PLECOSTACHYS SERPYLLIFOLIA (ASTERACEAE) NATURALIZED IN CALIFORNIA

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ABSTRACT

Plecostachys serpyllifolia, a small, sprawling shrub endemic to South Africa, is reported as naturalized for the first time for California. *Plecostachys serpyllifolia* is widely cultivated and likely escaped from residential gardens, commercial landscape plantings, or other sources. In southern California, it behaves as a facultative halophyte and a facultative wetland species that has naturalized in alkaline wetlands and moist sandy to rocky alkaline to saline sites mostly along the immediate coast (see photo on rear cover). Accordingly, we propose that *P. serpyllifolia* be added to the National List of Plants that Occur in Wetlands. We provide voucher documentation, and also review its distribution, ecology, and mode of introduction. *Phytologia 91(3): 542-565 (December, 2009).*

KEY WORDS: *Plecostachys serpyllifolia*, California, halophyte, hydrophyte, naturalized, wetlands

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Plecostachys serpyllifolia (P.J. Bergius) Hilliard & B.L. Burtt has not been reported previously in treatments of the Asteraceae that address nonnative species growing outside of cultivation in California (Hickman 1993; Bossard et al. 2000; Hrusa et al. 2002; DiTomaso & Healy 2003; Roberts et al. 2004; Rebman & Simpson 2006; Bossard & Randall 2007; Clarke et al. 2007; DiTomaso & Healy 2007; Riefner &

Boyd 2007; Grewell et al. 2007; Dean et al. 2008; Roberts 2008; Jepson Flora Project 2009). *Plecostachys serpyllifolia* was not included in the recent Flora of North America treatment of Gnaphalieae (Nesom 2006), nor has it been reported at all for North America (USDA, NRCS 2009).

Voucher specimens: **U.S.A.: CALIFORNIA: Los Angeles Co.**, City of Malibu, Zuma Lagoon at Westward Beach Rd., UTM (NAD 83) 11S 0331907E 3765293N, elev. 3 m, rare, moist sand around lagoon, 6 Aug 2004, *Riefner 04-367* (TEX), same locality, 10 Nov 2007, *Riefner 07-494* (RSA); City of Malibu, ocean bluff W of El Matador State Beach, UTM (NAD 83) 11S 0326052E 3768035N, elev. 2-6 m, local, seep on sea cliff with evaporate salt crust, 27 Dec 2008, *Riefner 08-385* (RSA, TEX); City of Malibu, ocean bluff W of El Matador State Beach, UTM (NAD 83) 11S 0326009E 3768041N, elev. 2-6 m, locally common on sea cliff ledges and seep with evaporate salt crust, 27 Dec 2008, *Riefner 08-387* (RSA, TEX); City of Malibu, ca. 0.2 mi E of La Piedra State Beach, UTM (NAD 83) 0325912E 3768075N, elev. ca. 3–6 m, common and invasive on coastal strand and bluff slope wetlands, 9 Jun 2009, *Riefner 09-108* (CDA, RSA, SBBG, SD, TEX, UC, UCR); City of Malibu, ca. 0.25 mi W of La Piedra State Beach near El Pescador State Beach, UTM (NAD 83) 0325662E 3768092N, elev. ca. 3–9 m, common and invasive on sea cliffs, mesic coastal bluff scrub, and slope wetlands, 9 Jun 2009, *Riefner 09-113* (CDA, RSA, SBBG, SD, TEX, UCR); City of Malibu, vicinity of La Piedra State Beach, UTM (NAD 83) 0325663E 3768090N, elev. ca. 4–6 m, common, mesic coastal bluff scrub, 9 Jun 2009, *Riefner 09-118* (RSA, TEX). **Orange Co.**, City of Lake Forest, Aliso Creek, S side of Portola Pkwy. and W of El Toro Rd., UTM (NAD 83) 11S 0439205E 3724613N, elev. 225 m, uncommon, seepage area on sandy alluvial terrace with evaporate salt crust, 9 Sep 2005, *Riefner 05-654* (RSA), same location, 16 May 2009, *Riefner 09-57* (RSA); City of Irvine, N side of Irvine Blvd. at SR-133 on-ramp, UTM (NAD 83) 0431786E 3728837N, elev. 64 m, rare, growing in sandy roadside wash, 26 Jul 2006, *Riefner 06-319* (RSA), not persistent in 2009; City of Newport Beach, Dover Beach, Newport Bay, vicinity of Morning Star Ln. and Polaris Dr., UTM (NAD 83) 0416290E 3720550N, elev. 3 m, rare, growing in coastal bluff scrub above high tide zone, 18 Mar 2007, *Riefner 07-153* (CDA, RSA); City of Laguna Beach, ocean bluff vicinity of West St. and Pacific Coast Hwy., UTM (NAD 83) 11S 0430540E 3707490N, elev. 4 m, local, coastal strand and bluff seep, 22 Oct 2008, *Riefner 08-308* (RSA, TEX); City of

Laguna Beach, vicinity of West St. and Pacific Coast Hwy., UTM (NAD 83) 11S 0430418E 3707700N, elev. 5 m, locally common, coastal bluff ledges, seep, and coastal strand, 30 Dec 2004, *Riefner 04-681* (RSA), same locality, 22 Oct 2008, *Riefner 08-312* (RSA, TEX); City of Dana Point, beach near Salt Creek, vicinity of Ritz Carlton Resort, UTM (NAD 83) 11S 0432734E 3704750N, elev. 2.5 m, uncommon, coastal strand-lagoon edge, 18 Jul 2009, *Riefner 09-151* (CDA, RSA, UC, UCR). **Riverside Co.**, City of Temecula, Vine St. at Peach Tree St., UTM (NAD 83) 11S 0491837E 3701394N, elev. ca. 341 m, rare, roadside ditch in sandy soil, 22 Aug 2006, *Riefner 06-395* (CDA, RSA, TEX), not persistent in 2009; City of Temecula, Wolf Valley Rd. at Wolf Creek Rd., UTM (NAD 83) 11S 0490185E 3702408N, elev. ca. 341 m, local, roadside ditch at edge of field, 22 Aug 2006, *Riefner 06-397* (CDA, RSA), not persistent in 2009; City of Temecula, Pechanga Pkwy. at Pechanga Resort Dr., UTM (NAD 83) 11S 0490557E 3701614N, elev. 338 m, weed in parking lot garden, 16 Dec 2008, *Riefner 08-369* (RSA, TEX). **San Diego Co.**, Leucadia, vicinity of Moonlight Beach, ca. 0.25 mi N of B St., UTM (NAD 83) 11S 0471954E 3657223N, elev. 2 m, uncommon, moist sand in perennial bluff seep with evaporate salt crust, 20 Apr 2009, *Riefner 09-31* (RSA, TEX). **Santa Barbara Co.**, City of Carpinteria, vicinity of Padaro Ln. at 101 Fwy., UTM (NAD 83) 11S 0265278E 3810619N, elev. ca. 4 m, uncommon weed in hedgerow, 30 Jan 2009, *Riefner 09-11* (CDA, RSA, TEX, UCR). **Ventura Co.**, City of Oxnard, Mandalay Bay, vicinity of Chesapeake Dr. and Viewpoint Pl., UTM (NAD 83) 11S 0294330E 3785124N, elev. 2 m, local, open sandy scrub along inlet channel and adjacent irrigated landscapes, 9 May 2009, *Riefner 09-50* (RSA, TEX).

Plecostachys serpyllifolia has in the past been placed in *Helichrysum*, but it now resides in a separate genus created for it and its close relative *P. polifolia* (Thunb.) Hilliard & B.L. Burtt. Molecular studies (Bayer et al. 2000) have confirmed the distinctiveness of *Plecostachys* and have shown it to be most closely related to the monotypic genus *Tenrhynea* of South Africa.

Both species of *Plecostachys* are native to the coastal regions of southern Africa. *Plecostachys serpyllifolia* is restricted to South Africa and grows on sandy coastal flats or damp slopes mostly near the sea. It has also been documented from an alkaline fen, where it is apparently rare

(Martin 1960). *Plecostachys polifolia* occurs mostly in South Africa but also barely reaches into Swaziland – it grows mostly in mountainous regions and usually in damp places along streams or cliffs near forests (Hilliard 1983; Goldblatt & Manning 2000).

Plecostachys serpyllifolia is a small to medium, straggling or mounded, much-branched shrub with white-tomentose stems and leaves, white to often pink-tinged phyllaries, and is known by the common names of Clipped Lime or Vaaltee [Afrikaans] (Bond & Goldblatt 1984). It differs from *P. polifolia* in having suborbicular or broadly elliptic leaves, 3–8 staminate florets, and involucral bracts with pure white petaloid tips that exceed the flowers (Hilliard 1983). *Helichrysum serpyllifolium* (P.J. Bergius) Less. and *H. orbiculare* (Thunb.) Druce both are synonyms of *P. serpyllifolia* (Hilliard 1983; Bond & Goldblatt 1984).

Widely cultivated in California, *P. serpyllifolia* was first introduced in the late 1980s as "*Helichrysum petiolatum microphyllum*" or "Nana" (San Marcos Growers 2009). However, it is best known in the horticultural industry as "*Helichrysum petiolare petite*" or "Petite Licorice." Other common names include Straw Flower or Trailing Licorice. Owing to the content of volatile oils, the leaves of *P. serpyllifolia* are lightly aromatic (Tucker & Maciarello 1996), hence the references to "licorice" for its common names. Because it is drought-tolerant, easy to establish, and tolerates poor quality or recycled water used for irrigation, *P. serpyllifolia* is frequently planted in southern California (Costello & Jones 1994; UCI 2000; Los Angeles Unified School District 2007; ASLA 2008; California Friendly Plants 2008; County of Riverside 2008; Santa Barbara County 2008). *Plecostachys serpyllifolia* is also cultivated in South Africa where it is recommended for landscaping of coastal areas, alkaline sites, and wetlands (New Plant Nursery 2007; New Hope Nursery 2009).

Confusion with Other Species

Plecostachys serpyllifolia resembles *Helichrysum petiolare* Hilliard & B.L. Burtt, which is also naturalized in California. The leaves of *H. petiolare* are similarly aromatic, but much larger (10–20 mm long), the heads are larger, and the achenes are smooth-surfaced (vs. glandular-papillate in *Plecostachys*).

Plecostachys serpyllifolia is well-established in southern California, but has apparently not been detected by botanists because it occupies a relatively narrow range of specialized habitats. It may have also been overlooked because it superficially resembles *Eriogonum cinereum* Benth. (Coastal or Ashy Leaf Buckwheat), which co-occurs with *P. serpyllifolia* in the northern part of its range. *Eriogonum cinereum* is a rounded 1.5 m tall shrub found on beaches and coastal bluffs that has grayish-tomentose oval leaves and white to pink perianth lobes. The horticultural industry, however, has recognized the ability of *P. serpyllifolia* to escape gardens and naturalize in native wetland habitats (sloughs and salt marshes), and recommend that it not be planted in landscapes that interface wildland areas (San Marcos Growers 2009). *Plecostachys serpyllifolia* has also naturalized in Portugal (Almeida & Freitas 2006; GCW 2009), likely in coastal environments. Owing to its widespread use in the horticultural industry, natural adaptation to coastal habitats, and its establishment outside of cultivation in another Mediterranean climate region, it is therefore not surprising to find *P. serpyllifolia* naturalized in coastal southern California.

Occurrence as a Hydrophyte

In southern California, *P. serpyllifolia* occurs from San Diego County to Santa Barbara County. It is an occasional weed of irrigated gardens and roadside habitats where it is rarely persistent. This species has naturalized in native habitats, including moist sandy flats and open scrub around bays and lagoons, in alkaline seeps and wetlands, on rocky sea cliffs, coastal bluff scrub, the coastal strand, and alkaline streamside terraces. With the exception of rocky cliff and coastal bluff scrub habitats, most of these sites support hydrophytic vegetation, hydric soils, and hydrological conditions characteristic of wetlands. *Plecostachys serpyllifolia* is also reported to occur in salt marshes (San Marcos Growers 2009), but we have not located any populations naturalized in this habitat. Away from the immediate coast, plants migrating from gardens may not persist in dry upland habitats through the summer drought, but may naturalize if dispersed to summer-moist urban environments or native perennial wetland habitats.

Much like its behavior in South Africa, *P. serpyllifolia* is most abundant in mesic sandy to rocky seashore habitats and alkaline wetlands in coastal southern California. Many nonnative species

recently established in southern California have been identified as facultative or facultative wetland plants based on frequency of occurrence in wetlands (Reed 1988) and the "individualistic concept of a hydrophyte" (Riefner and Boyd 1997). The individualistic concept recognizes that a plant species may exhibit considerable plasticity or ecological amplitude in its adaptations to wet environments, which may represent the entire population of the species or only a subset of individuals (Tiner 1991). Identification of hydrophytes is important since the determination of the presence or absence of hydrophytic vegetation is needed to delineate the jurisdictional (legal) boundaries of wetlands, which requires the use of wetland indicator plant status ratings, species abundances, and several mathematical formulas (Reed 1988; Tiner 2006; USACE 2006). Therefore, it is critical that a species be accurately assigned a wetland indicator status; especially when an unlisted hydrophyte like *P. serpyllifolia* might be confused with upland species such as *E. cinereum* and *H. petiolare*.

The known distribution of *P. serpyllifolia* in coastal southern California is shown on Figure 1. Thirteen sites of the 18 known populations were chosen for field study, which represent the diversity of habitats, substrates, moisture conditions, and vegetation communities occupied by persistent, reproducing populations of *P. serpyllifolia* in southern California. The five California sites reported as garden weeds or from roadside habitats (Fig. 1), where the plant is rarely persistent, were not included in the field evaluations. A formal jurisdictional wetland delineation was not conducted as part of this study. Field evaluations at each of the 13 *P. serpyllifolia* data sites, however, incorporated summary findings of the presence or absence of the three attributes of hydrophytic vegetation, hydric soils, and hydrology implicit to characterizing wetland communities; see USACE Wetland Delineation Manual and Arid West Regional Supplement (USACE 1987, 2006) and USDA, NRCS (2006) for technical guidance and procedures.

FIG. 1. Known distribution of *Plecostachys serpyllifolia* in southern California; a solid circle (●) identifies the locations of naturalized populations, and an open square (□) identifies locations of garden weeds or plants collected from roadside habitats.

Qualitative field examinations of hydrology, soils, frequency of occurrence, and associations with known facultative wetland species were conducted between June and August, 2009, to 1) determine if *P. serpyllifolia* functions as a hydrophyte in southern California, and 2) provide documentation to specify a wetland indicator status for addition to the National List of Plants that Occur in Wetlands (National List).

Several editions of the National List are available for use, including an approved list (Reed 1988) and a revised list compiled by USFWS (1998). Each species on these lists is assigned an indicator status reflecting its frequency of occurrence (not degree of wetness) in wetlands, which includes: obligate [OBL, >99% found in wetlands]; facultative wetland [FACW, 67-99% found in wetlands]; facultative [FAC, 34-66% found in wetlands]; facultative upland [FACU, 1-33% found in wetlands]; and upland [UPL, <1% found in wetlands].

Field examinations determined that naturalized populations of *P. serpyllifolia* (i.e., populations reproducing spontaneously outside of cultivation in wildland habitats) grow in close association with a predominance (greater than 50 percent) of plant species typical of wetlands. Plant species that comprise the hydrophytic vegetation community closely associated with *P. serpyllifolia* are listed in Table 1. Compiling lists of species with assigned ratings can serve an important role in evaluating the wetland indicator status of plants that occupy uplands or wetlands and species that grow in highly specialized habitats, such as saline environments (Lichvar and Dixon 2007).

Table 1. Hydrophytic plants found growing with or in close proximity to naturalized populations of *Plecostachys serpyllifolia* in coastal southern California. The facultative wetland indicator status of each plant is based on the Reed (1988) and USFWS (1998) lists. An asterisk (*) indicates a tentative assignment that requires further review, a plus (+) or minus (–) designation indicates the higher or lower part of the frequency range for a particular indicator (respectively), and a long dash (—) indicates the plant is not included on the list.

ASSOCIATED PLANT SPECIES	REED (1988) INDICATOR STATUS	USFWS (1998) INDICATOR STATUS
Acacia cyclops	—	—
Acacia longifolia	—	—
Agrostis stolonifera	FACW	FACW
Agrostis viridis (syn., *A. semiverticillata, Polypogon viridis*)	OBL	OBL
Amblyopappus pusillus	FACW–	FACW–
Anagallis arvensis	FAC	FAC
Apium graveolens	FACW*	FACW*
Artemisia californica	—	—
Arundo donax	FACW	FAC+
Aster subulatus var. *ligulatus*	FACW	FACW
Atriplex californica	FAC	FAC
Atriplex glauca	—	—
Atriplex lentiformis	FAC	FAC
Atriplex prostrata	—	FACW*
Baccharis salicifolia	FACW	FACW
Bassia hyssopifolia	FAC	FAC
Cakile maritima	FACW	FACW
Carpobrotus chilensis (*C. aequilaterus* of early floras)	—	FAC*
Carpobrotus edulis	—	—
Chenopodium ambrosioides	FAC	FAC
Chenopodium glaucum	FACW*	—
Chenopodium rubrum	—	FACU
Cortaderia selloana	—	—

ASSOCIATED PLANT SPECIES	REED (1988) INDICATOR STATUS	USFWS (1998) INDICATOR STATUS
Cotyledon orbiculata	—	—
Cotula coronopifolia	FACW+	FACW+
Distichlis spicata	FACW	FACW
Eriogonum parvifolium	—	—
Heliotropium curassavicum	OBL	OBL
Isocoma menziesii var. *vernonioides* (syn., *Haplopappus venetus*)	FACW*	FAC+
Isolepis cernua (syn., *Scirpus cernuus*)	OBL	OBL
Juncus acutus subsp. *leopoldii*	FACW	FACW
Juncus bufonius	FACW+	FACW+
Limonium arborescens	—	FAC*
Limonium perezii	—	—
Limonium ramosissimum	—	—
Matthiola incana	—	UPL
Medicago polymorpha (syn., *M. hispida*)	—	FACU–
Melilotus alba	FACU+	—
Melilotus indica	FAC	FAC
Myoporum laetum	—	FAC*
Plantago major	FACW–	FAC
Pluchea ordorata (syn., *P. purpurascens*)	OBL	FACW
Polypogon monspeliense	FACW+	FACW+
Pulicaria paludosa	—	FACW*
Rhus integrifolia	—	—
Ricinus communis	FACU	FACU
Rumex crispus	FACW–	FACW–
Rumex maritimus	OBL	FACW+
Salix lasiolepis	FACW	FACW
Stenotaphrum secundatum	FAC+	FAC+
Typha domingensis	OBL	OBL
Typha latifolia	OBL	OBL
Xanthium strumarium	FAC+	FAC+

Several of the species listed above lack an assigned wetland indicator status, which include *Carpobrotus edulis* (L.) N.E. Br., *Cortaderia selloana* (Schultes) Asch. & Graebner, *Limonium perezii* (Stapf) Hubb., and *Limonium ramosissimum* Maire. These species, however, are well-known invasive plants of California's estuarine wetlands (Grewell et al. 2007) and should be evaluated for the next revision of the National List. Accordingly, as a result of this evaluation, *P. serpyllifolia* frequently grows in close association with a predominance of hydrophytic plant species typical of wetlands in southern California. Outside of cultivation, *P. serpyllifolia* is occasionally found growing on mesic rocky cliff and coastal bluff scrub habitats that are influenced by ocean spray and fog-drip moisture, but do not support hydrophytic vegetation. *Plecostachys serpyllifolia*, however, has not established in dry upland communities such as coastal sage scrub, chaparral, grasslands, or in oak woodlands.

Indicators of hydrophytic vegetation and hydric soils generally provide reliable evidence that the timing, duration, and frequency of wet conditions are sufficient to support wetland communities (USACE 2006). Therefore, indicators of hydric soils and wetland hydrology were also recorded during this study to establish a frequency of occurrence of *P. serpyllifolia* in wetlands in order to specify a wetland indicator status for potential addition to the National List. Indicators of wetland hydrology summarized by USACE (2006) that are present at the 13 data sites includes Indicators A1.Surface Waters, A3.Soil Saturation, B1.Water Marks (stained rocks), B11.Salt Crusts (on rocks and alluvial surfaces), B12.Biotic Crusts (including green algal mats), and evidence of recent soil saturation such as C3.Oxidized Rhizospheres, and C4.Recent Iron Reduction. Landscape positions conducive to development of wetlands associated with these sites include a streamside terrace, fringe of lagoon or bay, toe-of-slope along coastal bluffs, and occurrences within or adjacent to high tides along ocean beaches. Hydric soil indicators (USDA, NRCS 2006) documented at the data collection sites includes Indicators S4.Sandy Gleyed Matrix, S5.Sandy Redox, F2.Loamy Gleyed Matrix, and F3.Depleted Matrix.

Table 2. Wetland attributes of hydrophytic vegetation, hydric soils, and hydrology associated with naturalized populations of *Plecostachys serpyllifolia* in coastal southern California.

DATA COLLECTION SITES	HABITATS	ATTRIBUTES OF WETLANDS PRESENT
Mandalay Bay, Ventura Co.	Bay Inlet Channel	Yes: Hydrophytic vegetation No: Hydric soils Yes: Hydrology
El Pescador (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Strand	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Bluff Scrub	Yes: Hydrophytic vegetation No: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Splash Zone on Cobbly Seashore	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
El Matador (R.H. Meyer) State Beach, Los Angeles Co.	Bluff Seep	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Zuma Lagoon, Los Angeles Co.	Lagoon	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Lake Forest, Aliso Creek, Orange Co.	Alluvial Stream Terrace	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Laguna Beach, Orange Co.	Rocky Coastal Bluff Scrub	No: Hydrophytic vegetation No: Hydric soils No: Hydrology
Laguna Beach,	Coastal	Yes: Hydrophytic vegetation

DATA COLLECTION SITES	HABITATS	ATTRIBUTES OF WETLANDS PRESENT
Orange Co.	Strand	Yes: Hydric soils Yes: Hydrology
Dana Point, Salt Creek, Orange Co.	Coastal Strand–Lagoon	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Leucadia, San Diego Co.	Bluff Seep	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology

Based on qualitative field observations of wetland hydrology, hydric soils, frequency of occurrence, and associations with known facultative wetland species, *P. serpyllifolia* functions as a hydrophyte at several locations in southern California. Accordingly, we believe *P. serpyllifolia* should be added to the National List and propose a FAC* wetland indicator status. Additional regional review may be needed to specifically define its frequency of occurrence in wetlands as the species undergoes further expansions of range and colonization of non-hydrophytic vegetation communities on sea cliffs and coastal bluff scrub habitats or mesic urban environments as a garden waif.

Occurrence as a Halophyte

Plecostachys serpyllifolia has not been identified previously as a halophyte on any of the databases listing salt-tolerant plants known from around the world (Aronson 1989; Menzel & Lieth 2003). However, it has always been difficult to characterize plant responses to salinity in a way that is meaningful for extrapolation from species to species, from one set of environment conditions to another, or whether the plant is a facultative or an obligate halophyte (Chapman 1975; Koyro 2003). These issues are certainly exacerbated for species introduced to new regions. Additionally, unlike the national list of wetland plants, which defines facultative (FAC), facultative wetland (FACW), and obligate wetland (OBL) plant indicator ratings, little research has been conducted to classify obligate halophytes, i.e., plants that are exclusive to saline habitats versus facultative halophytes, i.e., plants that occupy saline and non-saline environments.

In southern California, numerous species identified as halophytes by Aronson (1989) and Menzel & Lieth (2003) frequently occupy saline and non-saline riparian and freshwater wetland habitats, and are therefore best characterized as facultative halophytes. A few examples include *Agrostis stolonifera* L., *Arundo donax* L., *Chenopodium ambrosioides* L., *Cotula coronopifolia* L., *Cyperus odoratus* L., *Eleocharis palustris* (L.) Roemer & Schultes, *Isolepis cernua* (Vahl) Roemer & Schultes, *Juncus bufonius* L., *Leptochloa uninervia* (J. Presl) A. Hitchc. & Chase, *Paspalum distichum* L., *Plantago lanceolata* L., *Plantago major* L., *Polypogon monspeliensis* (L.) Desf., *Rumex crispus* L., *Schoenoplectus* (*Scirpus*) *californicus* (C.A. Meyer) Soják, *Typha angustifolia* L., *Typha domingensis* Pers., and *T. latifolia* L. Many of these plants grow with or in close proximity to *P. serpyllifolia*. Therefore, it is important to document known halophytes that grow in close association with *P. serpyllifolia* in southern California, which are shown in Table 3.

Table 3. Halophytic plants found growing with or in close proximity to naturalized populations of *Plecostachys serpyllifolia* in coastal southern California. Halophyte status is based on the Aronson (1989) and Menzel & Lieth (2003) databases. A long dash (—) indicates the plant is not included on the respective list.

ASSOCIATED PLANT SPECIES	ARONSON (1989) HALOPHYTE	MENZEL & LIETH (2003) HALOPHYTE
Acacia cyclops	Yes	Yes
Acacia longifolia	—	—
Agrostis stolonifera	Yes	Yes
Agrostis viridis (syn., *A. semiverticillata, Polypogon viridis*)	—	—
Amblyopappus pusillus	Yes	Yes
Anagallis arvensis	Yes	Yes
Apium graveolens	—	Yes
Artemisia californica	—	—
Arundo donax	Yes	Yes
Aster subulatus var. *ligulatus*	—	—

ASSOCIATED PLANT SPECIES	ARONSON (1989) HALOPHYTE	MENZEL & LIETH (2003) HALOPHYTE
Atriplex californica	Yes	Yes
Atriplex glauca	Yes	Yes
Atriplex lentiformis	Yes	Yes
Atriplex prostrata	Yes	Yes
Baccharis salicifolia	—	—
Bassia hyssopifolia	Yes	Yes
Cakile maritima	Yes	Yes
Carpobrotus chilensis (*C. aequilaterus* of early floras)	Yes	Yes
Carpobrotus edulis	Yes	Yes
Chenopodium ambrosioides	Yes	Yes
Chenopodium glaucum	Yes	Yes
Chenopodium rubrum	Yes	Yes
Cortaderia selloana	—	—
Cotula coronopifolia	Yes	Yes
Cotyledon orbiculata	Yes	Yes
Distichlis spicata	Yes	Yes
Eriogonum parvifolium	—	—
Heliotropium curassavicum	Yes	Yes
Isocoma menziesii var. *vernonioides* (syn., *Haplopappus venetus*)	—	—
Isolepis cernua (syn., *Scirpus cernnus*)	Yes	Yes
Juncus acutus subsp. *leopoldii*	Yes	Yes
Juncus bufonius	Yes	Yes
Limonium arborescens	Yes	Yes
Limonium perezii	Yes	Yes
Limonium ramosissimum	Yes	Yes
Matthiola incana	—	—
Medicago polymorpha (syn., *M. hispida*)	—	Yes
Melilotus alba	—	Yes
Melilotus indica	—	Yes
Myoporum laetum	—	—

ASSOCIATED PLANT SPECIES	ARONSON (1989) HALOPHYTE	MENZEL & LIETH (2003) HALOPHYTE
Plantago major	Yes	Yes
Pluchea ordorata (syn., *P. purpurascens*)	Yes	Yes
Polypogon monspeliense	Yes	Yes
Pulicaria paludosa	—	—
Rhus integrifolia	—	—
Ricinus communis	—	—
Rumex crispus	Yes	Yes
Rumex maritimus	Yes	Yes
Salix lasiolepis	—	—
Stenotaphrum secundatum	Yes	Yes
Typha domingensis	Yes	Yes
Typga latifolia	Yes	Yes
Xanthium strumarium	—	—

Based on observations of naturalized, persistent populations in wildland habitats, *P. serpyllifolia* apparently functions as a facultative halophyte in southern California. It is nearly always closely associated with substrates having a conspicuous evaporate salt crust, grows within the salt-spray and splash zones along the seashore, and it most often grows with or in close proximity to a predominance of well-known halophytes. Halophytes are plants capable of completing their life cycle in saline environments where the salt concentration of soil solution measures at least 5 g/l total dissolved solids or 85 mM NaCl (Aronson 1989; Koyro 2003). Electrical conductivity (EC) of a soil saturation extract (ECe) expressed as deciSiemens/meter (dS/m), however, is the preferred index of measurement used to classify saline soils and to identify halophytes (U.S. Salinity Laboratory Staff 1954; Aronson 1989). Accordingly, soil samples were collected and analyzed for pH and salinity to further clarify the potential halophyte status of *P. serpyllifolia* in southern California.

Soil samples to determine pH and salinity were collected from the same 13 wetland attribute study sites that represent the diversity of habitats, substrates, moisture conditions, and vegetation communities

occupied by *P. serpyllifolia* in southern California. Soil samples were collected in early June or in late August, 2009, from a depth of 0 – 10-inches within the root-zone of *Plecostachys* plants, mixed to produce a composite sample, cataloged, and then shipped to Wallace Laboratories (El Segundo, California) for analysis. The five California *P. serpyllifolia* populations reported as garden weeds or from roadside habitats, where the plant is rarely persistent, were not sampled for analysis.

Table 4. Results of pH and salinity analysis of soil samples collected from sites that represent the diversity of habitats typically occupied by *Plecostachys serpyllifolia* in southern California; pH and ECe dS/m measured in a saturation paste extract. The higher the ECe the more salts are in the soil.

DATA COLLECTION SITES	HABITATS	pH	ECe dS/m
Mandalay Bay, Ventura Co.	Bay Inlet Channel	6.92	63.20
El Pescador (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	7.51	43.20
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Strand	7.76	2.23
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Bluff Scrub	6.97	43.60
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	7.15	4.52
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Splash Zone on Cobbly Seashore	7.31	39.00
El Matador (R.H. Meyer) State Beach, Los Angeles Co.	Bluff Seep	7.26	11.70
Zuma Lagoon, Los Angeles Co.	Lagoon	7.08	10.30
Lake Forest, Aliso Creek, Orange Co.	Alluvial Stream Terrace	7.41	14.60
Laguna Beach, Orange Co.	Rocky Coastal Bluff Scrub	7.55	35.80
Laguna Beach, Orange Co.	Coastal Strand	7.68	6.87
Dana Point, Salt Creek,	Coastal Strand–	7.70	3.51

DATA COLLECTION SITES	HABITATS	pH	ECe dS/m
Orange Co.	Lagoon		
Leucadia, San Diego Co.	Bluff Seep	7.50	5.36

The Soil Survey Division Staff (1993) defines classes of soil salinity based on electrical conductivity as follows: non-saline (0 – 2 dS/m); very slightly saline (2 – 4 dS/m); slightly saline (4 – 8 dS/m); moderately saline (8 – 16 dS/m); and strongly saline (>16 dS/m). The minimum criterion used to determine if a plant behaves as a halophyte is an EC of at least 7 – 8 dS/m (Aronson 1989). Accordingly, based on preliminary analytical data, and its consistent occurrence with known halophytes, *P. serpyllifolia* appears to function as a facultative halophyte in southern California. Since salinity tolerance of plants is affected by many accessory factors (spring moisture, late season evapotranspiration that concentrates salts, drainage, nutrition, etc.), additional research to gain detailed knowledge regarding the salt tolerance of *P. serpyllifolia* and the mechanisms that enable this plant to grow in saline environments is warranted.

Competition with Native Species

Based on information available in the literature, *P. serpyllifolia* is not an aggressive colonizer in its native South Africa, nor does it appear to be invasive in Portugal. However, under optimal conditions of moisture, pH, and mild coastal environments in southern California, *P. serpyllifolia* can grow to nearly 1.5 m tall and form a dense colony of coalescing shrubs that can displace native species.

Plecostachys serpyllifolia has been observed to compete for space with *Juncus acutus* L. subsp. *leopoldii* (Parl.) Snog., which is a rare species of interest to the California Native Plant Society (CNPS List 4). Other rare plants, including *Eleocharis parvula* (Roemer & Schultes) Link ex Bluff, Nees & Schaurer (CNPS List 4), *Lycium californicum* Nutt. (CNPS List 4), *Malacothrix saxatilis* (Nutt.) Torrey & A. Gray var. *saxatilis* (CNPS List 4), and *Suaeda taxifolia* (Standley) Standley (CNPS List 4) were also observed growing in proximity to *P. serpyllifolia*. With the exception of *Malacothrix saxatilis*, each of these plants has been identified as a halophyte by Aronson (1989) and Menzel & Lieth (2003). Accordingly, the side-by-side comparisons of

halophytes versus the wetland indicator status of each plant shown in Tables 1 & 3 and the pH and salinity ranges shown in Table 4 may help identify rare native plant assemblages and natural communities that may be most susceptible to colonization by *P. serpyllifolia*.

CONCLUSION AND RECOMMENDATIONS

Although *P. serpyllifolia* is widespread in coastal southern California, most populations are small and non-invasive. Preliminary observations made during field investigations suggest that it can compete for space and displace native plants, especially in alkaline wetlands and in mesic to wet saline habitats along the immediate coast. Based on the occurrence of this species with acknowledged hydrophytes growing on hydric soils, *P. serpyllifolia* should be added at a minimum to the national list of wetland plants with a facultative (FAC*) indicator status. We believe that the frequency of occurrence of this species in wetlands, its associated species in California, and the distribution of the plant in its native land, the indicator status may quite possibly be facultative wetland (FACW).

Results of preliminary laboratory analysis indicate that *P. serpyllifolia* occupies very slightly saline to strongly saline soils throughout its known range in coastal southern California. Based on the occurrence of this species with acknowledged halophytes, its association with salty substrates, tolerance to recurrent wetting by high tides and salt sprays along the seashore, and the coastal distribution of the plant in its native land, *P. serpyllifolia* should be considered for addition to future revisions of the world-wide halophyte database.

Finally, there is concern about the possible invasiveness of this species. *Plecostachys serpyllifolia* apparently becomes invasive only in a narrow range of seashore habitats, which support numerous small native forbs and several rare species that might be displaced by this shrub. Given that, it is recommended that urban landscape programs discourage planting of *P. serpyllifolia* in coastal regions in order to deter its spread and establishment elsewhere in southern California.

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LITERATURE CITED

Almeida, J. D. De and H. Freitas. 2006. Exotic naturalized flora of continental Portugal – a reassessment. Bot. Complut. 30: 117–130.

American Society of Landscape Architects (ASLA). 2008. San Diego County invasive ornamental plant guide. San Diego Chapter, San Diego, CA.

Aronson, J. A. 1989. Haloph: a data base of salt tolerant plants of the world. Office of Arid Land Studies, University of Arizona, Tucson, AZ.

Bayer, R.J., C. F. Puttock, and S.A. Kelchner. 2000. Phylogeny of South African Gnaphalieae (Asteraceae) based on two non-coding chloroplast sequences. Amer. J. Bot. 87: 259–272.

Bond, P. and P. Goldblatt. 1984. Plants of the Cape flora: a descriptive catalogue. J. of South African Bot., supplementary Vol. 13.

Bossard, C. C., J. M. Randall, and M.C. Hoshovesky. 2000. Invasive plants of California's wildlands. University of California Press, Berkeley.

Bossard, C. C. and J. M. Randall. 2007. Nonnative plants in California. *in* M. G. Barbour, T. Keeler-Wolf, and A.A. Schoenherr, eds. Terrestrial vegetation of California, ed. 3. University of California Press, Berkeley. Pp. 107–123.

California Friendly Plants. 2008. Landscape plants and trees; listed alphabetically by botanical name. Available:

http://www.thegarden.org/siteDocs/CAFriendlyList-botanical.pdf [accessed May 2009].

Chapman, V.J. 1975. The salinity problem in general, its importance, distribution with special reference to natural halophytes. *in* A. Poljakoff-Mayber and J. Gale, eds. Plants in saline enviroments. Springer-Verlag, New York-Heidelberg-Berlin. Pp. 7–24.

Clarke, O.F., D. Svehla, G. Ballmer, and A. Montalvo. 2007. Flora of the Santa Ana River and environs. Heyday Books, Berkeley.

County of Riverside. 2008. County of Riverside guide to California friendly landscaping. Transportation and Management Agency, and Planning Department, Riverside, CA.

Costello, L.R. and K.S. Jones. 1994. Water use classification of landscape species (WUCOLS): a guide to the water needs of landscape plants. University of California Cooperative Extension, San Francisco and San Mateo County Office, CA.

Dean, E., F. Hrusa, G. Leppig, A. Sanders, and B. Ertter. 2008. Catalogue of nonnative vascular plants occurring spontaneously in California beyond those addressed in The Jepson Manual–Part II. Madroño 55: 93–112.

DiTomaso, J.M. and E.A. Healy. 2003. Aquatic and riparian weeds of the West. U.C. Agriculture and Natural Resources Publication 3421, Oakland, CA.

DiTomaso, J.M. and E.A. Healy. 2007. Weeds of California and other western states, Vol. 1, Aizoaceae–Fabaceae. U.C. Agriculture and Natural Resources Publication 3488, Oakland, CA.

Global Compendium of Weeds (GCW). 2007. *Plecostachys serpyllifolia* (Asteraceae). Available: http://www.hear.org/gcw/species/plecostachys_serpyllifolia/ [accessed January 2009].

Goldblatt, P. and J. Manning. 2000. Cape plants: a conspectus of the Cape flora of South Africa. Strelitzia 9. National Botanical Institute, Cape Town, South Africa & MBG Press, Missouri Botanical Garden, St. Louis, MO.

Grewell, B.J., J.C. Callaway, and W.R. Ferren, Jr. 2007. Estuarine wetlands. *in* M.G. Barbour, T. Keeler-Wolf, and A.A. Schoenherr, eds. Terrestrial vegetation of California, ed. 3. University of California Press, Berkeley, Los Angeles, London. Pp. 124–154.

Hickman, J.C. (ed.). 1993. The Jepson manual: higher plants of California. University of California Press, Berkeley.

Hilliard, O.M. 1983. *Plecostachys*. *in* O.A. Leistner, ed. Flora of Southern Africa, Vol. 33, part 7, fascicle 2 Gnaphaliinae (first part). Botanical Research Institute, Department of Agriculture, South Africa. Pp. 49–51.

Hrusa, F., B. Ertter, A. Sanders, G. Leppig, and E. Dean. 2002. Catalogue of non-native vascular plants occurring spontaneously in California beyond those addressed in The Jepson Manual–Part I. Madroño 46: 61–98.

Jepson Flora Project. 2009. Index to taxa recorded from California since The Jepson Manual (range extensions from outside California and new naturalizations). Available: http://ucjeps.berkeley.edu/interchange/I_index_newrange.html [accessed January 2009].

Koyro, H. 2003. Study of potential cash crop halophytes by a quick check system: determination of the threshold of salinity tolerance and the ecophysiological demands. *in* H. Lieth and M. Mochtchenko, eds. Cash crop halophytes: recent studies. Kluwer Academic Publishers, Dordrecht. Pp. 5–17.

Lichvar, R. and L. Dixon. 2007. Wetland plants of specialized habitats in the arid West. U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, ERDC/CRREL TR-07-8, Hanover, NH.

Los Angeles Unified School District. 2007. School design guide. City of Los Angeles, Los Angeles, CA.

Martin, A.R.H. 1960. The ecology of Groenvlei, a South African fen: Part II. The secondary communities. J. Ecol. 48: 307–329.

Menzel, U. and H. Lieth. 2003. Halophyte database version 2.0. *in* H. Lieth and M. Mochtchenko, eds. Cash crop halophytes: recent studies. Kluwer Academic Publishers, Dordrecht. Pp. 221–250.

Nesom, G.L. 2006. *Anaphalis*, *Euchiton*, *Facelis*, *Gamochaeta*, *Gnaphalium*, *Omalotheca*, *Pseudognaphalium*, *Xerochrysum* (Gnaphalieae). Flora of North America North of Mexico, Vol. 19. Oxford University Press, New York and Oxford.

New Hope Nursery. 2009. Wetland species catalogue. Cape Point, South Africa. Available: http://capepoint.com/index.php?option=com_content&view=article&id=62:wetland&catid=34:retail-plant-categories&Itemid=77 [accessed May 2009].

New Plant Nursery. 2007. Catalogue: new plants for your indigenous palette. George East, South Africa.

Rebman, J.P. and M.G. Simpson. 2006. Checklist of the vascular plants of San Diego County, ed. 4. San Diego Natural History Museum, San Diego, CA.

Riefner, R.E., Jr. and S. Boyd. 2007. New records of wetland and riparian plants in southern California, with recommendations and additions to the National List of Plant Species that Occur in Wetlands. J. Bot. Res. Inst. Texas 1: 709–730.

Roberts, F.M., Jr. 2008. The vascular plants of Orange County, California: an annotated checklist. F.M. Roberts Publications, San Luis Rey, CA.

Roberts, F.M., Jr., S.D. White, A.C. Sanders, D.E. Bramlet, and S. Boyd. 2004. The vascular plants of western Riverside County, California: an annotated checklist. F.M. Roberts Publications, San Luis Rey, CA.

San Marcos Growers. 2009. *Plecostachys serpyllifolia*. Available: http://www.smgrowers.com/products/plants/plantdisplay.asp?plant_id=1295 [accessed April 2009].

Santa Barbara County. 2008. Initiation draft Mission Canyon community plan. Santa Barbara County Planning and Development, Office of Long Range Planning, Santa Barbara, CA.

Soil Survey Division Staff. 1993. Soil survey manual. U.S. Department of Agriculture, Agricultural Handbook No. 18, Government Printing Office, Washington, D.C.

Tiner, R.W. 1991. The concept of a hydrophyte for wetland identification. BioScience 41: 236–247.

Tiner, R.W. 2006. Lists of potential hydrophytes for the United States: a regional review and their use in wetland identification. Wetlands 26: 624–634.

Tucker, A.O. and M.J. Maciarello. 1996. Volatile leaf oil of *Plecostachys serpyllifolia* (Berg.) Hilliard & B.L. Burtt. J. Essential Oil Research 8: 557–558.

U.S. Army Corps of Engineers (USACE). 1987. Environmental Laboratory, Wetlands Delineation Manual. Technical Report Y-87-1, U.S. Army Engineer Waterways Experimental Station, Vicksburg, MS.

U.S. Army Corps of Engineers (USACE). 2006. Interim regional supplement to the Corps of Engineers wetland delineation manual: arid west region. J.S. Wakeley, R.W. Lichvar, and C.V. Noble, eds. U.S. Army Engineer Research and Development Center, ERDC/EL TR-06-16, Vicksburg, MS.

USDA, NRCS. 2006. Field indicators of hydric soils in the United States, version 6.0. G.W. Hurt and L.M. Vasilas (eds.). USDA, NRCS in cooperation with the National Technical Committee for Hydric Soils.

USDA, NRCS. 2009. The PLANTS DATABASE. National Plant Data Center, Baton Rouge, LA. Available: http://plants.usda.gov [accessed June 2009].

U.S. Fish and Wildlife Service (USFWS). 1998. National list of vascular plant species that occur in wetlands: 1998 national summary. Washington, D.C. Available: http://www.fws.gov/pacific/ecoservices/habcon/pdf/1998%20National%20list.pdf [accessed June 2009].

U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. Agricultural Handbook No. 60, USDA, U. S. Government Printing Office, Washington, D.C.

University of California Irvine (UCI). 2000. University of California, Irvine, green and gold plan: a summary of campus landscape planning, implementation, and management goals for the UCI Campus. Office of Campus and Environmental Planning, Irvine CA.