, Robert S. 2007. Response to fire of Ceanothus roderickii (Rhamnaceae), a federally endangered California endemic shrub. Madrono. 54(1): 13-21. [70019]

11. Boyd, Robert S.; Serafini, Lisa L. 1992. Reproductive attrition in the rare chaparral shrub Fremontodendron decumbens Lloyd (Sterculiaceae). American Journal of Botany. 79(11): 1264-1272. [21440]

12. Calflora. 2020. The Calflora database: Information on California plants for education and conservation, [Online]. Berkeley, CA: Calflora (Producer). Available: http://www.calflora.org/. [76012]

13. Cheng, Sheauchi, ed. 2004. Forest Service Research Natural Areas in California. Gen. Tech. Rep. PSW-GTR-188. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 338 p. [88290]

14. Collins, Brandon M.; Miller, Jay D.; Kane, Jeffrey M.; Fry, Danny L.; Thode, Andrea E. 2018. Characterizing fire regimes. In: van Wagtendonk, Jan W.; Sugihara, Neil G.; Stephens, Scott L.; Thode, Andrea E.; Shaffer, Kevin E.; Fites-Kaufman, Jo Ann, eds. Fire in California's ecosystems. 2nd edition. Oakland, CA: University of California Press: 71-86. [93077]

15. Conrad, C. Eugene. 1987. Common shrubs of chaparral and associated ecosystems of southern California. Gen. Tech. Rep. PSW-99. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 86 p. [4209]

16. Dayton, William A. 1931. Important western browse plants. Misc. Publ. No. 101. Washington, DC: U.S. Department of Agriculture. 214 p. [768]

17. Flora of North America Editorial Committee, eds. 2020. Flora of North America north of Mexico, [Online]. Flora of North America Association (Producer). Available: http://www.efloras.org/flora_page.aspx?flora_id=1. [36990]

18. Fried, Jeremy S.; Bolsinger, Charles L.; Beardsley, Debby. 2004. Chaparral in southern and central coastal California in the mid-1990s: Area, ownership, condition, and change. Resource Bulletin PNW-RB-240. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 86 p. [50376]

19. Garrison, George A.; Bjugstad, Ardell J.; Duncan, Don A.; Lewis, Mont E.; Smith, Dixie R., comps. 1977. Forest and range ecosystems of the United States. Washington, DC: U.S. Department of Agriculture, Forest Service. 1:7,5000,000; map, colored. [86817]

20. Gibbens, R. P.; Schultz, A. M. 1962. Manipulation of shrub form and browse production in game range improvement. California Fish and Game. 48: 49-64. [21984]

21. Graves, George W. 1932. Ecological relationships of Pinus sabiniana. Botanical Gazette. 94(1): 106-133. [63160]

22. Halsey, Richard W. 2005. Chaparral, California's unknown wilderness. In: Fire, chaparral, and survival in southern California. San Diego, CA: Sunbelt Publications: 1-30. [61469]

23. Hanes, Ted L. 1976. Vegetation types of the San Gabriel Mountains. In: Latting, June, ed. Symposium proceedings: Plant communities of southern California; 1974 May 4; Fullerton, CA. Special Publication No. 2. Berkeley, CA: California Native Plant Society: 65-76. [4227]

24. Hanes, Ted L. 1981. California chaparral. In: Di Castri, F.; Goodall, D. W.; Specht, R. L., eds. Mediterranean-type shrublands. Amsterdam: Elsevier Science Publishers B.V.: 139-174. [13576]

25. Harris, Richard W.; Leisler, Andrew T. 1979. Direct seeding woody plants in the landscape. Leaflet 2577e. [Oakland, CA]: Division of Agricultural Sciences, University of California. 13 p. [94816]

26. Harrison, Susan. 1997. How natural habitat patchiness affects the distribution of diversity in Californian serpentine chaparral. Ecology. 78(6): 1898-1906. [64476]

27. Horton, J. S. 1951. Vegetation. In: Some aspects of watershed management in southern California vegetation. Misc. Pap. 1. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station: 10-17. [10685]

28. Horton, Jerome S. 1949. Trees and shrubs for erosion control of southern California mountains. Berkeley, CA: U.S. Department of Agriculture, Forest Service, California Forest and Range Experiment Station; California Department of Natural Resources, Division of Forestry. 72 p. [10689]

29. Hyland, Bob. 1990. Fremontodendron `California glory'. Public Garden. Wayne, PA: Journal of the American Association of Botanical Gardens and Arbors. 6(2): 41-42. [21985]

30. Kartesz, J. T. The Biota of North America Program (BONAP). 2015. Taxonomic Data Center, [Online]. Chapel Hill, NC: The Biota of North America Program (Producer). Available: http://bonap.net/tdc [Maps generated from Kartesz, J. T. 2010. Floristic synthesis of North America, Version 1.0. Biota of North America Program (BONAP). [in press]. [84789]

31. Kearney, Thomas H.; Peebles, Robert H.; Howell, John Thomas; McClintock, Elizabeth. 1960. Arizona flora. 2nd ed. Berkeley, CA: University of California Press. 1085 p. [6563]

32. Keeler-Wolf, Todd. 2007. Mojave desert scrub vegetation. In: Barbour, Michael G.; Keeler-Wolf, Todd; Schoenherr, Allan A., eds. Terrestrial vegetation of California. Berkeley, CA: University of California Press: 609-625. [82716]

33. Keeley, Jon E. 1987. Role of fire in seed germination of woody taxa in California chaparral. Ecology. 68(2): 434-443. [5403]

34. Keeley, Jon E. 1991. Seed germination and life history syndromes in the California chaparral. The Botanical Review. 57(2): 81-116. [36973]

35. Keeley, Jon E. 2004. Ecological impacts of wheat seeding after a Sierra Nevada wildfire. International Journal of Wildland Fire. 13(1): 73-78. [48465]

36. Keeley, Jon E.; Davis, Frank W. 2007. Chaparral. In: Barbour, Michael G.; Keeler-Wolf, Todd; Schoenherr, Allan A., eds. Terrestrial vegetation of California. Berkeley, CA: University of California Press: 339-366. [82706]

37. Keeley, Jon E.; McGinnis, Thomas W.; Bollens, Kim A. 2005. Seed germination of Sierra Nevada postfire chaparral species. Madrono. 52(3): 175-181. [94243]

38. Keeley, Jon E.; Pfaff, Anne H.; Safford, Hugh D. 2005. Fire suppression impacts on postfire recovery of Sierra Nevada chaparral shrublands. International Journal of Wildland Fire. 14: 255-265. [56122]

39. Keeley, Jon E.; Soderstrom, Thomas J. 1986. Postfire recovery of chaparral along an elevational gradient in southern California. The Southwestern Naturalist. 31(2): 177-184. [4771]

40. Keeley, Jon E.; Syphard, Alexandra D. 2018. South Coast bioregion. In: van Wagtendonk, Jan W.; Sugihara, Neil G.; Stephens, Scott L.; Thode, Andrea E.; Shaffer, Kevin E.; Fites-Kaufman, Jo Ann, eds. Fire in California's ecosystems. 2nd ed. Oakland, CA: University of California Press: 319-351. [92958]

41. Kelman, Walter M. 1991. A revision of Fremontodendron (Sterculiaceae). Systematic Botany. 16(1): 3-20. [13995]

42. Kelman, Walter; Broadhurst, Linda; Brubaker, Curt. 2006. Genetic relationships among Fremontodendron (Sterculiaceae) populations of the central Sierra Nevada foothills of California. Madrono. 53(4): 380-387. [94276]

43. Krochmal, A.; Paur, S.; Duisberg, P. 1954. Useful native plants in the American southwestern deserts. Economic Botany. 8: 3-20. [2766]

44. Kuchler, A. W. 1964. Manual to accompany the map of potential vegetation of the conterminous United States. Special Publication No. 36. New York: American Geographical Society. 166 p. [1384]

45. LANDFIRE Biophysical Settings. 2009. Biophysical setting 0511050: Northern and central California dry-mesic chaparral. In: LANDFIRE Biophysical Setting Model: Map zone 05, [Online]. In: Vegetation Dynamics Models. In: LANDFIRE. Washington, DC: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory; U.S. Geological Survey; Arlington, VA: The Nature Conservancy (Producers). Available: https://www.landfire.gov/national_veg_models_op2.php [2013, December 5]. [87579]

46. Little, Elbert L., Jr. 1950. Southwestern trees: a guide to the native species of New Mexico and Arizona. Agric. Handb. No. 9. Washington, DC: U.S. Department of Agriculture, Forest Service. 109 p. [20317]

47. Little, Elbert L., Jr. 1976. Atlas of United States trees. Volume 3. Minor western hardwoods. Misc. Publ. 1314. Washington, DC: U.S. Department of Agriculture, Forest Service. 13 p. [+ 290 maps]. [10430]

48. Lowe, Charles H. 1964. Arizona's natural environment: Landscapes and habitats. Tucson, AZ: The University of Arizona Press. 136 p. [20736]

49. Meyer, Susan E. 2008. Fremontodendron Coville: fremontia, flannelbush. In: Bonner, Franklin T.; Karrfalt, Robert P., eds. Woody plant seed manual. Agric. Handbook No. 727. Washington, DC: U.S. Department of Agriculture, Forest Service: 544-546. [79243]

50. Minnich, Richard A. 1976. Vegetation of the San Bernardino Mountains. In: Latting, June, ed. Symposium proceedings: Plant communities of southern California; 1974 May 4; Fullerton, CA. Special Publication No. 2. Berkeley, CA: California Native Plant Society: 99-124. [4232]

51. Minnich, Richard A. 1999. Vegetation, fire regimes, and forest dynamics. In: Miller, P. R.; McBride, J. R., eds. Oxidant air pollution impacts in the montane forests of southern California: A case study of the San Bernardino Mountains. Ecological Studies, Vol. 134: Analysis and synthesis. New York: Springer-Verlag: 44-80. [30370]

52. Minnich, Richard A. 2007. Southern California conifer forests. In: Barbour, Michael G.; Keeler-Wolf, Todd; Schoenherr, Allan A., eds. Terrestrial vegetation of California. Berkeley, CA: University of California Press: 502-538. [82711]

53. Minnich, Richard A.; Franco-Vizcaino, Ernesto. 1997. Protecting vegetation and fire regimes in the Sierra San Pedro Martir of Baja California. Fremontia. 25(3): 13-21. [40197]

54. Missouri Botanical Garden. 2020. Fremontodendron 'California Glory'. In: Missouri Botanical Garden, [Online]. St. Louis, MO: Missouri Botanical Garden (Producer). Available:

http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?taxonid=287267 [2020, June 1]. [94279]

55. Moran, Reid. 1977. Plant notes from the Sierra Juarez of Baja California, Mexico. Phytologia. 35(3): 205-214. [20382]

56. NatureServe. 2013. International Ecological Classification Standard: Terrestrial Ecological Classifications of the United States and Canada. In: NatureServe Central Databases. Arlington, VA, (Producer). 1530 p. [89169]

57. NatureServe. 2020. NatureServe Explorer: An online encyclopedia of life, [Online]. Version 7.1. Arlington, VA: NatureServe (Producer). Available: http://explorer.natureserve.org/. [69873]

58. Nord, Eamor C. 1974. Fremontodendron Cov. fremontia. In: Schopmeyer, C. S., ed. Seeds of woody plants in the United States. Agriculture Handbook No. 450. Washington, DC: U.S. Department of Agriculture, Forest Service: 417-419. [7669]

59. O'Geen, Anthony T.; Dahlgren, Randy A.; Sanchez-Mata, Daniel. 2007. California soils and examples of ultramafic vegetation. In: Barbour, Michael G.; Keeler-Wolf, Todd; Schoenherr, Allan A., eds. Terrestrial vegetation of California. 3rd ed. Berkeley, CA: University of California Press: 71-106. [82692]

60. Orozco, Jessica M. 2016. A vascular flora of the South Fork Tule River, southern Sierra Nevada, Tulare County, California. Claremont, CA: Claremont Graduate University. 101 p. Thesis. [94280]

61. Pase, Charles P. 1982. Californian (coastal) chaparral. In: Brown, David E., ed. Biotic communities of the American Southwest--United States and Mexico. Desert Plants. 4(1-4): 91-94. [8891]

62. Price, Theresa Lorez. 2008. Flora of Mount Ord, central Arizona and habitat characteristics of Fremontodendron Californicum. Tempe, AZ: Arizona State University. 120 p. Thesis. [94820]

63. Raunkiaer, C. 1934. The life forms of plants and statistical plant geography. Oxford, England: Clarendon Press. 632 p. [2843]

64. 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(1): 115-124. [83389]

65. Sampson, Arthur W.; Jespersen, Beryl S. 1963. California range brushlands and browse plants. Berkeley, CA: University of California, Division of Agricultural Sciences; California Agricultural Experiment Station, Extension Service. 162 p. [3240]

66. Scheibe, John S. 1984. Differences in the home ranges of Peromyscus truei and Dipodomys panamintinus (Rodentia). The Southwestern Naturalist. 29(1): 7-13. [94286]

67. Skinner, Carl N.; Taylor, Alan H. 2018. Southern Cascades bioregion. In: van Wagtendonk, Jan W.; Sugihara, Neil G.; Stephens, Scott L.; Thode, Andrea E.; Shaffer, Kevin E.; Fites-Kaufman, Jo Ann,

eds. Fire in California's ecosystems. 2nd ed. Oakland, CA: University of California Press: 195-218. [92956]

68. Society of American Foresters. 1954. Forest cover types of North America (exclusive of Mexico). Washington, D.C.: Society of American Foresters. 67 p. [2196]

69. Stickney, Peter F. 1989. Seral origin of species comprising secondary plant succession in northern Rocky Mountain forests. FEIS workshop: Postfire regeneration. Unpublished draft on file at: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. 10 p. [20090]

70. Sudworth, G. B. 1908. Forest trees of the Pacific Slope. Washington, DC: U.S. Department of Agriculture, Forest Service. 441 p. [19270]

71. Sweet, Muriel. 1962. Common edible and useful plants of the West. Healdsburg, CA: Naturegraph Company. 64 p. [54095]

72. Syphard, Alexandra D.; Brennan, Teresa J.; Keeley, Jon E. 2019. Extent and drivers of vegetation type conversion in southern California chaparral. Ecosphere. 10(7): 02796. 10.1002/ecs2.2796. [94564]

73. Takeda, Donald. 1971. Effects of fire on the Joshua tree/pinyon-juniper ecotone in southern California. Los Angeles, CA: California State University. 42 p. Thesis. [63129]

74. Thompson, Robert S.; Anderson, Katherine H.; Bartlein, Patrick J. 1999. Digital representations of tree species range maps from "Atlas of United States trees" by Elbert L. Little, Jr. (and other publications). In: Atlas of relations between climatic parameters and distributions of important trees and shrubs in North America. Denver, CO: U.S. Geological Survey, Information Services (Producer). On file at: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT; FEIS files. [92575]

75. Thorne, Robert F. 1982. The desert and other transmontane plant communities of southern California. Aliso. 10(2): 219-257. [3768]

76. U.S. Environmental Protection Agency. 2013. Level III ecoregions of the continental United States. Corvallis, OR: U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory. 1:7,500,000; map, colored. [92749]

77. USDA, NRCS. 2020. The PLANTS Database, [Online]. U.S. Department of Agriculture, Natural Resources Conservation Service, National Plant Data Team, Greensboro, NC (Producer). Available: https://plants.usda.gov/. [34262]

78. Van de Water, Kip M.; Safford, Hugh D. 2011. A summary of fire frequency estimates for California vegetation before Euro-American settlement. Fire Ecology. 7(3): 26-58. [85190]

79. van Wagtendonk, Jan W.; Fites-Kaufman, Joann. 2006. Sierra Nevada bioregion. In: Sugihara, Neil G.; van Wagtendonk, Jan W.; Shaffer, Kevin E.; Fites-Kaufman, Joann; Thode, Andrea E., eds. Fire in California's ecosystems. Berkeley, CA: University of California Press: 264-294. [65544]

80. van Wagtendonk, Jan W.; Sugihara, Neil G.; Stephens, Scott L.; Thode, Andrea E.; Shaffer, Kevin E.; Fites-Kaufman, Jo Ann, eds. 2018. Fire in California's Ecosystems. 2nd ed. Oakland, CA: University of California Press. 550 p. [92941]

81. van Wagtendonk, Jan W.; Sugihara, Neil G.; Stephens, Scott L.; Thode, Andrea E.; Shaffer, Kevin E.; Fites-Kaufman, Jo Ann. 2018. Appendix one: Fire regime attributes for each vegetation type discussed in the bioregional chapters. In: van Wagtendonk, Jan W.; Sugihara, Neil G.; Stephens, Scott L.; Thode, Andrea E.; Shaffer, Kevin E.; Fites-Kaufman, Jo Ann, eds. Fire in California's ecosystems. 2nd ed. Oakland, CA: University of California Press: 523-527. [92969]

82. Vankat, John L.; Major, Jack. 1978. Vegetation changes in Sequoia National Park, California. Journal of Biogeography. 5(4): 377-402. [17353]

83. Vankat, John Lyman. 1970. Vegetation change in Sequoia National Park, California. Davis, CA: University of California. 197 p. Dissertation. [43459]

84. Wangler, Michael J.; Minnich, Richard A. 1996. Fire and succession in pinyon-juniper woodlands of the San Bernardino Mountains, California. Madrono. 43(4): 493-514. [27891]

85. Wiggins, Ira L. 1980. Flora of Baja California. Stanford, CA: Stanford University Press. 1025 p. [21993]

86. Wilson, James L.; Ayres, Debra R.; Steinmaus, Scott; Baad, Michael. 2009. Vegetation and flora of a biodiversity hotspot: Pine Hill, El Dorado County, California, USA. Madrono. 56(4): 246-278. [80220]

87. Zedler, Paul H. 1995. Fire frequency in southern California shrublands: Biological effects and management options. In: Keeley, Jon F.; Scott, Tom, eds. Brushfires in California: Ecology and resource management: Proceedings; 1994 May 6-7; Irvine, CA. Fairfield, WA: International Association of Wildland Fire: 101-112. [43325]