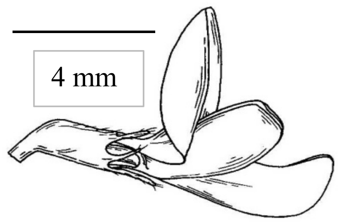
I. SPECIES	*Acmispon glaber* (Vogel) Brouillet [Updated 2017] = *Lotus scoparius* (Nutt. in Torr. & A. Gray) Ottley

NRCS CODE:
[none for Acmispon]
[LOSC2 code for *L. scoparius*]

Tribe: **Loteae** Family: **Fabaceae** Subclass: **Rosidae**
Subfamily: **Papilionoideae** Order: **Fabales** Class: **Magnoliopsida**

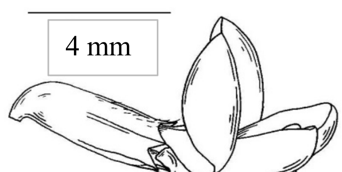


Acmispon glaber var. *brevialatus*
[= *Lotus scoparius* var. *brevialatus*]

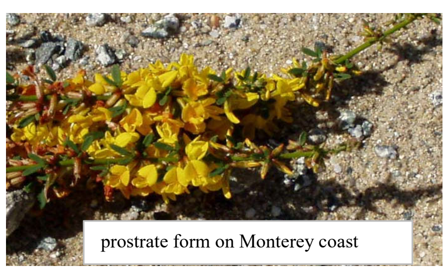
15 mm

seedling with linear cotyledons and first pair of true leaves

erect form



Acmispon glaber var. *glaber*



prostrate form on Monterey coast

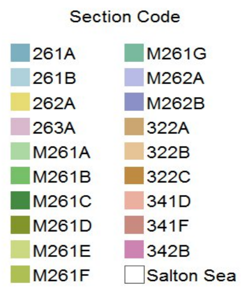
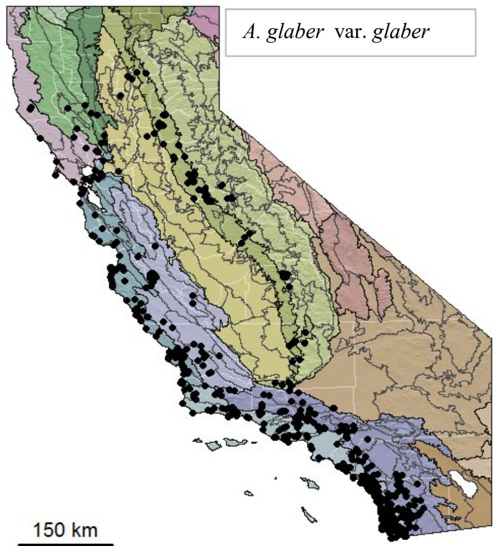
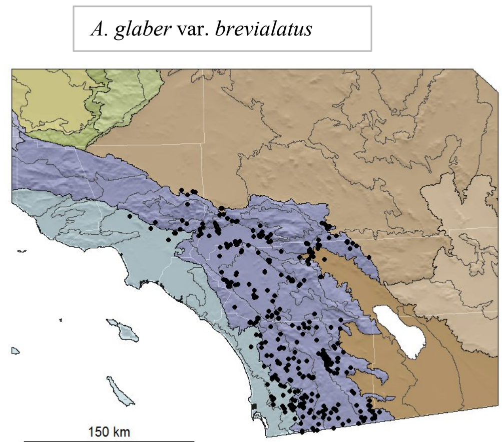
A. Subspecific taxa **1. no NRCS code** **2. no NRCS code**	1. *Acmispon glaber* (Vogel) Brouillet var. *glaber* 2. *Acmispon glaber* (Vogel) Brouillet var. *brevialatus* (Ottley) Brouillet [accepted by Baldwin et al. (2012), Jepson eFlora (2017)]
B. Common name (taxa numbered as above; names listed first used below)	General for species: deerweed, California broom 1. coastal deerweed, common deerweed, deerweed, coastal deerbroom 2. short-winged deerweed, desert deerweed, desert deerbroom, western bird's foot trefoil (Roberts 2008, Allen & Roberts 2013, Calflora 2016, USDA PLANTS 2016).

C. Synonyms **1. LOSCS2** **2. LOSCB** (taxa numbered as above)	**1. *Lotus scoparius* (Nutt.) Ottley var. *scoparius*** *Hosackia scoparia* Nutt. in T. and G. *H. glaber* Greene *H. crassifolia* Nutt., not Benth *L. glaber* Greene, not Mill. *L. scoparius* (Torr. & A. Gray) Ottley *L. scoparius* (Nutt. in T. & G.) Ottley ssp. *scoparius* (Ottley) Munz *Lotus scoparius* (Nutt.) Ottley var. *perplexans* Hoover p.p. *Syrmatium glabrum* Vogel **2. *Lotus scoparius* (Nutt.) Ottley var. *brevialatus* Ottley** *Hosackia glabra* (Vogel) Torr. var. *brevialata* (Ottley) Abrams *Lotus scoparius* (Torr. & A. Gray) Ottley var. *brevialatus* Ottley *Lotus scoparius* (Nutt. in T. & G.) Ottley ssp. *brevialatus* (Ottley) Munz
D. Taxonomic issues	For many years, taxa now recognized to be within the genera *Acmispon* and *Hosackia* had been classified as members of the very large genus *Lotus* (Ottley 1923, Munz & Keck 1968, Isely in Hickman 1993). Brouillet (2008) placed all native North American taxa of *Lotus* into two major groups, Ottleya and Acmispon, and reorganized California taxa into the genera *Acmispon* and *Hosackia* based on genetic and morphological data. In his treatment, *Acmispon* differs from *Hosackia* in having inconspicuous gland-like rather than scarious stipules and ovoid to oblong rather than linear to oblong pods. Brouillet assigned *L. scoparius* to the genus *Acmispon* and formally published recombinations that included the two varieties also recognized by Isely in Hickman (1993) and provided the treatment for the second edition of the Jepson Manual and the Jepson eFlora (Brouillet 2012). Not all experts agree with this concept, and not all herbaria are annotating specimens to *Acmispon*. The USDA PLANTS database currently uses *Lotus scoparius* and has not assigned an NRCS code for *Acmispon* synonyms (USDA PLANTS 2016), whereas the Integrated Taxonomic System (ITIS) database version 2011 for Fabaceae of North America accepts the shift to *Acmispon glabrus* (note spelling difference, publication did not use *A. glaber,* for ITIS search see: http://www.itis.gov/advanced_search.html). Of five previously recognized subspecific taxa of *L. scoparius* (Ottley 1923, Munz & Keck 1968), the three from the Channel Islands were reassigned to *L. dendroideus* by Isely (1981); Brouillet (2012) placed all three Channel Islands taxa in *Acmispon dendroideus*. Isely's treatment of the genus recognized the two varieties, *L. s.* var. *scoparius* and *L. s.* var. *brevialatus* and was adopted in Hickman (1993). These two varieties were considered by Munz (1974) to be different subspecies based on strong differentiation of floral traits and habitat affinity. Genetic, ecological, and hybridization studies by others also justify subspecific status (Steppan 1991, Montalvo & Ellstrand 2000, 2001). A number of important publications on the ecology and genetics of *A. glaber/L. scoparius* were published before the nomenclatural change to *Acmispon*. When discussing these papers, we use the names *Lotus scoparius* and *L. s.* var. *scoparius* and *L. s.* var. *brevialatus.*
E. Taxonomic relationships	Over 45 taxa of *Lotus* were recognized in Isely's treatment in Hickman (1993) for California. These taxa had been grouped and regrouped into various species as well as subgenera or genera based on morphology for over a century. Allan & Porter (2000) analyzed DNA (ITS and nuclear ribosomal DNA), geographic, and morphological data for more than 45 taxa of *Lotus* together with additional related taxa of Loteae and found several geographically distinct lineages. *L. argophyllus* (A. Gray) E. Greene var. *fremoniti* (A. Gray) Ottley and *L. nevadensis* (S. Watson) E. Greene were the most closely related taxa to *L. scoparius,* with *L. a.* var. *adsurgens* Dunkle, *L. a.* var. *niveus* (E. Greene) Ottley, *L. dendroideus* (E. Greene) E. Greene, and *L. nuttallianus* E. Greene belonging to the same clade. Further work by Sokoloff (2000) recommended recognition of four genera of North American Loteae, including *Hosackia, Syrmatium, Acmispon* and *Ottleya;* each of which had at some time included *L. scoparius*.
F. Related taxa in region	*Acmispon argophyllus* (A. Gray) Brouillet, *A. a.* var. *argophyllus*, *A. a.* var. *adsurgens* (Dunkle) Brouillet, *A. a.* var. *argenteus* (Dunkle) Brouillet [= *Lotus argophyllus*]; *A. dendroideus* (Greene) Brouillet, *A. d.* var. *dendroides, A. d.* var. *traskiae* (Abrams) Brouillet, and *A. d.* var. *veatchii* (Greene) Brouillet [= *L. dendroideus*]; *A. nevadensis* (S Watson) Brouillet, *A. n.* var. *nevadensis*, *A. n.* var. *davidsonii* (Greene) Brouillet [= *L. nevadensis*]. Of these related taxa, only *A. argophyllus* var. *argophyllus* is likely to overlap in distribution with *A. glaber*. It overlaps with short-winged deerweed in the Southern California Mountains and Valleys ecological section and with common deerweed in the Sierra Nevada Foothills and Central California Coast ecological sections (see III. B. Map for ecological sections). The other varieties of *A. argophyllus* and *Acmispon dendroideus* occur in the Channel Islands where *A. glaber* is unlikely to occur naturally, and *A. nevadensis* occurs at higher elevations than *A. glaber* (Brouillet 2012, Jepson eFlora 2017).

G. Other	The Latin name "scoparius" in *Lotus scoparius* refers to the broom-like form evident in the common name "California broom." The Latin name "glaber" refers to the nearly glabrous plant parts. The other common name, "deerweed," refers to its use as browse by deer. *A. glaber* var. *brevialatus* (= *Lotus scoparius* var. *brevialatus*) is the form found naturally in hot summer, interior habitats of Riverside, Los Angeles, San Bernardino, and San Diego counties (Steppan 1991; Montalvo & Ellstrand 2000, 2001). In areas where the two varieties come together in Los Angeles, Riverside, and San Diego counties, intermediate floral forms can be found in hybrid zones (see mapped distributions in section III. B. Map, below). Both varieties have been planted widely for roadside revegetation, erosion control, and habitat restoration, resulting in their occurrence in areas where they do not exist naturally and where they may be maladapted relative to the home variety. Some disjunct populations of variety *glaber* have occurred inland for many years along major waterways and may possibly be natural populations.

II. ECOLOGICAL & EVOLUTIONARY CONSIDERATIONS FOR RESTORATION

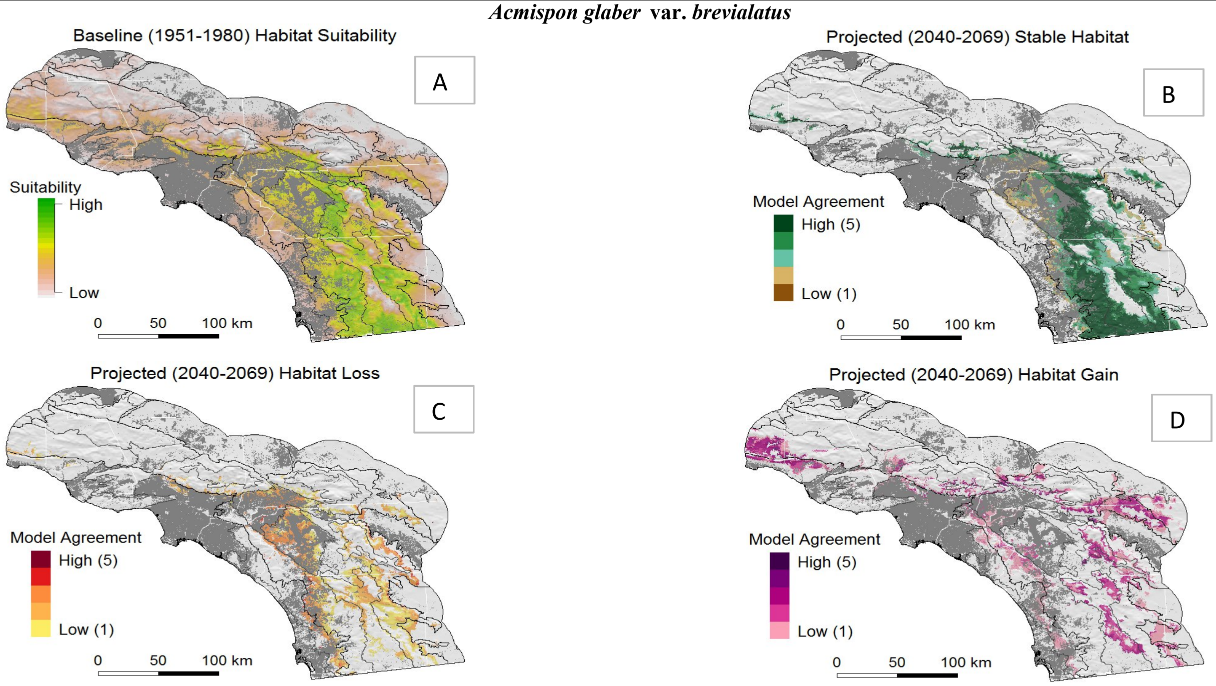
A. Attribute summary list (based on referenced responses in full table)	Taxonomic stability - moderate (higher in var. *b.*) Flowering age - usually second year Longevity - short, about 5 to 10 yr Parity - polycarpic Stress tolerance - moderate to high Environmental tolerance - somewhat broad Reproduction - seeder (facultative sprouter) Fragmentation history - historical and recent Habitat fragmentation - high at low elevations Distribution - var. *glaber* widespread in Calif. var. *brevialatus* regional- only in southern Calif., common Seeds - dormant, long-lived; fire follower, seeds heat scarified Seed dispersal distance - short Pollen dispersal - intermediate to far Breeding system - mixed self and outcross Population structure - high (at species level); low within vars. Adaptive trait variation - present Chromosome number - stable Genetic marker polymorphism - intermediate to high Average total heterozygosity - intermediate to high Hybridization potential - high between varieties 1. *Acmispon glaber* var. *glaber* SDM projected midcentury suitable habitat: 1–58% stable SDM projected midcentury habitat gain: loss > gain under all 5 future climate scenarios (assuming unlimited dispersal) 2. *Acmispon glaber* var. *brevialatus* SDM projected midcentury suitable habitat: 65–98% stable SDM projected midcentury habitat gain: loss < gain in 4 of 5 future climate scenarios (assuming unlimited dispersal)
B. Implications for seed transfer (summary)	To avoid outbreeding depression and maladaptation, match the variety native to the site and to the environment of source populations relative to planting location, especially when choosing source populations for restoration, mitigation, and roadside landscaping through wildland areas (Montalvo 2004). There are tangible risks associated with moving seeds of the two deerweeds among divergent habitats (such as among Ecological Sections or divergent Subsections within Sections) or from mixing seeds from populations originating from very different environments (see VIII. Ecological Genetics). Reproduction and gene dispersal depend largely on declining bee pollinators in dire need of conservation action (Murry et al. 2009). Stable bee populations and dispersal corridors across environmental gradients will be important for this taxon to disperse and adapt to climate change, especially in areas with high levels of habitat fragmentation. In high fragmentation areas, decision support tools suggest assisted migration, if needed to mitigate for climate change, should be in small steps such as among adjacent ecological subregions from south to north or from lower to higher elevation, without mixing varieties so as to minimize risks of maladaptation and outbreeding depression.  Studies of bee visitation to varieties *glaber* and *brevialatus* within experimental arrays showed bees moved freely between the two floral forms providing ample opportunity for hybridization (see VI. E. Pollination: A. Montalvo, P. Aigner, R. Alarcon, J. Burger 2003 unpublished data). Paul Aigner and Ruben Alarcon observing bee visits to three plants of each variety of *Acmispon glaber* in spring 2003 at the University of California Riverside, Motte Rimrock Reserve. Photo by A. Montalvo.

III. GENERAL	
A. Geographic range	Western California and northern Baja California. Plants have been introduced into Arizona. 1. Variety *glaber* is distributed in cismontane California below 1,500 m from Humboldt and Plumas Counties south into Baja California. 2. Variety *brevialatus* occurs from Los Angeles Co. south into Baja California, primarily in the hotter and drier interior regions of Riverside, Los Angeles, western San Bernardino, and eastern San Diego Counties.
B. Distribution in California; Ecological Section and Subsection (sensu Goudey & Smith 1994; Cleland et al. 2007) 	Map includes validated herbarium records (CCH 2016) as well as occurrence datafrom CalFlora (2016) and field surveys (Riordan et al. 2018). Legend has Ecological Sections; black lines are Subsections.  1. *Acmispon glaber* var. *glaber* Ecological Section/Subsection: Northern California Coast 263A: g,l,m Northern California Coast Ranges M261B: b,f Northern California Interior Coast Ranges M261C: a,c Sierra Nevada M261E: f,g,m,p Sierra Nevada Foothills M261F: b,c,d,e Great Valley 262A: c,f,g,l,o,y Central California Coast 261A: a,b,c,f,g,h,j,k,l Central California Coast Ranges M262A: c,e,f,h,i Southern California Coast 261B: a,b,d-g,i,j Southern California Mountains and Valleys M262B: b-f,j,k,l,n,o Mojave Desert 322A: g (border with M262B) 2. *Acmispon glaber* var. *brevialatus* Ecological Section/Subsection: Southern California Coast 261B: g,i Southern California Mountains and Valleys M262B: b,d-g,i-p Mojave Desert 322A: g,n,p (border with M262B) Colorado Desert 322C: a,b (border with M262B)
C. Life history, life form	Perennial subshrub, living 5 – 10 years (Montalvo 2004 and pers. obs.) but can reach 20 yr (Sawyer et al. 2009). Component of early stages of vegetation recovery after wildfire.
D. Distinguishing traits	Generally erect, suffrutescent subshrub, 0.4 – 1.5 m tall, with many flexible green branches arising from a woody base. Branches are mostly glabrous except toward tips. Prostrate ecotypes of *A. glaber* var. *glaber* occur occasionally along coast bluffs and sand dunes, especially near Monterey. The flimsy, alternate leaves are pinnately compound with three (occasionally four to five) oblong to oblanceolate (broader above the middle) leaflets, usually 4 – 10 mm long with short, sparse, appressed hairs, and are subtended by small, gland-like stipules. The sessile, usually two to seven flowered, umbellate inflorescences are in the axils of leaves. The yellow pea-like flowers are 7 – 10 (occasionally to 15) mm long, have short pedicels, and sometimes bear a red splotch of varying intensity on the back of the banner. Flower traits separate the varieties. In *A. glaber* var. *glaber,* the keel of the corolla is about as long as the wings and the calyx has broad triangular teeth; in *A. g.* var. *brevialatus* the keel is longer than the shortened wings and the calyx has narrow teeth (see I. Photos). The small indehiscent pods bear one to two (rarely three) seeds that vary from brown to greenish brown with or without dark brown mottling (modified from Montalvo 2004).
E. Root system, rhizomes, stolons, etc.	Seedlings have a taproot but mature plants have a branched taproot system that becomes somewhat fibrous (Hellmers et al 1955).
F. Rooting depth	Deerweed is a relatively shallow-rooted plant. Excavated roots penetrated soil up to 1.1 m (3.7 feet; Hellmers et al. 1955).

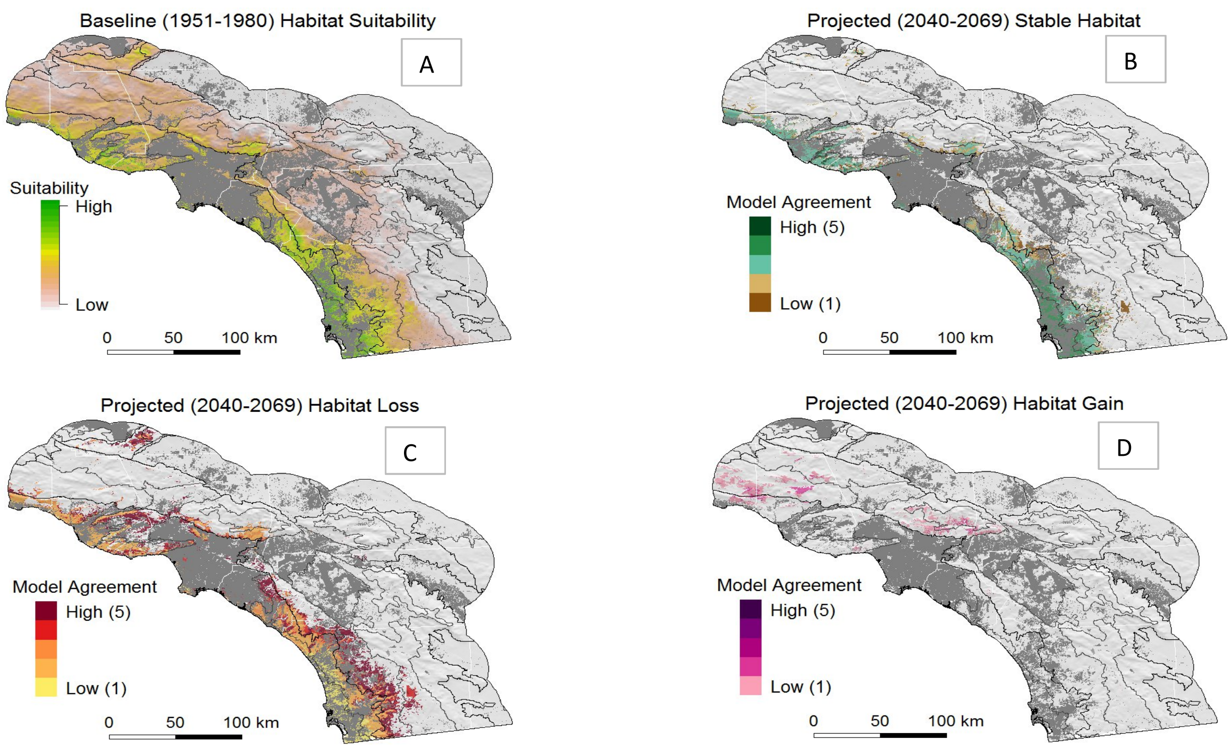
IV. HABITAT	
A. Vegetation alliances, associations	The Manual of California Vegetation (Sawyer et al. 2009) uses the name *Lotus scoparius* and treats the two varieties as a single taxon for the purposes of vegetation classification. The taxon is considered co-dominant to other shrubs in 30 different coastal sage scrub, upland sage scrub, chaparral, and desert scrub alliances. Within many areas, *L. scoparius* may become dominant for several years following fire, forming the *Lotus scoparius* shrubland alliance until other, longer-lived taxa dominate. Also listed as codominant in the *Carex pansa* herbaceous alliance in coastal sand dune vegetation and the *Artemisia druncunculus* alliance in annual or perennial grassland (this would be var. *scoparius*). Deerweed occurs as a co-dominant in alliances dominated by *Artemisia californica, Adenostoma fasciculatum, A. sparsifolium,* several different *Arctostaphylos* species, *Baccharis pilularis, Corethrogyne filaginifolia, Encelia californica, Eriogonum fasciculatum, Lepidospartum squamatum, Malacothamnus fasciculatus, Salvia mellifera, S. apiana, Rhus ovata, Simmondisia chinensis, Venegasia caroides,* or other shrubs (Sawyer et al. 2009).
B. Habitat affinity and breadth of habitat	In southern California, plants are more frequent on gentle slopes (< 5°) compared to steeper slopes (Kirkpatrick & Hutchinson 1980). 1. *Acmispon g.* var. *glaber* primarily of shrublands and associated open areas in the coastal regions of California and also inland habitats north of Los Angeles. 2. *Acmispon g.* var. *brevialatus* primarily in the hotter and drier interior regions of southern California.
C. Elevation range	Several meters above sea levelto about 1,500 m (Montalvo 2004).
D. Soil: texture, chemicals, depth	Prefers well-drained soils but can occur on a wide range of soil textures. Most common on unconsolidated soils and "other" soils than on granite (Kirkpatrick & Hutchinson 1980). Found on soils derived from a variety of parent materials including granite, serpentinite, gabbro, andesite, sandstone, and shale (Montalvo pers. obs.).
E. Precipitation	Both varieties occur primarily in the Mediterranean climate zone with cool to cold moist winters and warm to hot dry summers. In southern California, plants occupy Ecological Sections with 10–25 in (250–640 mm) precipitation (261B Southern California Coast) and 10–40 in (250–1020 mm) of precipitation (M262B Southern California Mountains and Valleys), with variety *brevialatus* growing in the lower end of the precipitation range in southern California. Variety *glaber* also occurs along the central and northern California coast, North Coast Ranges, and Sierra Nevada. Precipitation in ecological sections in central and northern California occupied by *A. glaber* var. *glaber* ranges from 14 to 50 in (350 – 1,270 mm) in the Central California Coast (261A), 40 to 100 in (1,020 – 2540 mm) in the Northern California Coast (263A), 30 to 80 in (760 – 2030 mm) in the Northern California Coast Ranges (M261B), 20 to 40 in (510 – 1020 mm) in the Northern California Interior Coast Ranges (M261C), 20 to 80 in (500 – 2030 mm) in the Sierra Nevada (M261E), and 20 to 40 in (510 – 1020 mm) and in the Sierra Nevada Foothills (M261F). In the Great Valley (262A) it occurs primarily in Subsections with 10 – 25 in (250 – 640 mm). Some north coastal forms of variety *glaber* (such as the prostrate forms on sand dunes) may receive higher annual precipitation.
F. Drought tolerance	Drought tolerant. Plants can become dormant and drop leaves facultatively during prolonged summer drought, thereby avoiding rather than enduring the worst of annual drought conditions (Nilsen & Muller 1980, Montalvo & Ellstrand 2000). The ability to be facultatively drought-deciduous is commonly associated with shallow-rooted shrubs of coastal sage scrub vegetation in California. Seasonality of leaf production, nutrient accumulation, and leaf drop in response to summer drought has been studied extensively in *L. s.* var. *scoparius* (Nilsen & Muller 1980, 1981a, 1981b, 1982; Nilsen & Schlesinger 1981, Nilsen 1982).
G. Flooding or high water tolerance	Upland species of well-drained soils. May occur in well-drained sandy to gravely soil of infrequently flooded alluvial fans and alluvial terraces along major stream channels (Kirkpatrick & Hutchinson 1980, Montalvo, pers. obs.).
H. Wetland indicator status for California	None.
I. Shade tolerance	Shade intolerant. Requires full sun or nearly full sun.

V. CLIMATE CHANGE AND PROJECTED FUTURE SUITABLE HABITAT

Acmispon glaber* var. *brevialatus



Acmispon glaber* var. *glaber



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; http://frap.fire.ca.gov/data/frapgisdata-sw-fveg_download).

B. SDM summary	Species distribution modeling suggests that projected 21st century climate could affect the two varieties of *A. glaber* differently. Assuming a future of continued high greenhouse gas emissions, Riordan et al. (2018) predicted 1–58% of baseline suitable habitat for *A. g.* var. *glaber* would remain suitable (stable) under mid-century conditions across future climate scenarios from five general circulation models (GCMs) (V. A. Fig. B). Predicted gain in suitable habitat (0–23%) was negligible and loss exceeded gain under all five climate scenarios (V. A. Figs. C-D). Riordan et al. (2017) predicted a greater degree of stable suitable habitat for *A. g.* var. *brevialatus* (65–98%). Modest gain in suitable habitat (26–32%) exceeded loss under four of five climate scenarios. Only under the wettest scenario did loss (35%) exceed gain (13%) for variety *brevialatus*. The spatial pattern of suitable habitat loss differed between varieties, with losses predicted along the eastern range edge of variety *glaber* and along the western range edge of variety *brevialatus*, especially in the Perris Valley and Hills (M262Bk) and the Fontana Plain-Calimesa Terraces (M262Bj) Ecological Subsections. Principe et al. (2013) predicted severe climate stress for *A. g.* var. *glaber* in southern California, with high losses in habitat suitability under midcentury climate conditions. Riordan & Rundel (2014) modeled *A. glaber* at the species level and predicted greater (88–97%) habitat stability under midcentury climate. Their analyses suggested projected land use may pose a greater threat relative to climate change for *B18* and combined habitat losses from projected land use and climate change ranged from 23 to 27% at midcentury and 30 to 35% at the end of the 21st century. The combined effects of climate change, land use, and altered fire regimes could negatively affect both varieties of *A. glaber*. Primarily an obligate seeder and fire follower, *A. glaber* can temporarily dominate vegetation communities following fire (see IV. A. Vegetation alliances, VI. D. Regeneration after fire or other disturbance). Too-frequent fire, however, may be detrimental for the species because the seed bank has insufficient time to recharge and seedlings compete poorly in areas dominated by non-native grasses and forbs (see VII. A. Competitiveness). High fire frequencies can cause the conversion of mixed chaparral and sage scrub to annual grasslands (Haidinger & Keeley 1993, Talluto & Sudding 2008, Zedler et al. 1983). In southern California, human activity is the primary driver of fire (Keeley & Syphard 2016), with fire ignitions and fire frequencies increasing with human population growth and the proximity of developed lands (Syphard et al. 2009). Projected population growth and land use will likely increase fire activity in the region this century. In addition, the high level of habitat conversion and fragmentation throughout the lower elevations of the species range creates a considerable barrier to dispersal and gene flow that could negatively affect the adaptive capacity and ability of the species to respond to changing conditions. Much of the coastal, low elevation suitable habitat in southern California has been developed. Land use may compound projected climate-driven losses in habitat suitability for southern California shrublands (Riordan & Rundel 2014).
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, not population level persistence. 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	Seeds of *L. scoparius* germinate in mid- to late winter during the rainy season in gaps, along roadsides, or following a fire (DeSimone & Zedler 1999, Montalvo 2004).
B. Growth pattern (phenology)	Plants establish quickly from seed with normal rainfall and typically reach flowering size the second year. At low elevations in southern California, mature plants flush leaves and seedlings begin to emerge in late November if fall rainfall is ample (A. Montalvo pers. obs.). Most seedling and vegetative growth occurs from mid-January to late May (study in Santa Barbara Co., Nilsen & Schlesinger 1981; A. Montalvo pers. obs. Riverside Co. and San Diego Co.). Flowering occurs sequentially over a long season, primarily from March to June but may start as early as December or January in warm, wet winters and last much longer in more moist, coastal areas and in years with long-lasting soil moisture. Seeds mature within six weeks of pollination and tend to hold on the stems until the end of flowering (A. Montalvo pers. obs.). Plants drop leaves during the summer drought and if drought begins early, so does leaf drop. Seed production is highly variable and can be very low in years that have an early onset of drought (DeSimone & Zedler 2001).
C. Vegetative propagation	None.

D. Regeneration after fire or other disturbance	Obligate seeder and colonizer. The hard seed coat is scarified by fire and most seedlings are recruited the first rainy season following fire (Keeley et al. 2006). Seedlings also emerge in open, disturbed areas of coastal sage scrub, chaparral, desert scrub, washes, coastal strand, or along roadsides (Montalvo 2004). Plants are generally killed by fire (Keeley & Keeley 1984). They have a thin epidermis, do not resprout, and have a broom-like canopy that is susceptible to burning (Sawyer et al. 2009). About 2 to 3 years after fire in sage scrub vegetation, and following a burst of herbaceous species, deerweed can become the dominant canopy species, eventually becoming replaced by long-lived shrub species. Its abundance gradually decreases in 5 to 10 years after fire (Montalvo 2004).
E. Pollination  *Osmia* visiting var. *brevialatus*	Flowers are visited and pollinated primarily by native bees in the genera *Bombus, Hoplitus, Anthophora, Habropoda, Osmia, Agapostemon,* and *Anthidium,* but flowers are also visited by butterflies and the non-native honeybee, *Apis mellifera* (Jones & Cruzan 1999, A. Montalvo, P. Aigner, R. Alarcon unpublished data). Species of *Osmia* and *Anthophora* are known to forage or travel distances of several hundred to over 1000 meters, while *Apis* and *Bombus* have been documented to forage many hundreds to thousands of meters, but proximity of nesting habitat to foraging habitat is essential to maintaining bee populations (Zurbuchen et al. 2010). Bee pollination is essential to both the reproduction and gene dispersal of *A. glaber* among habitat patches, and conservation of nesting and foraging habitat for bees is as impotant as conservation of habitat for plants. Native bee populations have suffered declines in recent years. Habitat fragmentation from agriculture and urbanization are responsible for much decline and result in decreases in pollination services (e.g., Kremen et al 2002). The three most common species of *Bombus* that visit deerweed in southern California are particularly sensitive to urban development (Schochet et al. 2016), with each species of *Bombus* responding differently to variables at a range of spatial scales. Variables included percentage of impervious surfaces and sage plant cover, distances to major roads, and distance to coast for habitat reserves, fragments, and urban areas. Furthermore, the presence of invasive Argentine ants on plants resulted in fewer bee visits to flowers of native plants, including *A. glaber* (Hanna et al. 2015). The ants tend to occur in and close to urban areas.
F. Seed dispersal	Primarily gravity. The indehiscent pods tend to drop to the ground and may be passively dispersed short distances (Montalvo 2004). DeSimone & Zedler (2001) found that for *L. s.* var. *scoparius* in the foothills of Orange Co., seeds dispersed a meter or less from parent shrubs.
G. Breeding system, mating system	Flowers are self-compatible and insect-pollinated (Moldenke 1976, Hickman 1993, Jones & Cruzan 1982, 1999, Montalvo & Ellstrand 2001). Inbreeding coefficients based on allozymes of 12 southern California populations were low for all populations, a pattern consistent with substantial cross pollination, severe loss of inbred progeny, or both (mean inbreeding coefficient = 0.09) (Montalvo, Clegg, & Ellstrand, unpublished manuscript cited in Montalvo 2004).
H. Hybridization potential	**Among varieties:** In experimental arrays of potted plants, bees moved freely between flowers of the two varieties (P. Aigner, A. Montalvo, R. Alarcon, J. Burger pers. obs.). Experimental cross pollinations by hand between *L. s.* var. *scoparius* and var. *brevialatus* (currently = *A. glaber* var. *glaber*, and *A. glaber* var. *brevialatus,* respectively) produced hybrids with flowers of intermediate form but with wings as long as the keel (Montalvo & Ellstrand 2001, Montalvo 2004). The two varieties hybridize where they come into contact naturally and hybrids have been observed in narrow hybrid zones (Isely 1981, Steppan 1991, Montalvo & Ellstrand 2001). Many areas of overlap may be due to natural secondary contact, but some are clearly due to seeding projects along roads and utility corridors. **Among species:** Putative hybrids have been reported between deerweed and *L. junceus* (Benth.) Greene (= *Acmispon junceus* (Benth.) Brouillet) and *L. benthamii* Green (= *Acmispon cytisoides* (Benth.) Brouillet) in central and northern California, as well as between other members of the species complex (Isely 1981), but these have not been confirmed with genetic studies. Liston and others (1990), however, did genetic studies on San Clemente Is. and documented hybridization between the rare *L. scoparius* ssp. *traskiae* (Noddin) Raven (= *Acmispon dendroideus* (Greene) Brouillet var. *traskiae* (Eastw. ex Abrams) Brouillet), and the more widespread *L. argophyllus* (A. Gray) E. Greene var. *ornithopus* (E. Greene) Ottley (combined by Brouillet (2008) into *Acmispon argophyllus* var. *argenteus* (Dunkle) Brouillet). They concluded that genetic assimilation of the rare species by the widespread species is possible.
I. Inbreeding and outbreeding effects	Montalvo and Ellstrand (2001) directly tested the potential for "outbreeding depression," a loss of fitness upon crossing genetically differentiated populations, by crossing individuals from six populations of the two varieties in every combination and testing the progeny in two common gardens at wild sites. Seeds per flower and seedling emergence decreased significantly with an increase in genetic distance of the crossed parental populations. Among variety crosses were only 70 percent as fit as within variety crosses by the time seedlings emerged, and further fitness differences accumulated after seedlings were outplanted into field plots. In these common gardens, success of progeny decreased with increasing differences between parental environments and the transplant location.

VII. BIOLOGICAL INTERACTIONS	
A. Competitiveness	Mature plants do not compete well with later seral shrubs of sage scrub vegetation. In mature vegetation, seedling emergence is associated with gaps in the vegetation (DeSimone & Zedler 2001). Seedlings do appear to compete well in the matrix of new shrubland vegetation that emerges following fire or mechanical clearing. However, seeds do not appear to accumulate in the seedbank or compete well in areas that have become dominated by non-native grasses and forbs (DeSimone & Zedler 2001). In western Riverside Co., an average of 41.9 seedlings/square meter emerged from soils collected from shrub-dominated plots whereas only 6.3 emerged from soils of grass-dominated plots (Cox & Allen 2008).
B. Herbivory, seed predation, disease	Plants develop flower galls. Larvae of 27 species of butterflies in the Lycaenidae were successfully reared on the leaves and flowers of *L. scoparius* collected in Riverside, California (Pratt & Ballmer 1991). Genera included *Lycaena, Atlides, Callophrys, Chlorostrymon, Erora, Ministrymon,* and *Satyrium*. Larval Nepticulidae butterflies in the species *Microcalyptris lotella,* mine the stems (Wagner 1987). Seed predation after seed dispersal in shrubland can be high (70%) but can be much lower in grassland and the shrub/grassland ecotone (DeSimone & Zedler 2001).
C. Palatability, attractiveness to animals, response to grazing	The plants provide valuable forage for deer, especially in drought years or after fire when growth of herbaceous vegetation is sparse (Conrad 1987, Dale 2000). Plants tend to branch after light grazing (Montalvo pers. obs.).
D. Mycorrhizae or nitrogen fixing nodules	Roots form symbiotic associations with nitrogen fixing bacteria within root nodules and with arbuscular mycorrhizal fungi (Montalvo 2004, A. Montalvo pers. obs.). *Acmispon glaber* and related species of *Acmispon* possess a gene (NSP1) that regulates nodulation and the formation of the symbiosis between their roots and *Rhizobium,* and allelic variation was found within species for the NSP1 gene (Dorman et al. 2014).

VIII. ECOLOGICAL GENETICS	
A. Ploidy	Both varieties have 2n = 14 chromosomes (Munz & Keck 1968, Grant 1995). Ploidy levels in the related *Acmispon argophyllus, A. dendroideus,* and *A. nevadensis* are also 2n = 14 (Brouillet 2009).
B. Plasticity	Most plasticity is in vegetative traits rather than in traits of the flowers (A. Montalvo pers. obs.).
C. Geographic variation (morphological and physiological traits)	There is genetically based geographic variation in floral form. The morphological differences between varieties were retained in common garden studies for two generations (Montalvo & Ellstrand 2001). In San Diego Co., Steppan (1991) detected distinct discontinuities in floral morphology between varieties and moderate correlations among environmental variables and floral traits of wild populations. Montalvo and Weaver (unpublished data) measured floral traits of plants from 12 populations raised in a common environment and compared each pair of populations for genetic, floral, geographic, and environmental differences. The degree of difference in floral morphology correlated with environmental distance. Genetic distance correlated with floral morphological distance, but not geographic distance. These results are consistent with floral form having a genetic basis and with environmental factors playing a role in influencing genetic divergence in floral form.
D. Genetic variation and population structure	Populations of both varieties of deerweed are genetically variable, and there are significant genetic differences among populations of the two varieties (Montalvo & Ellstrand 2000, 2001). An analysis of genetic marker data (13 allozyme loci) from three populations of *Lotus scoparius* var. *brevialatus* and nine populations of *L. s.* var. *scoparius* from southern California showed significant population substructure due primarily to differences among populations of the two varieties. In an analysis of all populations, 18% of the variation was due to differences among populations, while analysis of just var. *brevialatus* or var. *scoparius* populations showed only 1 and 8 % of the variation due to differences among populations. Thus, populations within a variety are substantially more genetically similar to each other than to populations of the other variety. For var. *glaber*, 84.6% of the 13 loci were polymorpic, with an average of 5.4 alleles/locus. For var. *brevialatus*, 69.2% of loci were polymorphic with an average of 3.8 alleles/locus. The lower average number of alleles in var. *brevialatus* may be due in part to the lower sample of three compared to nine populations for var. *scoparius* (Montalvo & Ellstrand, unpublished data). Total heterozygosity averaged 0.25 for var. *scoparius* populations and only 0.13 for var. *brevialatus* populations.
E. Phenotypic or genotypic variation in interactions with other organisms	In a study of plants from 12 populations, P. Aigner and A. Montalvo (unpublished) found large differences in nectar production among the two varieties which appears to correlate with use of the flowers by different groups of bees. Nectar foraging bees tend to prefer *A. glaber* var. *glaber*, which produces significantly more nectar, and pollen foraging bees tend to prefer variety *brevialatus.* There is variation in the NSP1 gene in *Acmispon* species responsible for nodulation and colonization by N-fixing *Rhizobium*. In a sample of nine *Acmispon glaber* from one population, Dorman et al. (2014) found two alleles. For the widespread *Acmispon argophyllus,* five alleles were detected in samples from six populations and there were obvious differences in allele frequencies among populations. Further studies are needed to reveal if there are differences in colonization frequency associated with different plant genotypes and strains of *Rhizobium* as found for *Lotus corniculatus* (Lieven-Antoniou & Whittam 1997).

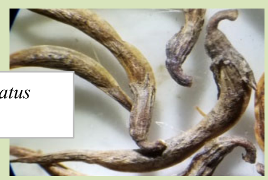
F. Local adaptation	Common garden experiments testing plants originating from seed collected from 12 southern California source populations (both varieties represented) demonstrated a significant home site advantage (Montalvo & Ellstrand 2000, 2001). On average, plants survived and produced more flowers in the common garden most similar to the site where seeds were first collected. Environmental similarity (based on a variety of climate, soil, and coastal influence variables) of source sites relative to planting sites was much more important than the geographic distance between source and planting sites in predicting performance in the common gardens.
G. Translocation risks	Montalvo & Ellstrand (2001) found significant "outbreeding depression," a loss of fitness upon crossing genetically differentiated populations, in experiments with *Lotus scoparius*. They crossed individuals from six populations of the two varieties in every combination and tested the progeny in two common gardens at wild sites. Progeny from crosses among varieties suffered significantly lower seedling emergence, survival, growth, and flower production. The substantial genetic differentiation of populations from different environments, evidence for local adaptation (see F. above), and the demonstrated lower success of hybrids created from parents of contrasting environments or varieties show that there is substantial risk to establishing populations from seed sources collected from divergent environments o sites that naturally support the contrasting variety (Montalvo 2004). The size of the risk increases with the scale of the genetic and habitat differences among populations.

IX. SEEDS

2 mm

Note the longer length:width ratio of var. *brevialatus* seeds and longer pods (left) compared to var. g*laber* seeds and pods (right). Photos were taken at the same magnification. (A. Montalvo, RCRCD)

A. glaber var. *brevialatus*
SAR-ACGLB -0915



fruits

A. glaber var. *glaber*
SAM-ACGLG-0615

A. General	Seeds of *A. g.* var. *glaber* are narrow bean-shaped, curved, and 1.2 – 2 mm (sometimes 3 mm) long. Seeds of *A. g.* var. *brevialatus* are generally narrower (ca. 3 to 4 x longer than wide). Standard purity and germination ranges from about 95% and 80%, respectively (S&S Seeds pers. com.), to 90% and 60% (Stover Seed Company 2008).
B. Seed longevity	Long-lived in soil seed bank and in cool, dry storage. Went & Munz (1949) included *L. s.* var. *brevialatus* seeds from Riverside Co. east of Temecula in their seed longevity study started in 1947. Seeds were dried to low moisture content and stored in vacuum vials. Seed tests (likely untreated seeds) yielded 7%, 20% , 0%, and 10% germination in 1947, 1948, 1967, and 1997, respectively (Went & Munz 1949, Michael Wall, Rancho Santa Ana Botanic Garden, personal communication).
C. Seed dormancy	Some seeds germinate without treatment, but most of the hard seeds require heat or mechanical scarification to break dormancy. Of several treatments including a control, soil heated to 100 °C for 1 hour, ash /chemical fertilizer, and heat plus fertilizer, Christensen & Muller (1975) found heat treatment yielded the highest germination. Keeley (1987) found heating seeds in their pods to 120 °C for 5 minutes increased germination over that of unheated controls from 43% to 60%. Others have found similar germination increases relative to controls after scarifying seed pods with sandpaper compared to heating pods to 120 °C for 5 minutes (Staci Cibotti, pers. com.). Pods or cleaned seeds can also be covered with boiling water and left to soak to break dormancy (Atwater 1980, Young & Young 1986, Emery 1988; Montalvo & Ellstrand 2000, 2001). For seed testing, a hot water soak before germinating at 20°C improved germination from 30% to 64% with 32% hard seed (dormant seed) remaining (Atwater 1980).
D. Seed maturation	The indehiscent pods ripen in about 4 to 6 weeks (Montalvo 2004). Pods are brown and dry when seeds are mature. Bright green seeds are not ripe. Seeds turn a more olive-green to brown when mature.
E. Seed collecting and harvesting	In southern California the small pods can be collected from May to July and sometimes later depending on location (Montalvo 2004). Plants can flower and set seed later in the summer along the central and northern coasts of California where peak blooming can be as late as mid July (A. Montalvo pers. obs.). When ripe, seeds are stripped from stems into open containers or on to tarps.

F. Seed processing	Care needs to be taken to avoid breaking seeds during thrashing to remove them from stems and pods. For most planting purposes, the pod can be left on the seed, but germination can be improved if seeds are removed from pods. To clean, sift through a sieve to remove chaff. To remove seeds from pods, rub pods with a wooden block over a medium screen or #16 sieve, shake to release seeds through sieve, and resieved several times through #12 and #16 sieves (Wall & Macdonald 2009). Seeds can then be separated from chaff with a seed blower (speed set to 1.75 for Oregon seed blower; speed depends on blower tube diameter and manufacturer). Pods can also be broken up by spinning in a blender with taped blades, but breakage can be difficult to control. The seeds of var. *brevialatus* tend to be more narrow and susceptible to breakage, so take care when switching among varieties.
G. Seed storage	Store seeds dry. They store best under cool, dry storage conditions.
H. Seed germination  Note glands at base of cotyledons.	 Some seeds germinate without treatment, but heat treatment significantly increases germination percentages (see IX. C. Seed dormancy). Seedlings tend to emerge 7 to 14 days after sowing and watering in the cool rainy season (Montalvo, pers. obs.). In seed tests, Mirov & Kraebel (1939) recorded 6 days from sowing to start of germination. Cibotti (pers. com.) reported germination in a greenhouse from 7 to 28 days after planting with most occurring between 10 and 15 days. Photos by A. Montalvo.
I. Seeds/lb	Seed weights are variable. Reports range from about 143,000 to over 382,000 seeds/lb for variety *glaber* and 220,000 to over 401,800 seeds/lb for variety *brevialatus* . *L. s.* var. *scoparius:* 314 seeds/gram ~ 143,000 seeds/lb (Golden Gate National Park nursery). *A. g.* var. *glaber:* (removed from pods) 536 seeds/0.0014 lb ~382.857 seeds/lb (A. Montalvo pers. obs.) *A. g.* var. *brevialatus:* (removed from pods) 643 seeds/0.0016 lb. ~401,875 seeds/lb (A. Montalvo pers. obs.) *L. s.* var. *brevialatus* : 220,000 seeds/lb (Stover Seed Company 2008, http://www.stoverseed.com/websearch/itemsheet.cfm?ic=LOSCO) *Acmispon glaber* average live seed per bulk lb (includes pods): 158,840 (S&S Seeds 2017).
J. Planting	Whole pods can be dry or wet broadcast in the fall for revegetation and restoration, although success can be increased if seeds are removed from pods (J. Burger, personal communication). Seedling plugs can also be used for small projects and are best planted out early in the rainy season. In one study, seeds were sown February 8–9 in plug flats and the resulting seedling plugs were planted in the field March 20 (Montalvo & Ellstrand 2000). In a more successful round, seeds were surface sown in plugs flats on December 18–19 and the seedlings outplanted February 14–15. Greenhouse temperatures were ambient during seedling emergence but kept within 4.4 and 32.2°C (Montalvo & Ellstrand 2001). For container plant production, heat-treated seeds (see IX. C. Seed dormancy) may be mixed with media and sown on surface of plug flats filled with well-draining medium such as Sunshine Mix #4 (nursery protocol by Young, Betty, 2001, USDI NPS - Golden Gate National Parks, San Francisco, California. In: NPNPP (2016)).
K. Seed increase activities or potential	Plants can be grown to increase seeds, but seeds can be wild-collected in quantity from large stands of plants for several years after wildfire. The Irvine Ranch Conservancy in Orange Co. initiated a 1-acre seed increase field for *A. g.* var. *glaber* in fall 2009 and another in 2015 at a different location (J. Burger & M. Garrambone, personal communication). Plants were installed at a planting density of 1 plant/28 square feet. At the first site, many plants flowered by the end of the first growing season but not enough for seed harvest. Four seasons of seed yield from the first field averaged 22 PLS lb./acre, with the highest yield in the wettest year. Three of four years had below average rainfall and there was insufficient supplemental irrigation. Yield at the second site was 112 PLS lb./acre. The low yield at the first site was due, in part, to missing many fruits before dispersal and to drought. Fruits ripen over a long period, requiring regular attention and multiple collection dates. Harvest is slow and labor intensive.
X. USES	
A. Revegetation and erosion control	Deerweed is an important, fast growing, early successional species used extensively in roadside revegetation, erosion control, post-fire mitigation, and habitat restoration in California, especially in coastal and upland sage scrub (Montalvo 2004). Newton and Claassen (2003) recommend use of this plant that has nitrogen fixing nodules for disturbed lands within the central western California and southwestern California regions.

B. Habitat restoration	Plants and seeds area frequently used in restoration of coastal sage scrub and other shrubland habitats. Seedling emergence within seeded sites can be highly variable among sites and years. The young seedlings do not compete well with non-native grasses, so weed control prior to planting is important. Treating the seeding area with herbicide can improve seedling emergence (Bell et al. 2016). Kimbal et al. (2014) conducted experiments in Orange County to determine if the establishment and growth of plants was sensitive to atmospheric nitrogen deposition, drought, and added water. Establishment from seed and growth of plants was significantly improved by addition of water compared to reduced water treatments. Few plants established under water reduction. Additional nitrogen did not affect growth under added water, but nitrogen addition stunted plants under ambient water. Results suggest nitrogen deposition can negatively affect restoration plantings and post-fire recovery of common deerweed except when high rainfall follows planting or fire.
C. Horticulture or agriculture	**Horticulture:** Plants are occasionally used in naturalistic, dry garden landscapes. The long branches yield long, arching sprays of small yellow flowers in the spring (A. Montalvo pers. obs.). The flowers provide a great food source for native bees in a bee-friendly garden. Recommended for low water gardens (O'Brien et al. 2006, Perry 2010). Added water in spring during drought extends leaf retention and flowering. Plants are not adapted to summer water. Dormant plants can be trimmed back in late summer and fall. **Agriculture:** Padgett et al. (2000) examined the effect of four types of supplemental irrigation on establishment of plants from seeds planted outdoors in Riverside (variety not indicated) including no supplemental water, spring water (March 1–July 1), summer water (July 1–Oct. 1), and continuous water (Dec. 1995–Oct 1996). Seedling emergence was not improved by irrigation, and by the end of the second year seedling survival was highest in the unirrigated control plots. Addition of summer water after seedling establishment significantly reduced survival of seedlings.
D. Wildlife value	The flowers and seeds are an important food resource for a variety of insects and seed-foraging rodents and birds (Duncan 1968). Plants supply food for rodents (Meserve 1976), scarab beetles (Evans 1985), and the larvae of many species of butterflies (Howe 1975, Pratt & Ballmer 1991). The plants provide valuable forage for deer, especially in drought years when growth of herbaceous vegetation is sparse (Dale 2000). Conrad (1987) states that the plants provide staple to low value browse for deer and livestock.
E. Plant material releases by NRCS and cooperators	None.
F. Ethnobotanical	The Native American Ethnobotany Database (NAE 2016) lists several uses by native peoples including: decoction of foliage for coughs (Costanoan); food for livestock (Diegueno); fiber for building materials (Costanoan); for house construction (Costanoan and Cahuilla); and roots for soap (Diegueno).
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XIII. LINKS TO REVIEWED DATABASES & PLANT PROFILES

Fire Effects and Information System (FEIS)	*Lotus scoparius* / *Acmispon glaber*, not available (see http://www.feis-crs.org/feis/ for updates)
Calflora	https://www.calflora.org/
Calscape	https://calscape.org/Acmispon-glaber-()
Jepson Interchange	https://ucjeps.berkeley.edu/interchange/
Jepson eFlora (JepsonOnline, 2nd ed.)	https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=91709
USDA PLANTS	https://plants.sc.egov.usda.gov/java/nameSearch
Native Plant Network Propagation Protocol Database (NPNPP)	https://npn.rngr.net/propagation/protocols

GRIN (provides links to many resources)	https://www.ars-grin.gov/
Flora of North America (FNA) (online version)	Fabaceae not available (see http://floranorthamerica.org/families for updates)
Native American Ethnobotany (NAE)	http://naeb.brit.org/uses/search/?string=Lotus+scoparius
Rancho Santa Ana Botanic Garden Seed Program, seed images	http://www.hazmac.biz/rsabghome.html
XIV. IMAGES	All images by Arlee Montalvo (copyright 2017) with rights reserved, or Arlee Montalvo for RCRCD (copyright 2017) 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 and the Riverside-Corona Resource Conservation District.

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