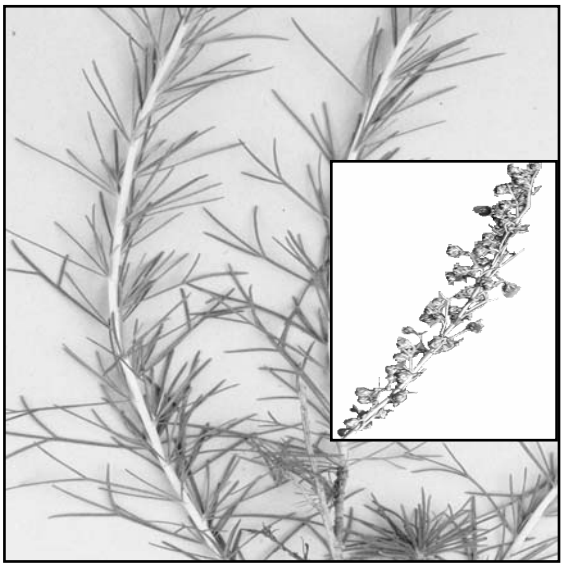
***Artemisia californica* Less.** California sagebrush
ASTERACEAE

Synonyms: None



General Description.—Mature California sagebrush are 0.6 to 2.5 m tall and abundantly branched from the base (Munz and Keck 1968, Hickman 1993). The common name refers to its strong, sage-like aroma and being endemic to California and Baja California. The stems are whitish with appressed hairs, long, slender, leafy, and flexible. The somewhat hairy gray-green leaves are soft, entire to divided into narrow linear segments, giving the entire shrub a wispy appearance. The many small flower heads are less than 5 mm wide, arranged in racemes, and have 15 to 30 disk florets per flower head. Plants are diploid with n = 9 chromosomes (Hickman 1993).

Range.—California sagebrush occurs in California from Contra Costa Co. south into Baja California, including the Channel Islands, at elevations of less than 800 m (Munz and Keck 1968, Hickman 1993). Historically, it was the dominant shrub on north-facing slopes in coastal sage scrub but has declined to about a third of its past abundance in many areas of southern California, especially inland on north-facing slopes where it is being replaced by exotic annual grasses (Minnich and Dezzani 1998).

Ecology.—California sagebrush is common in sage scrub and coastal strand on dry slopes and fans (Munz and Keck 1968, Hickman 1993). It is an indicator species of sage scrub (Kirkpatrick and Hutchinson 1977), occurs on virtually all soil types except serpentine (Westman 1981a), and its range is limited primarily by cold winter temperatures (Malanson and O'Leary 1995). Leaves are drought-deciduous and seasonally dimorphic (Westman 1981b, Gray 1982). In California, shoot and new leaf production begins with the winter rains, usually in December, and continues throughout winter and spring. Leaf drop and production of smaller leaves occurs during the summer drought (Westman 1981b). The shallow, branched roots (Harrison and others 1971) allow for rapid water absorption and growth response to shallow rains (Gray 1982). The thin leaf cuticle and numerous stomata allow a high photosynthetic rate in response to water availability (Poole and Miller 1975, Gray 1983). Consequently, there is a higher transpiration rate and longer period of water stress compared to species with thick leaves and deep roots (Poole and Miller 1975, Gray 1982). Roots form associations with arbuscular mycorrhizal (AM) fungi, but the beneficial nature of the interaction may be facultative and is potentially affected adversely by nitrogen deposition (Sigüenza 2000, Yoshida and Allen 2001).

Studies on chemistry of leaves, litter, and soil below shrubs documented the presence of both soluble compounds and volatile monoterpenes and sesquiterpenes that inhibit germination or growth of some plants (Halligan 1973, 1975, 1976). Small mammalian herbivores and seed eaters often restrict foraging to beneath shrub canopies and to within a short distance of protective cover (Halligan 1973, 1974) and may contribute to conspicuous bare zones on the edge of shrub stands and under canopies.

Reproduction.—Flowering of California sagebrush tends to peak in late fall, but in Baja California, summer rains may trigger flowering during summer (Minnich 1985). The reduced flowers are typical of other wind-pollinated species of *Artemisia*. The single-seeded fruits (achenes) ripen in December and January, with some variation among years and habitats, and are primarily wind-dispersed (Eliason and Allen 1997, DeSimone and Zedler 1999). Achenes are tiny (about 60 micrograms) and in bulk amount to about 14,300,000 seeds/kg. (personal communication with S&S Seeds, Carpenteria, California). Seeds germinate in canopy openings or in small grassland clearings generated by gophers (*Thomomys* spp.), but seedlings suffer high mortality

from gopher activity (Eliason and Allen 1997, DeSimone and Zedler 1999, 2001). Seedlings emerge in the rainy season, and most growth occurs by May.

Seed Germination.—Seeds will germinate when fresh, but stored seeds may need cold stratification to enhance germination (De Hart 1994). While testing the combined effects of light and fire components on germination, 73 percent of seeds exposed to light germinated on soil, but seeds in the dark did not germinate (Keeley 1987). These results are consistent with field data that show germination may be limited by reduced light (Elliason and Allen 1997, Montalvo and others 2002). Certain components of fire also influence germination. In light, treatment with leachate from charred wood (charrate) alone or with heat increases germination by 5 to 14 percent, but germination is about a third lower when seeds are subjected to high temperatures (70 to 120 ^{o}C). In contrast, in darkness both heat and charrate alone stimulate germination, although heat and charrate together generally decrease germination. Thus buried seeds may require some exposure to fire in order to germinate, but such exposure yields inferior germination compared to light alone (Keeley 1987).

Genetics and Geographic Variation.—Near the coast, plants vary in pubescence, color, chemistry, and physiology (O'Brien 1980). Shrubs vary between a green form with sparse hairs on the leaves to a form with dense hairs that give the plants a gray hue. Populations differ in the distinctness of forms and in their relative frequency. Seedlings raised together generally retain the grayness of their parents but can become grayer with age (O'Brien 1980). Differences in pubescence also correspond to differences in water content, rate and timing of shoot elongation, leaf retention, and chemistry. The lower leaf-water content of gray plants negatively impacts larval growth and fecundity of the beetle, *Trirhabda sericotrachyla* (O'Brien 1980).

Fire Effects.—California sagebrush resprouts after fire about 25 percent of the time (Keeley 1998). Resprouting appears to be lower in burns through dense vegetation, where plants are older, or if fire intensity is high (Malanson and O'Leary 1982, Keeley 1998, Minnich and Dezzani 1998). Seedling emergence after fire is variable and low (Zedler and others 1983, Keeley 1998). Seedlings tend to appear the second year from seeds of resprouts or seeds blown in from adjacent areas. Under high fire intensities or frequency, California sagebrush will likely be extirpated because of its poor resprouting ability and poor competitive ability of seedlings (Malanson and O'Leary 1982, Malanson and Westman 1991). Development, increased fire frequency, competition with exotic grasses, poor growth in grasslands, and air pollution are each detrimental to this shrub's survival (Eliason and Allen 1997, Allen and others 1998, Minnich and Dezzani 1998, Keeley 1998).

Horticulture.—California sagebrush can be compact if kept pruned and subjected to occasional pinching. These aromatic plants remain attractive in the dry season with occasional water (Schmidt 1980, Keator 1994). It prefers well-drained soils and a low organic matter content (Wasowski and Wasowski 1995). Naturally occurring prostrate or low-mounding varieties are in cultivation (Browse 1987, Perry 1992, Wasowski and Wasowski 1995) and look good in dry borders or as a foreground to contrasting taller shrubs (Keator 1994).

Benefits.—California sagebrush provides habitat for many plant and animal species and is an important component of critical habitat for the rare California gnatcatcher, *Polioptila californica* (Weaver 1998). The bird forages preferentially in California sagebrush and the often co-dominant shrub *Eriogonum fasciculatum* Benth. (Beyers and Wirtz 1997), in part because they house a high number and diversity of arthropods. Osborne (1998) found high diversity and abundance of arthropods in both species and concluded that *A. californica,* together with other sage scrub shrub species, is important to the maintenance of high arthropod species richness and abundance in coastal sage scrub. California sagebrush is also involved in species-specific interactions. For example, it is the host for *Trirhabda sericotrachyla*, an herbivorous beetle whose developmental cycle is closely associated with the seasonal growth of its only known host plant (O'Brien 1980).

Historical Uses.—Leaves of California sagebrush have been used by Native Americans for smoking, in sweat-houses, and various other purposes (Bean and Saubel 1972). The Cahuilla used the plant to ensure proper maturation of girls into women. It is said to stimulate the uterine mucosa, ensuring rapid childbirth and, if regularly consumed as a decoction prior to the onset of each menstruation, to prevent menstrual cramps and alleviate menopausal trauma. Fresh or dried leaves were chewed to alleviate colds (Bean and Saubel 1972). Costanoan Indians applied leaves to wounds or aching teeth for pain reduction, and as a decoction to bathe patients with colds, coughs, rheumatism, or to be consumed and used as a poultice for treatment of asthma (Bocek 1984).

Growth and Management.—California sagebrush should be planted using shallow seeding methods such as hydroseeding or dry broadcasting followed by seed imprinting. Shallow methods are superior to planting with a range drill because the seeds need light for germination (Montalvo and others 2002). Attempts to use annual legumes as nurse plants can result in reduced seedling growth and survival (Marquez and Allen 1996), but seedling survival may be unaffected when sown with other native species at low density (Montalvo and others 2002). Clearing weeds before planting is critical. California sagebrush can return vigorously to areas where all vegetation has first been removed, even when sown with a variety of other species. Spring rains or artificial late fall and spring irrigation may enhance survival of seedlings (Williams and Hobbs 1989, Elliason and Allen 1997, Padgett and others 2000). However, survival is not enhanced by late-season watering in wet years (DeSimone and Zedler 2001).

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