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Cover:
Linanthus maculatus subsp. ***emaculatus*** (Jacumba Mountains linanthus)

Photo: Duncan Bell

Editors' Note: After five years under the able jurisdiction of Michael Honer, the editorship of *Crossosoma* has been turned over to Michelle Cloud-Hughes and Fred Roberts. All of us at Southern California Botanists heartily thank Michael for his years of labor to publish this excellent journal.

Michelle Cloud-Hughes is a botanist and restoration ecologist specializing in the flora of the southwestern deserts, particularly the Cactaceae. She worked for the Soil Ecology and Restoration Group at San Diego State University from 1997 to 2013 and started her own company, Desert Solitaire Botany and Ecological Restoration, in 2010. As an inveterate grammarian, Miehelle's editorial role in *Crossosoma* will be the revision and polishing of articles to ensure the most informative experience possible for our readers.

Fred Roberts is a long-time southern California botanist and artist. He has authored several books including *Illustrated Guide to the Oaks of the Southern California Floristic Province*, *Vascular Plants of Orange County*, and *Wildflowers of Orange County and the Santa Ana Mountains*, with co-author Bob Allen, in addition to supplying much of the artwork recently used in *Leaflets*. Fred has contributed to *Crossosoma* since the mid-1980s, when the journal's format was very basic compared to current articles, whieh often include detailed graphs, maps, tables, and color images. Fred brings to *Crossosoma* his experiences as a contributor and his skills with document layout and graphics programs he has applied to his books and other publications.

Notes on a new subspecies of *Linanthus maculatus* from San Diego and Imperial Counties

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Abstract: *Linanthus maculatus* subsp. *maculatus* is known from Riverside and San Bernardino Counties in the vicinity of the Little San Bernardino Mountains. *L. maculatus* subsp. *emaculatus* J.M. Porter, D.S. Bell & R. Patt. was recently described from Palm Canyon Wash and the adjacent drainage at the eastern base of the Jacumba Mountains in San Diego and Imperial Counties, California. We describe the habitat and distribution of this new subspecies. A review of collections of *L. maculatus* subsp. *emaculatus* shows that the earliest collections were in 2010 and that this taxon was rapidly recognized as distinctive. An assessment of threats and conservation needs of this new subspecies leads us to propose that *L. maculatus* subsp. *emaculatus* be given the CNPS global rank of G2 and CNPS California Rare Plant Rank 1B.1.

Background: *Linanthus maculatus* (Parish) Milliken is a diminutive, ephemeral annual characterized by white corollas bearing red to maroon spots at the base of each lobe and alternate, narrowly ovate leaves. While red spots at the corolla lobe bases are not an uncommon trait in *Linanthus*, alternate leaves are unusual. This in part explains its former inclusion in *Gilia* (Patterson 1989; Day 1993) and Grant's 1999 suggestion that it should be treated in the monotypic genus, *Maculigilia*. *Linanthus maculatus* usually flowers between April and May (Patterson and Porter 2011; Jepson Manual Online 2013), but it has been observed in flower as early as February and often flowers in March (pers. obs.). A population in Whitewater Canyon, Riverside County, CA has been shown to be self-incompatible (LaDoux 2004) and presumably pollinated by soft-winged flower beetles of the family Melyridae (L. Johnson, pers. com.). *Linanthus maculatus* plants are remarkably small, usually no larger than a quarter. This species is endemic to California and is only known from a few areas in the Mojave and Colorado deserts. The California Native Plant Society has designated it as a California Rare Plant Rank (CRPR) 1B.2, meaning that it is both rare and fairly endangered across its range (CNPS 2016).

Linanthus maculatus was recently split into two subspecies: *L. maculatus* subsp. *maculatus* from Riverside and San Bernardino Counties in the vicinity of the Little San Bernardino Mountains, and *L. maculatus* subsp. *emaculatus* J.M. Porter, D.S. Bell & R. Patt., in Imperial and San Diego Counties, where it is found in a small number of locations at the eastern base of the Jacumba Mountains (Porter & Patterson 2015) (Figure 1A). As the name of the new subspecies implies (*emaculatus* = without spots), *Linanthus maculatus* subsp. *emaculatus* differs from *Linanthus maculatus* subsp. *maculatus* in that it lacks the eharacteristic red spots at the base of the corolla lobes (eover photo). The subspecies also differ in the length of the style, which is much shorter than the stigma lobes in subsp. *maculatus*, but as long as or longer than the stigma lobes in subsp. *emaculatus*.

Distribution: *Linanthus maculatus* subsp. *emaculatus* is a narrow endemic found in Palm Canyon Wash and the drainage immediately to the south at the eastern base of the Jacumba Mountains in San Diego and Imperial Counties, California. Its elevation range is from approximately 335 to 580 meters (1100 to 1900 ft.).

The population in Palm Canyon Wash is found from the head of the drainage near Dos Cabezas Spring down to the elevation of 345 m (1130 ft.) near the old railroad tracks (Figure 1B). The census numbers in Palm Canyon Wash in 2013, ranged from a few localized plants to clusters of over 150 individuals. The southern population mainly occurs on the margins and base of the sand ramp that has formed on the northeastern facing side of a large boulder hill. In 2013 over 600 individuals were observed here in an area of approximately one acre. Smaller, scattered subpopulations have also been found on the north side of this boulder hill, to the southwest along the road, and at the base of a small dune system on the northwest side of the road.

This new subspecies represents a significant extension of the overall range of *Linanthus maculatus*. Previously, the species was known from a series of populations around the bases of the Little San Bernardino Mountains and eastern San Bernardino Mountains (Figure 1A).

Habitat: *Linanthus maculatus* subsp. *emaculatus* is found in the western Sonoran/ Colorado Desert within washes in an area best described as ocotillo woodland, although the majority of the ocotillos are on the benches above the washes (Figure 2A). Perennial species most directly associated with *Linanthus maculatus* subsp. *emaculatus* include *Acmispon haydonii* (Orc.) E. Greene, *Ambrosia dumosa* (A. Gray) Payne, *Ambrosia salsola* A. Gray, *Bebbia juncea* (Benth.) Greene, *Cylindropuntia wolfii* (L.D. Benson) M.A. Baker, *Ephedra nevadensis* S. Watson, *Lupinus excubitus* M.E. Jones var. *medius* (Jepson) Munz, *Petalonyx thurberi* A. Gray, *Psorothamnus schottii* (Torrey) Barneby, *Psorothamnus spinosus* (A. Gray) Barneby, and *Simmondsia chinensis* (Link) C. Schneider. Annual associates include *Brassica tournefortii* Gouan, *Chaenactis fremontii* A. Gray, *Chylismia*

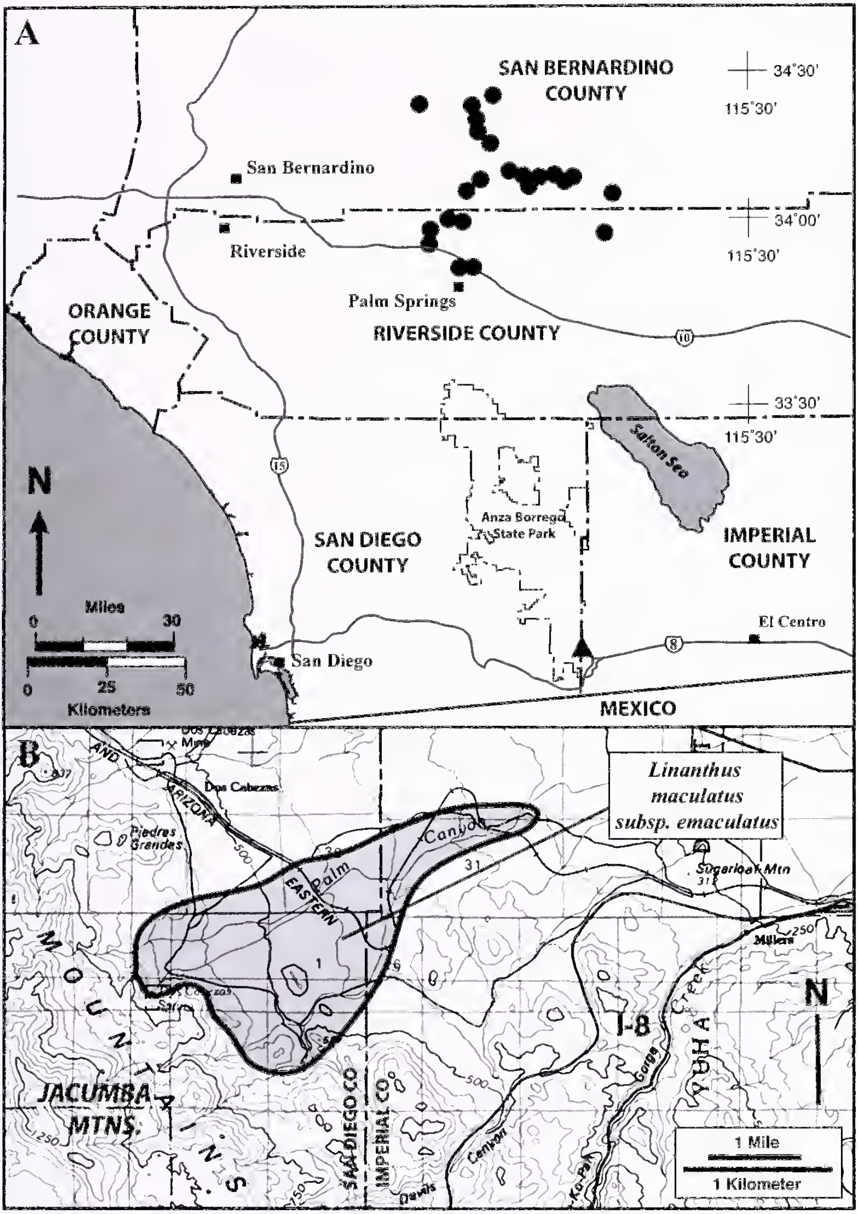

Figure 1A: Distribution of both *Linanthus maculatus* subsp. *maculatus* (indicated on map with circles), and *Linanthus maculatus* subsp. *emaculatus* (indicated by the single triangle in the lower section of map. **Figure 1B:** The entire known distribution of *Linanthus maculatus* subsp. *emaculatus*, known from just a few square miles in the upper portion of Palm Canyon Wash.

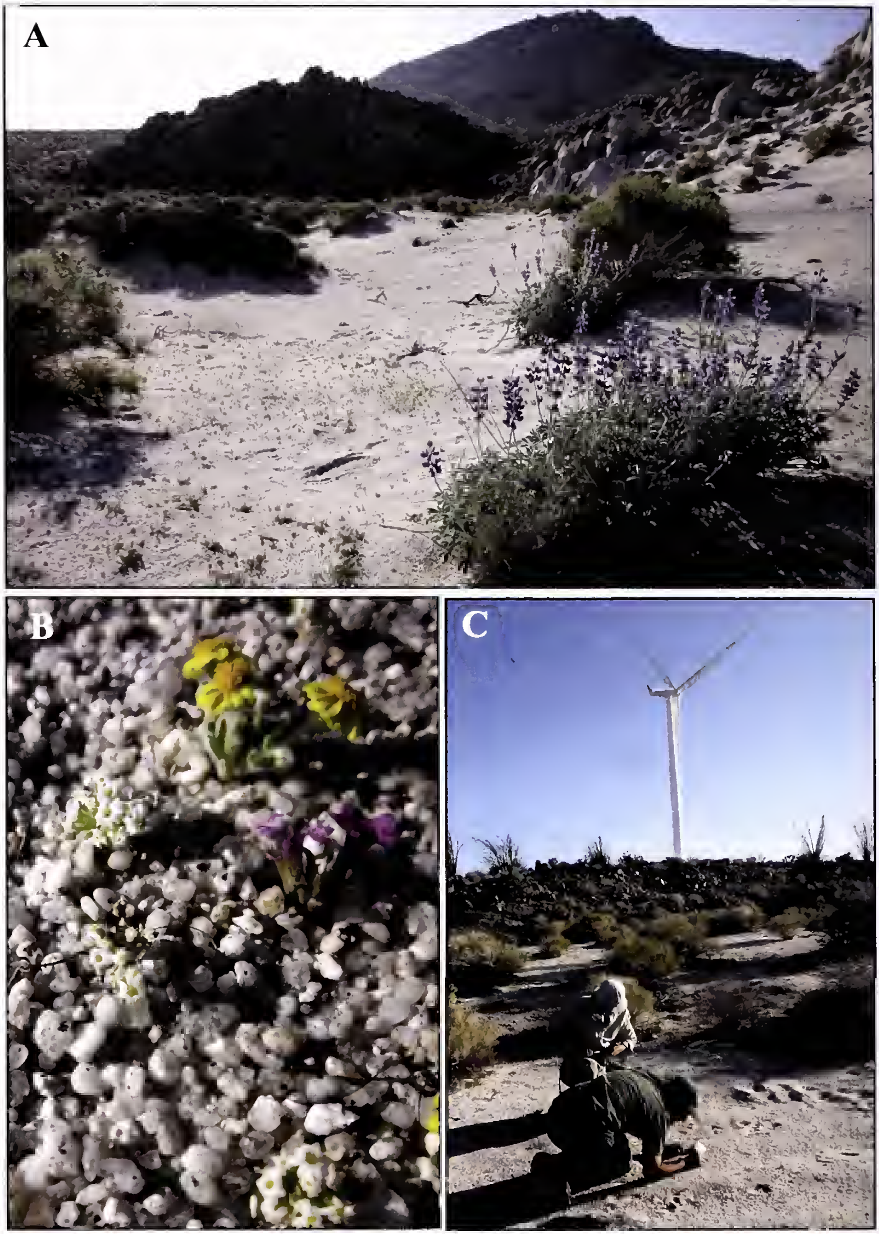

Figure 2A: Habitat of *Linanthus maculatus* subsp. *emaculatus*. **Figure 2B:** *Linanthus maculatus* subsp. *emaculatus* and typical associates, *Eriophyllum wallacei* and *Diplacus bigelovii*. **Figure 2C:** The author and Jane Tirrell collecting information and monitoring a population of *Linanthus maculatus* subsp. *emaculatus* at the Ocotillo Wind Energy Facility.

claviformis (Torrey & Fremont) Raven, *Cryptantha micrantha* (Torrey) I.M. Johnston, *Diplacus bigelovii* A. Gray, *Eriogonum thomasii* Torrey, *Eriophyllum wallacei* A. Gray, *Erodium cicutarium* (L.) L'H-r. *Eschscholzia minutiflora* S. Watson, *Malacothrix glabrata* A. Gray, *Phacelia crenulata* Torrey, *Phacelia distans* Benth., and *Schismus barbatus* (L.) Thell. (Figure 1B).

Linanthus maculatus subsp. *emaculatus* occurs mainly on a specific soil consisting of opaque, quartz- or plagioclase-like decomposed granite between the texture of sand and gravel. It is found in open flat sections of wash bottoms, in small drainages within these washes, on the margin of sand dunes, and occasionally on fine gravelly slopes. This differs significantly from *Linanthus maculatus* subsp. *maculatus,* which generally occurs in open, flat drainage systems.

Collection History: The first collection of *Linanthus maculatus* subsp. *emaculatus,* from Palm Canyon Wash, was made by Larry Hendrickson in April of 2010 and identified as *Linanthus maculatus* (*Hendrickson 4927* [SD], California Consortium of Herbaria, 2013). Curious about this range extension of nearly 100 miles, Bell visited this population in March of 2012 and found Hendrickson's population as well as the second, previously undocumented population to the east. None of the individuals within these populations had the spots at the base of their corolla lobes characteristic of *L. maculatus*, and it was therefore determined that these populations possibly represented an undescribed subspecies. This information was passed to Porter, who then visited these populations and verified that this was a subspecies distinct from the San Bernardino and Riverside County populations.

Within months of determining that the Imperial County populations of *Linanthus maculatus* were a distinct subspecies, construction began on the Ocotillo Wind Energy Facility (OWEF) in the immediate vicinity of the newly-recognized subspecies. On return to the location in November of 2012, Bell found that bulldozers had missed the easternmost population of *Linanthus maculatus* subsp. *emaculatus* by only 20 meters. This raised serious concern that these two small populations, which were the only ones known at the time, were in immediate danger of extirpation.

In March of 2013 nearby regions of Anza-Borrego Desert State Park (ABDSP) in San Diego County were surveyed for additional populations of *Linanthus maculatus* subsp. *emaculatus*. During this survey, additional larger populations were discovered near the head of Palm Canyon Wash and in the drainage to the south of Palm Canyon Wash (*D.S. Bell 4589* [RSA]; *D.S. Bell 4590* [RSA]; *D.S. Bell 4591* [RSA]).

Management & Conservation Threats/Needs: *Linanthus maculatus* subsp. *emaculatus* is found in Imperial County on Bureau of Land Management (BLM) land and in San Diego County on land managed by ABDSP. The populations in ABDSP are larger than the populations on the adjacent BLM lands but are localized in a few narrow areas highly susceptible to OHV activity. During fieldwork in March of 2013, we noted evidence of recent OHV activity in the drainage from Dos Cabezas Spring, and at least one vehicle was observed driving in the southern wash, which is clearly not an open route. Although the northern section of Palm Canyon Wash from the railroad tracks to Mortero Palms is not shown on park maps as an open OHV route, it is heavily used as such. This drainage was surveyed for *Linanthus maculatus* subsp. *emaculatus* in spring of 2013, but no plants were found. Although the section of this drainage surveyed seemed too rocky/gravelly for *L. maculatus* subsp. *emaculatus,* there were other sections of the drainage with potential habitat, and further surveys could lead to discoveries of new occurrences.

The habitat in ABDSP at the base of the sand ramp where the largest population was found was in excellent condition in March of 2013. However, this area is extremely vulnerable to OHV use, as it is very close to both the ABDSP road and the border of the park and is therefore an easily-aceessible area for OHV users seeking sand dunes. A heavily-impacted sand dune area less than a mile to the northeast on the ABDSP border appears to be suitable habitat for *L. maculatus* subsp. *emaculatus,* but no plants have been observed there to date. The smaller subpopulation, growing beside the ABDSP to the west of the sand ramp locality, is vulnerable to OHV use, camping, and other forms of roadside recreation.

Non-native plant species were present at the ABDSP *Linanthus maculatus* subsp. *emaculatus* localities but not in large numbers. Non-native plants noted included *Brassica tournefortii*. *Erodium cicutarium*, and *Schismus barbatus.* If population densities of *Brassica tournefortii* were to increase, this could pose another major threat for *Linanthus maculatus* subsp. *emaculatus,* as it could be crowded out by this invasive non-native species (Bangle, et al 2008).

The two populations of *Linanthus maculatus* subsp. *emaculatus* in Imperial County are small and highly localized. The western population in Imperial County occurs on the southern margin of Palm Canyon Wash near where the train tracks cross the wash. While very near the OWEF, this population is not actually located within the wind farm (Fig. 2C). OHV traffic and non-native weeds are currently the most significant threats to this population, but expansion of the OWEF would present the most substantial threat.

The easternmost population of *Linanthus maculatus* subsp. *emaculatus* in Imperial County, also located in Palm Canyon Wash, is currently the most threatened population. Until 2012 this population was relatively safe, as it was away from any large, open travel route. But in the summer of 2012, the OWEF project was granted permission to break ground, and a large access route was quickly bulldozed across Palm Canyon Wash, missing this population by approximately 20 meters. A substantial amount of suitable habitat was lost due to this bulldozing, but the known population was not damaged. The greatest threats to this small, localized population are impacts from OWEF maintenance vehicles and OHVs. With the increased traffic due to the development of the OWEF, the potential increase of non-native plant species, particularly *Brassica tournefortii,* from tires and undercarriages of vehicles is a new threat to this population. Trash dumping has not yet been observed in this area, but this is a new potential threat common along well-maintained roads. Fire can also be a potential threat, as wind turbines can throw sparks, leak hot oil, and occasionally explode, causing fires, as was seen in January of 2015 when one of the wind turbines at the Ocotillo Wind Farm exploded into flames (Hales, 2015). The introduction of non-native species will also increase the fuel load for these potential fires (Keeley 2011).

Recommendations: Based on criteria used by NatureServe (2016) and CNPS (2016) to establish conservation status ranks, it is recommended that *Linanthus maculatus* subsp. *emaculatus* be considered for the global rank of G2: imperiled "at high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors," and a CNPS California Rare Plant Rank of 1B.1: seriously threatened in California with over 80% of occurrences threatened. It is also suggested that land managers of both BLM and ABDSP revisit these populations/occurrences annually during appropriate flowering times (March-April) to evaluate these populations. These annual evaluations should include population estimates, GPS coordinates, current threats, and any other relevant information that will add to and assist in the proper management of this unique subspecies.

Acknowledgements: A big thank you to the Southern California Botanists Alan Romspert Grant in Desert Botany for helping to fund the study of this species. Anza-Borrego Desert State Park was very kind to allow us permission to make vouchers of *Linanthus maculatus* subsp. *emaculatus,* which are housed at the RSA/POM Herbarium at the Rancho Santa Ana Botanic Garden in Claremont, California. Thank you to the Rancho Santa Ana Botanic Garden and the California Native Plant Society for continued support.

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The Impact of Invasive Forbs on Fine Fuel Loads in Degraded Coastal Sage Scrub

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ABSTRACT: Plant invasions can affect native ecosystems by changing fuel properties such as fine fuel accumulation. Invasive forb impacts on fine fuels are relatively overlooked compared to the impact of grasses, so our study sought to investigate the impact of invasive forbs on fine fuels in a degraded coastal sage scrub (CSS) plant community. Our study site was located in the San Jose Hills on the campus of California State Polytechnic University, Pomona. Species measured included the native species *Acmispon glaber, Artemisia californica, Eriogonum fasciculatum, Salvia apiana*, and *Salvia mellifera,* and the invasive species *Centaurea melitensis* and *Hirschfeldia incana.* We measured the functional traits of leaf size (LS), specific leaf mass (SLM), leaf dry matter content (LDMC), and twig dry matter content (TDMC). We also measured biomass of leaf litter of native shrubs and the standing dead biomass of invasive forbs to determine their effects on fine fuel accumulation. We estimated the percent cover of species throughout the study area to understand how the abundance of each species contributes to fine fuels at the community scale. All native species possessed large values of SLM except *A. californica*, which was more similar to the values found in the invasive forbs. All native species had relatively large values of LDMC and TDMC, suggesting high flammability. *H. incana* and *S. apiana* had the largest leaf sizes, and *Salvia apiana* had the highest biomass of leaf litter of the native shrubs. There was a significant relationship between the percent cover of each species and its contribution to fine fuels throughout the community. In addition, our data showed that *C. melitensis* contributed more to fine fuel accumulation than *H. incana* in our study site. We found that non-native forb invasion has the potential to significantly increase fine fuel accumulation in degraded CSS.

KEYWORDS: Coastal sage scrub; fine fuels; plant functional traits; invasive forbs; fire regime; *Hirschfeldia incana*; *Centaurea melitensis*.

INTRODUCTION

One way plant invasions affect native ecosystems is by changing fuel properties, which in turn affect fire behavior and fire regimes. The effects of invasive plant species on fire regimes are particularly dramatic when they alter disturbance regimes beyond the range of variation to which native species are adapted, resulting in community changes and ecosystem-level transformations (Brooks et al. 2004). The effect of invasive grasses in altering fire regimes has been well-studied in a number of ecosystems (D'Antonio and Vitousek 1992); however, some ecosystems are invaded by forb species, whose effect on fire regimes is not as well-known.

When grasses and annual forbs invade woody communities they increase the amount of fine fuels available to burn. Fine fuel, the dead standing biomass and/or fallen leaf litter left after the growing season, easily ignites and carries fire (Keeley et al. 2012). The accumulation of fine fuels ultimately alters fire regime characteristics such as the frequency, intensity, extent, type, and seasonality of fire (Brooks et al. 2004). Two factors that influence fine fuel accumulation in a plant community are 1) the abundance of plant species, and 2) the attributes of each species that contribute to flammability and fuel accumulation (i.e., plant functional traits, Cornelissen et al. 2003). Measuring plant functional traits of native and invasive species provides a way to quantify their relative contributions to fuel accumulation in a community.

Studies of plant functional traits are useful for cross-species comparisons of life-history strategies, trade-offs, and responses to eeosystem processes (e.g. nutrient cycling) (Lavorel and Garnier 2002; Westoby et al. 2002; Cornelissen et al. 2003; McGill et al. 2006; Westoby and Wright 2006). In addition, plant functional traits can indicate the effect of a species on ecosystem processes such as fire disturbance (Lavorel and Garnier 2002). Funetional traits that affect fuel accumulation and flammability include leaf and twig dry matter content (LDMC and TDMC), leaf size (LS), and fine litter accumulation (Diaz and Cabido 2001; Lavorel and Garnier 2002; Cornelissen et al. 2003). LDMC and TDMC measure the density of plant tissue and are positively correlated with flammability (Cornelissen et al. 2003). Leaf size (LS) is also related to flammability, as smaller leaves tend to dry out more quickly. Here, we compare traits associated with flammability and fuel aecumulation among native and invasive species in a coastal sage scrub (CSS) ecosystem.

CSS is a model ecosystem for studying the effects of invasive species on fire regimes. The CSS plant community is adapted to a fire regime consisting of crown fires with a fire return interval of about 40 years (Keeley et al. 2005; Talluto and Suding 2008). The plant community of CSS is characterized by summer deeiduous shrubs, scattered low trees, and fire-following forbs. Species of this plant community, such as *Artemisia californica* and *Eriogonum fasciculatum*, possess specific traits and strategies that have allowed them to adapt to the dry edaphic conditions and alluvial fans and slopes of California (Gray and Schlesinger 1981; O'Leary and Westman 1988). Over the past 50 years, CSS has experienced major declines due to general development, habitat loss, and fire (Allen et al. 2000; Talluto and Suding 2008). Less than 10% of CSS remains, in part because anthropogenic changes to its fire regime have resulted in shorter fire return intervals, increased levels of invasion, and further degradation (e.g., Bozzolo and Lipson 2013; Brooks et al. 2004, Keeley and Brennan 2012).

In this study, we examine the effect of the invasive forbs *Centaurea melitensis* and *Hirschfeldia incana* on fine fuel accumulation in degraded CSS. We hypothesize that due to their rapid growth rates and annual life-history strategies, both of these species contribute significantly to fine fuels, perhaps even exceeding that of the native shrubs. We measured functional traits associated with flammability in order to determine the impacts of invasive forbs on fire regimes. To determine the fine fuel accumulation of species, we measured the biomass of leaf litter of five native shrubs and the dead standing biomass of the invasive forbs *C. melitensis* and *H. incana*. We also measured the abundance of the dominant species in the community in order to test whether the most abundant species necessarily contributed the most to fine fuel accumulation.

METHODS

Study Site

The Voorhis Ecological Reserve (VER) is located on the campus of the California State Polytechnic University in Pomona, California (34° 3' 32.76"N, 117° 49' 44.75" W). It contains 31 ha of coastal sage scrub, woodlands, and invasive grasslands. Due to its location in the San Jose Hills, it has been identified as an important ecological area connecting the San Gabriel Mountains and the Chino Hills to the Santa Ana Mountains. Our study area was a south-facing slope composed of a degraded CSS plant community.

Study Species

The five most abundant native woody shrubs were studied: *Acmispon glaber* (Vogel) Brouillet, *Artemisia californica* Less., *Eriogonum fasciculatum* Benth., *Salvia apiana* Jeps., and *Salvia mellifera* Greene. Invasive species studied included the annual forbs *Centaurea melitensis* L. and *Hirschfeldia incana* (L.) Lagr.-Fossat., both of which are native to the Mediterranean Basin and commonly found in disturbed habitats (Moroney and Rundel 2012).We chose to focus on these species because they were abundant on the study site. Other species found in the study site included the native succulent *Opuntia littoralis* (Engelm.) Cockerell, the native annual forb *Deinandra fasciculata* (D. C.) Greene, and the non-native annual grasses *Avena fatua* L., *Bromus diandrus* Roth, *Bromus hordeaceus* L., and *Bromus madritensis* L.

Functional Trait Measurements

Traits were measured from 24 *A. glaber*, 21 *S. mellifera*, 20 *E. fasciculatum*, 20 *A. californica*, and 9 *S. apiana*. Fewer *S. apiana* were measured due to its lower abundance at this site. Fourteen plots in the study area were flagged, and these plots were used to sample invasive species. Three forbs were sampled per plot for a total of 42 *H. incana* and 42 *C. melitensis*. All individuals sampled were in full sunlight, mature, and lacked any obvious damage from herbivores or disease. Methodology for measuring leaf size, specific leaf mass, leaf dry matter content, and twig dry matter content followed Cornelissen et al. (2003). Replicates of three leaves per trait of each individual were measured.

The specific leaf mass (SLM) is the oven dry mass divided by the one-sided area of the leaf. The SLM of *S. mellifera*, *S. apiana*, *E. fasciculatum*, *A. glaber*, and *H. incana* was measured on the 24 and 31 of May 2012. The SLM of *C. melitensis* was measured on 15 May 2015. Leaf size was measured with a CI-203 leaf area meter (CID, Camas, WA). The leaves of *A. californica* were too small to be registered by the leaf area meter; therefore, pictures of leaves were taken using a Panasonic Lumix DMC-TS30 digital camera. The surface area of the leaf was estimated using Image J software (Schneider et al. 2012). *A. californica* leaves were collected and measured on 10 and 26 June 2015. Leaves of all species were dried in an oven at 60°C for at least 72 h and weighed immediately after removal from the oven.

The leaf dry matter content (LDMC) is the oven-dry mass of a leaf divided by its water-saturated fresh mass. Samples of *S. mellifera, S. apiana, E. fasciculatum, and A. californica* were collected and processed on 24 and 31 May 2012. *Acmispon glaber* was measured on 13 May 2015. Leaves were collected in the field and re-hydrated by placing the cut-end of the stem in deionized water and storing the stem in the dark for eight to 16 hours. The leaves were then cut from the stem, blotted dry, and the mass was measured immediately. Each leaf was then dried in an oven at 60°C for at least 72 hours, and the mass was immediately measured once removed from the oven.

Twig dry matter content (TDMC) is the oven-dry mass of a terminal woody twig divided by its water-saturated fresh mass. Field sampling and re-hydration procedures were the same as the SLM procedure, and were conducted on 27 July and 2 August 2012. Following re-hydration, leaves were removed from the twig and blotted dry. The water-saturated fresh mass of the twig was then measured. Samples were then dried in an oven at 40°C. Every 24 hours throughout the drying process, the mass of the samples were measured, and the oven dry mass was recorded when equilibrium was reached. We only measured TDMC of woody native shrubs for our study and did not measure TDMC for herbaceous annuals because they lack woody structures.

To estimate the individual fine fuel load contributions per plant, two methods were employed. For perennial shrubs, fallen litter was measured using a 10 x 10 cm^2 quadrat placed under the shrub canopy in an effort to ensure that only litter from the shrub was included. For annuals, three whole, completely dead individuals were collected from each plot, and the three measurements were averaged per plot. Sampling was conducted on 12 October and 3 November 2012. Samples were brought to the lab and dried in the oven at 60°C for 24 to 36 hours. The mass was measured immediately after samples were removed from the oven.

Species Abundance Sampling and Fine Fuels

We used quadrat sampling to estimate the abundance of all species across the majority of the VER. One 6.2 ha canyon was excluded because of an abundance of *Toxicodendron diversilobum* and topography that is too steep to navigate safely. Sampling occurred on 4 May, 10 May, and 22 June 2013. Seventy-two randomly generated points were created in the VER using ArcMap 10.3 (ESRI, Redlands, CA). The coordinates were uploaded to Garmin GPS units and located in the field. Once the coordinates were located, a 1 x 1 m quadrat was laid down in a northwestern orientation. The number of individuals in the plot was counted for the following species: *C. melitensis, H. incana, A. glaber, A. californica, E. fasciculatum, S. apiana,* and *S. mellifera*. Percent cover was estimated visually for all species present in the quadrat. Any species not identifiable in the field was collected and identified later in the lab. In order to estimate the total area covered by each species in the landscape, the average percent cover (PC) in one square meter for each species was calculated and was then multiplied by 233,666.5 m^2, which is the total area of the VER that we sampled. In order to estimate the total fine fuel (FF) contributions of the shrub species throughout the VER, the fallen litter (FL) data were converted to kg per square meter and were then multiplied by the estimate of total abundance to obtain an estimate of fine fuels in kilograms for each species (Equation 1).

Equation 1: $FF\ (kg) = FL\ kg/m^2 \times PC\ x233.666.5\ m^2$

For the forbs, the average number of individuals per square meter was calculated from the quadrat data, and this number was multiplied by the average grams per individual. This value was then multiplied by the total area of the landscape in order to obtain an estimate of the fine fuels of these species across the sampled area of the VER.

Statistical Analysis

We used Kruskall-Wallis Ranked Analysis of Variance (ANOVA) tests in order to test for differences in functional traits and fine fuels among the species. This test was used because our data violated the normality assumption of ANOVA. Leaf size did not violate ANOVA assumptions, so a one-Factor ANOVA was used instead. Pairwise multiple comparison procedures, Dunn's Method, or Tukey's Test were used to determine differences among the species. A simple linear regression was used to determine if there was a relationship between percent cover and fine fuel biomass.

RESULTS

Plant Functional Traits

Hirschfeldia incana had the largest leaf size while *Acmispon glaber* had the smallest leaves ($F = 86.381$, $df = 6$, $P < 0.001$). *Eriogonum fasciculatum*, *A. glaber*, *S. apiana*, and *S. mellifera* had a greater SLM than *H. incana*, *C. melitensis* and *A. californica* ($H = 111.845$, $df = 6$, $p < 0.001$; Table 1). *Eriogonum fasciculatum* and *S. apiana* had the greatest LDMC of the five species measured ($H = 31.639$, $df = 4$, $p < 0.0001$; Table 1). *Eriogonum fasciculatum* and *A. californica* had the greatest TDMC, whereas *S. apiana* had the lowest ($H = 31.449$, $df = 4$, $p < 0.001$; Table 1). *Salvia apiana* had the greatest fallen leaf litter of the shrubs examined

Species	Leaf Size (mm/mm^2)	SLM (mg/mm^2)	LDMC (mg/g)	TDMC (mg/g)	Fallen Litter (g/m^2)	Individual Biomass (g)
Eriogonum fasciculatum	69.93 ± 6.95^{CD} (56)	0.377 ± 0.055 (19)^{A}	459.96 ± 14.347 (21)^{A}	591.03 ± 7.97 (33)^{A}	314.21 ± 45.87 (19)^{B}	
Artemisia californica	46.88 ± 3.04^{CD} (10)	0.0762 ± 0.00236 (10)^{C}	354.1 ± 44.96 (9)^{B}	577.82 ± 10.24 (34)^{A}	308.7 ± 35.25 (18)^{B}	N/A
Acmispon glaber	10.85 ± 0.89^{D} (62)	0.322 ± 0.0311 (22)^{AB}	306.55 ± 6.6 (18)^{B}	520.34 ± 34.26 (27)^{B}	241.15 ± 40.12 (20)^{B}	N/A
Salvia mellifera	251.67 ± 18.04 (58)^{C}	0.184 ± 0.0092 (20)^{AB}	357.11 ± 13.73 (24)^{B}	474.36 ± 8.86 (30)^{B}	464.61 ± 57.89 (18)^{AB}	N/A
Salvia apiana	763.96 ± 63.16 (24)^{B}	0.214 ± 0.0107 (8)^{AB}	418.04 ± 14.495 (24)^{AB}	411.36 ± 9.26 (27)^{C}	774.88 ± 155.2 (8)^{A}	N/A
Hirschfeldia incana	1,477.97 ± 153.58 (35)^{A}	0.08571 ± 0.00386 (35)^{C}	X	N/A	N/A	1.60 ± 0.22 (42)
Centaurea melitensis	193.08 ± 12.66 (25)^{CD}	0.0879 ± 0.00294 (25)^{C}	X	N/A	N/A	1.91 ± 0.30 (42)

Table 1: Functional trait means and standard errors of species sampled. The numbers in parentheses denote the sample size and "N/A" represents traits not applicable in that species. An "X" indicates traits that were not measured. Letters represent significant differences among species from the results of Dunn's Tests ($p < 0.05$), except for leaf size, where a Tukey Test was used.

(H = 21.351, df = 4, p < 0.001; Table 1). Individual biomass did not significantly differ between *C. melitensis* and *H. incana* (U = 89, n = 14, p = 0.696; Table 1).

Percent Cover, Abundance, and Total Fine Fuels

The top ten most abundant species were *A. californica, E. fasciculatum, H. incana, Sambucus nigra ssp. caerulea, C. melitensis, Bromus madritensis, S. mellifera, Bromus diandrus, Quercus agrifolia, and Brassica nigra* (Fig. 1). The average number of *C. melitensis* and *H. incana* individuals per square meter were 14.95 and 10.85, respectively. *Artemisia californica* had the largest estimate of fine fuel biomass in the VER (8822.56 kg), whereas *S. apiana* had the lowest estimate (120.71 kg; Fig. 2). The relationship between percent cover and fine fuel biomass in the VER was found to be significant (R^2 = 0.842, F = 26.743, p = 0.004). However, *C. melitensis* falls outside the 95% confidenee interval, suggesting that it may have contributed more to the fine fuel load than expected based on its abundance alone (Fig. 3).

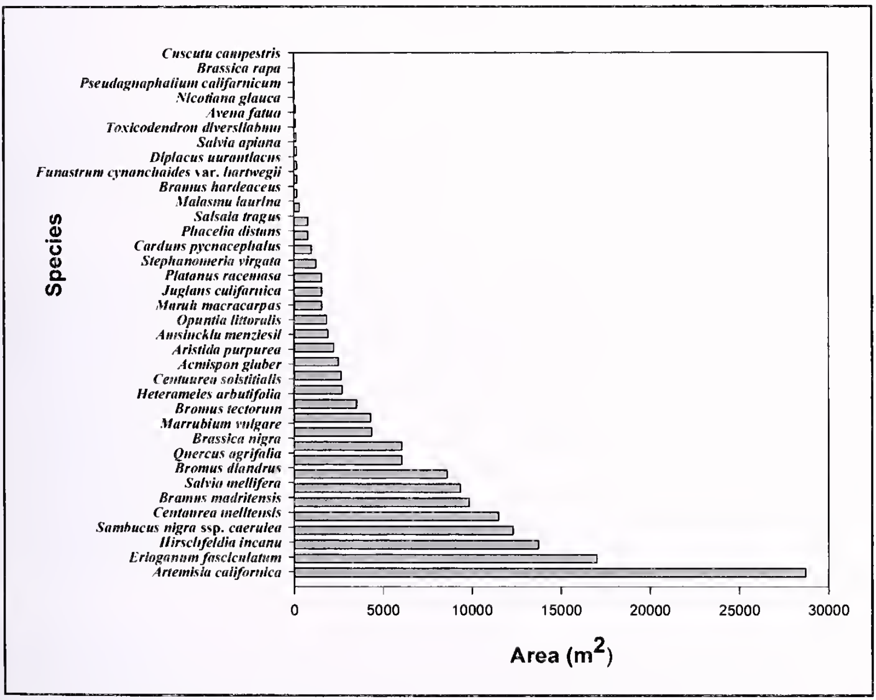

Figure 1: Estimated cover of plant species found in the study area.

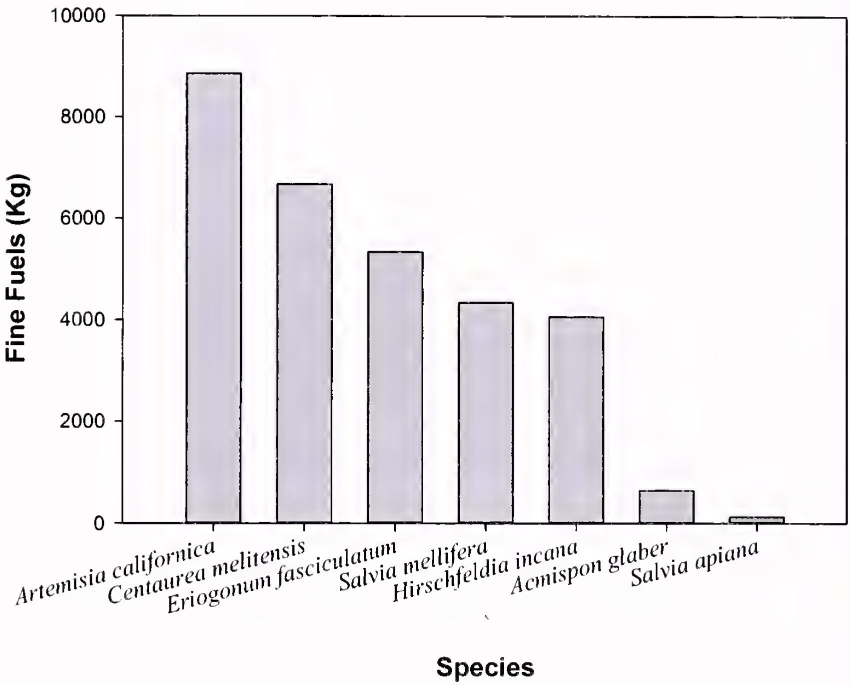

Figure 2: Estimated fine fuels (kg) contributed by species throughout the study area.

DISCUSSION

The VER, located in the center of urban southern California, has an abundance of invasive species. Previous studies suggested that invasive grass species lead to increased fuel loads, resulting in increased fire intensity (Smith and Tunison 1992; D'Antonio et al. 2000; Rossiter et al. 2003). These alterations to the fire regime in CSS can lead to a type-conversion from a shrubby CSS habitat to a more open, invasive-dominated prairie with shorter fire return intervals (Keeley and Brennan, 2012). This type-conversion process may be occurring in the VER, as five of the ten most abundant species are invasive annuals (Fig. 1). While many of these invasive annuals are grasses, there is also an abundance of forbs. Invasive forbs have become successful invaders that increase the amount of fine fuels available, amplifying the flammability of shrublands.

All the native species examined exhibited traits associated with high flammability. The LDMC and TDMC of the shrub species were very large, which indicates that these species dry out relatively quickly and can ignite easily. Leaf size is associated with flammability because smaller leaves dry out more quickly (Cornilessen et al. 2003). Leaf size varied greatly among the species. *Eriogonum fasculatum, A. californica, A. glaber*, and *C. melitensis* all had small leaf sizes, suggesting that they contribute the most to flammability in the community. *Hirschfeldia incana* had the largest leaf size; however, its leaves do not persist as long as leaves of the native shrubs, which may also contribute to flammability.

The abundance of the species examined is an important factor in determining their fine fuel contributions to the plant eommunity. More abundant species, such as *A. californica*, contribute much more to the fuel load than *S. apiana*, yet *C. melitensis* contributed a large input despite its lower abundance (Figs. 2 and 3). Therefore, the impact of plant species on the fire regime in an ecosystem must consider the individual effect of each species in conjunction with the abundance of that species (Parker et al. 1999).

The observed pattern of fine fuel accumulation of *C. melitensis* may be explained by its growth form. This species consists of a single stem that is distally branched. In contrast, *H. incana* forms multiple branching stems and can appear bushy. This bushier growth habit limits the number of individuals that can grow within

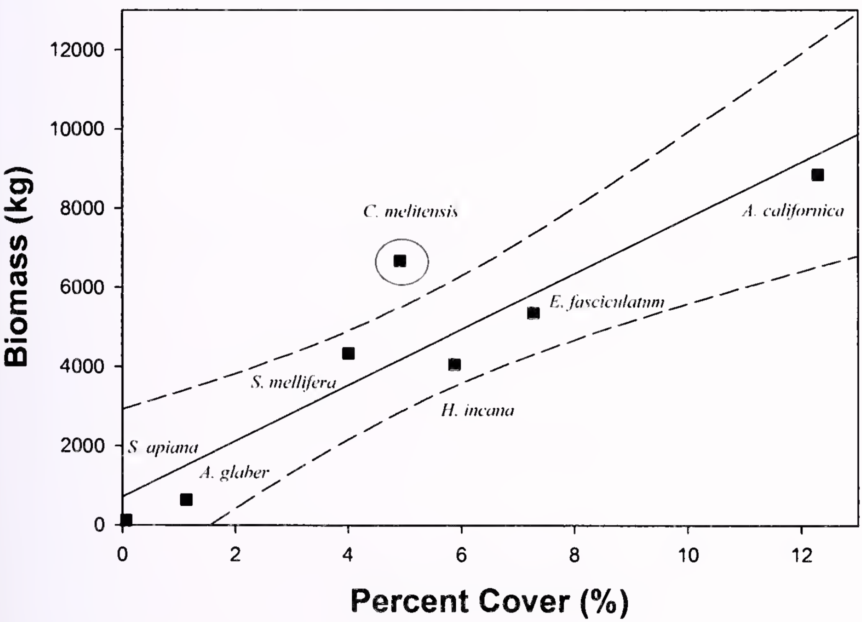

Figure 3: Relationship between fine fuel biomass (kg) and average percent cover of native shrubs and invasive forbs, including upper and lower 95% confidence intervals. *C. melitensis* (circled) exhibited relatively high fine fuels despite its lower percent cover. This result suggests that it contributes more to fine fuels than would be expected based on its abundance in the community.

a defined area. Therefore, while there was no significant difference in standing biomass between these two species, more individuals of *C. melitensis* can be packed into a given area, leading to greater fine fuel accumulation in spite of its lower percent cover.

The invasive forbs contributed 35% of the total fine fuels in the VER (Fig. 2). *Centaurea melitensis* and *H. incana* covered more area than the invasive grass species (*Bromus* sp; Fig. 1). *C. melitensis* had the second highest contribution of fine fuels after *A. californica* (Fig. 2). The significant contribution of two invasive forbs to fuel accumulation implies that invasive forbs can have a significant effect on CSS fire regimes. This fine fuel accumulation would be significantly lower in pristine stands of coastal sage scrub where grasses and forbs are low in abundance. Similar to the grass-fire cycle, the contribution of forbs to fine fuel accumulation suggests that there is a potential for a forb-fire cycle to be present (D'Antonio and Vitousek 1992).

Invasive annual grasses are certainly the leading causes of fine fuel additions in CSS due to their growth habit and phenology. However, while forbs have not been studied as extensively as grasses, they may constitute an important phase of type conversion because of their eontributions to fine fuel accumulation (Coleman and Levine 2007). Our study also suggests that by themselves, invasive forbs may lead to a forb-fire cycle. The effects of increased invasive forb abundance on fire regimes should be the focus of additional fire ecology research in coastal sage scrub.

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SOUTHERN CALIFORNIA BOTANISTS
ALFRED J. McCLATCHIE (1861-1906)

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ALFRED JAMES MCCLATCHIE.

ABSTRACT: Biographical, botanical, and bibliographical information is presented for Alfred J. McClatchie. He was interested in all forms of life, from bacteria and algae to ferns, flowering plants and even fresh water shrimp.

McClatchie was one of the first resident southern California botanists to publish descriptions of new species.

KEYWORDS: McClatchie, southern California, Throop, *Ribes, Galium, Eucalyptus*

In an introductory note for a 1998 reprinting of an Anstruther Davidson article, Tim Ross wrote "...Davidson, along with Dr. H.E. Hasse of Soldier's Home, Santa Monica, and Alfred J. McClatehie of Pasadena, were apparently Los Angeles County's first resident botanists to begin describing their own botanical novelties." He further states "Apparently specifics of [McClatchie's] birth and death are unverified...." These words led the present authors to locate Anna Davidson's six-page obituary of McClatehie, "A Real Teacher," which was published in Charles Lummis' journal, *Out West*, in 1906. (Davidson 1906), and to further comb available records to fill in the few details of McClatchie's life not covered in that article.

In a questionnaire he filled out for Lummis, Alfred James McClatchie stated that he was born in Quebec on May 25, 1861. His parents, George C. and Margaret (Lunan) McClatchie appear in the 1861 Canadian census on a farm south of the village of Herdman on the border with New York state. Alfred was the first of nine children. In 1863 the family moved to Michigan, where George McClatchie spent the first year selling sewing machines in Grand Rapids. The next year was spent on a rented farm near Pentwater. Finally in December 1865, the family settled south of Ludington in Mason County, on 80 acres, half of which they eventually converted to peach orchards. George also taught school during winter terms and served as county clerk, township treasurer, "and most other county offices."

Alfred also taught school and served a year as justice of the peace before going off to Olivet College in Olivet, Michigan, where he was a student from 1883 through 1888. After teaching in the Olivet public schools for a year, he went on to study botany at the University of Nebraska under Charles E. Bessey. He received his Bachelor's degree in 1890 and later was later awarded an honorary Master's degree from Olivet. He spent the next summer surveying for the Burlington and Missouri River Railroad and then moved to southern California, possibly due to respiratory problems.

Alfred spent his first winter at Whittier, where he found work as an engineer for a development company. He taught sehool in Santa Monica in the summer of 1891 and then in Elsinore in Riverside County. McClatchie was married in Compton on September 9, 1891 to Anna Dorothy Morrison, a graduate of the State Normal School in Los Angeles.

In 1892, McClatchie joined the faculty of the Throop University in Pasadena, renamed the Throop Polytechnic Institute in 1893, where his students included his wife and two sisters-in-law. Until 1920, Throop was a vocational school that included a grammar school, high school, and college. His title was Instructor of Botany and Zoology, but he also taught physics and chemistry during the school's first year. His *Guide in the Study of Plants, For Beginners* demonstrated McClatchie's teaching method, which stressed microscopic examination, beginning with blue-green algae and then working through more and more complex life forms (McClatchie 1893). MeClatchie's interests were wide-ranging, including bacteria, algae, rusts, mildew, mosses, ferns, and plants (Davidson 1906). He even discovered a new species of small freshwater shrimp, *Caridina pasadenae,* in the streams around Pasadena (Kingsley 1897).

McClatchie published the findings of his laboratory methods and field discoveries. In 1894, McClatchie's published *Notes on Germinating Myxomycetous Spores* in the Botanical Gazette (McClatchie 1894e). *Additions to the Flora of Los Angeles County and Catalina Island*, describing three new species of *Ribes* and two of *Galium*, appeared in two installments in Jepson's journal *Erythea* (McClatchie 1894a, 1894b, 1897). Of those species, *Ribes amarum* McClatchie and *R. montigenum* McClatchie are still recognized species, while his *R. hesperium* has been reduced to a variety as *R. californicum* var. *hesperium* (McClatchie) Jeps. *Galium grande* McClatchie is still recognized as a species while his *G. occidentale* is now considered a synonym of *G. californicum* subsp. *flaccidum* (Greene) Dempster & Stebbins.

He explained his teaching method in an article in Popular Science Monthly: "What this work ought to do for its students, then, is to train the powers of observation; to teach them to discover truth for themselves; to train them in expressing discovered truths in the form of drawings and in written and oral language; to train them in the power of getting thoughts from the writings of other investigators; to lead them to see the beauties and harmonies of nature, and incidentally to give them information in any occupation they may choose." (McClatchie 1895a).

In 1895, *Flora of Pasadena*, which also covered much of the San Gabriel Mountains and listed 1056 species of plants, fungi, slime molds, and liehens, was published as part of Hiram A. Reid's *History of Pasadena* (MeClatchie 1895b). This is one of the first local California floras published.

McClatchie indicated his interest in Botany and fungi and his affiliation with the Throop Polytechnic Institute in the *Naturalist's Directory* (Cassino 1895) and subsequently expanded his declared interests to include bacteria (Cassino 1896). The *Naturalist's Directories* were small books that listed the names, addresses, and interests of naturalists from around the world, providing the means for communication among naturalists.

By May 1896 McClatchie had left Throop, reportedly to aceept a professorship at Pomona College, although this did not come to pass. During this period he taught bacteriology at the summer sehool at Coronado near San Diego, gave public lectures on botany, mycology and bacteriology, and began testing of local water and milk supplies. This work led to publication of two works not yet located, published by the Southern California Academy of Sciences (SCAS 1939). These are *Milk: composition, nature, hygiene and economic methods of handling*, published in August 1897 and *Milk supply of Los Angeles*, published November 15, 1897.

McClatchie was listed as a member of the Southern California Academy of Sciences in May 1896, but indications are that he may have joined and contributed lectures several years earlier (SCAS 1896). Alfred McClatchie maintained his affiliation with the Southern California Academy of Sciences after leaving the Throop Polytechnic Institute until his death (Cassino 1898; Cassino 1905).

In Mareh of 1897, the Southern California Academy of Sciences published his *Seedless Plants of Southern California*, in which he attempted to list the known bacteria, fungi, lichens, algae, bryophytes, and ferns found from Point Conception to the Mexican Boundary and inland as far as the summits dividing the coast and drainages (McClatchie 1897). In it he described seven new species of fleshy fungi.

Early in 1898, McClatchie became professor of Agriculture and Horticulture at the University of Arizona's Experiment Station in Phoenix. About the same time, he became a collaborator in the U. S. Bureau of Forestry, culminating in his work *Eucalypts Cultivated in the United States* (McClatchie 1902). This was his longest work: 106 pages with 91 plates and a key to the forest tree species known to be cultivated in the United States at that time. *Eucalyptus* species were more extolled for their aesthetic and utilitarian purposes than any other forest trees planted on this continent (McClatchie 1902).

In poor health, McClatchie returned to southern California in June of 1904, buying a farm in Montebello. He sold his herbarium of more than 5,000 specimens to Stanford University for incorporation into the Dudley Herbarium. Expecting to recover, he made plans to continue his studies on *Eucalyptus*, but he continued to weaken. He died in Montebello on February 11, 1906, survived by his wife and a son.

There are currently 220 herbarium specimens collected by McClatchie, representing 191 taxa, listed in the Consortium of California Herbaria database

(CCH 2016). The collection dates span from 1890 to 1903. Over half of his specimens are at the University of California, Berkeley (UC), with most of the rest split evenly between the Dudley Herbarium (DS), now housed at the California Academy of Sciences (CAS), and the New York Botanical Garden (NY). Assessment of his collections from Elsinore in Riverside County indicates that he was there at least between April and June 1892. Many of his specimens collected between 1890 and 1893 were from the Pasadena area, made prior to publication of the Pasadena flora (McClatehie 1895). Apparently few of the 5,000 herbarium specimens McClatchie sold to Stanford have, as yet, been recorded in the CCH database through the California Academy of Sciences (CAS).

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NOTEWORTHY COLLECTION

Ramalina menziesii Tayl. non Tuck (RAMALINACEAE). Santa Barbara, California. On coast live oak, elderberry and ash, San Antonio Creek Trail, Tuckers Grove County Park, Santa Barbara, Santa Barbara County. Lat: 34.457279 N, Long: -119.779338 W. Altitude: 92.05 m. (302 ft.), March 20, 2015. Linda Tucker 17 (SBBG). This collection was a thallus about 10cm long and 1.5 cm wide, with the typical net-like holes, which was cut from its supporting branch by the collector. Larger thalli about 15 cm long with many netlike branches were collected along the same trail by Heather Liu (Heather Liu s.n.) in April 2015. Identifications made by Dr. Shirley Tucker.

Santa Barbara, Santa Barbara County: W.G. Farlow, Santa Barbara, 1884 or 1885, MIN (two collections lacking specific location and date); Chester C. Kingman s.n., Santa Ynez Mts., Los Banoas Canyon (sic), Sept. 7, 1910, Lichenes Boreali Americani, MIN. Note: Las Banoas Canyon probably meant "Las Canoas" (The Flumes), which carried water from Rattlesnake Canyon to Mission Creek above the Santa Barbara Mission; Helen Evangeline Greenwood s.n., on branches of live oak trees, Cliff Drive, Santa Barbara, Aug. 1911, Herbarium of the Sullivant Moss Society, MIN. These collections were borrowed from MIN and verified by Dr. Shirley Tucker. No additional collections have been made in or adjacent to Santa Barbara since 1911 until the present collections, which will be deposited at SBBG.

Previous knowledge: *Ramalina menziesii*, the "Laee Lichen" or "California Spanish Moss," is abundant in fog zones close to the coast throughout most of California. In Santa Barbara County it covers the oaks on the northern flanks of the Santa Ynez Range. However, it is unaccountably absent from the south-facing flanks of the range above Santa Barbara and has not been collected in the city since 1911. It has been sought in the parks and canyons within and near Santa Barbara without success. The closest locations to Santa Barbara for collections of this lichen in recent years are Refugio Pass about 20 miles WNW on the ridge of the Santa Ynez Range and on Santa Cruz Island and Santa Rosa Island, 20 miles or more off the coast. *Ramalina menziesii* was designated the official California state lichen in June 2015.

Significance: Finding the Lace Lichen again in Santa Barbara after an absence of over 100 years brings questions. Cities, even those lacking industry like Santa Barbara, are often called "lichen deserts," because the environment is inevitably drier due to building, street paving, and removal of native vegetation. Many lichen species, particularly large foliose and fruticose species, do not tolerate urbanization. It is not surprising that the Lace Lichen would be intolerant of city conditions. However it is odd that it has not survived in the many areas of the city where native vegetation persists. The thalli at Tuckers Grove were large enough that they were certainly several years old. Some were attached to the substrate branches, not merely blown in. So the present habitat at Tuckers Grove is favorable for growth of this lichen. Yet this species is absent in other habitats favoring lichens in Santa Barbara, such as the Santa Barbara Botanical Garden, where a May 2007 "Bioblitz" survey found 172 species of lichens including three other *Ramalina* species commonly associated with *R. menziesii* (S. Tucker, Bulletin of the California Lichen Society 17 [1, 2]: 1-8, 2010).

- Shirley Tucker, Lichens collection curator, Cheadle Center for Biodiversity and Ecological Restoration, University of California, Santa Barbara, CA 93106, tucker@lifesci.ucsb.edu.

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