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CONTENTS

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UNDERSTORY VEGETATION OF A SOUTHERN CALIFORNIA BLACK WALNUT (*Juglans californica*) WOODLAND

VICTORIA L. TENBRINK, RONALD D. QUINN, and GARY C. CARLTON
Department of Biological Sciences
California State Polytechnic University, Pomona, CA 91768

ABSTRACT: Understory plants in a stand of native southern California black walnut, *Juglans californica*, were sampled on a north-facing slope at Cal Poly, Pomona. Of a total of eight species of grasses and herbs, all but one are naturalized annuals from Europe that are common to disturbed sites. The single, native understory species, *Asclepias fascicularis*, is a perennial, also common to disturbed sites. Species richness and variation among plots was low, with *Bromus diandrus* the dominant species in terms of cover. Neither shade from overstory trees nor position on the slope explained variation among sample plots.

KEYWORDS: black walnut, Juglandaceae, *Juglans californica*, understory, Pomona, southern California black walnut, walnut, woodland

INTRODUCTION

The southern California black walnut, *Juglans californica* S. Watson var. *californica* (Juglandaceae) is endemic to coastal southern California, with limited distribution (Wilken 1993a). Ancestral walnut woodlands and forests, probably never widespread, were present in southern California in the early Pliocene (Axelrod 1966). Currently, within a range that stretches from Ventura County to San Bernardino County, an estimated 58.5 km^2 (5850 ha) of southern California black woodland are all that exist. With about 89 percent these woodlands in private ownership, this already small area continues to decline, due to destruction and fragmentation that accompanies urbanization (Davis et al. 1998). Sawyer and Keeler-Wolf (1995) apply the term "rare" to the species, and report the Nature Conservancy Heritage Program's designation of the woodlands as G2 S2.1, which is "very threatened." It is important to study and document walnut woodland communities as a basis for their conservation.

Southern California black walnut trees occur in pure stands, as codominants with coast live oak, *Quercus agrifolia* Nee (Fagaceae), as isolated stands in chaparral, and occasionally in coastal sage scrub (Davis et al. 1998). This habitat diversity suggests that highly variable understories could be expected; a situation documented by Leskinin (1972) and Swanson (1967). These workers examined three sites that were characterized by shrub understories; one in the Santa Susana Mountains, and two in the Santa Monica Mountains of Los Angeles County (Leskinin 1972). Two additional sites, one at Sulphur Mountain in Ventura County, and one in Brea Canyon at the boundary of Orange and Los Angeles counties were characterized by variable, mixed grass-shrub understories (Swanson 1967). These two studies are the only documentation of black walnut understories, in contrast to numerous studies of oak woodland understories (Maranon and Bartolome 1993; Callaway et al. 1991; McClaran and Bartolome 1989; Saenz and Sawyer 1986; Holland 1980).

The purpose of this study was to describe the existing understory plant composition and structure of a remnant of southern California walnut woodland. We also wanted to search for California native plants in the understory of this woodland, and attempt to relate the distribution of plant species within the understory to selected environmental variables, namely, position on the slope, shading from the canopy, and proportion of bare ground. The community chosen for this study is approximately 2.3 ha of mature southern California black walnut trees in the San Jose Hills of Los Angeles County, at the California State Polytechnic University, Pomona (Cal Poly, Pomona) John T. Lyle Center for Regenerative Studies. Because the site is part of the Cal Poly, Pomona campus, the opportunity exists to continue studying aspects of this woodland understory, especially, changes in species composition over time.

Our site has a history of cattle grazing dating at least as far back as the California Ranchero period of the early 1800's (Pomerening 1990). Therefore, we expected to find mostly naturalized Eurasian understory plants, but hoped to find some native plant species associated with the walnuts. Swanson (1967) found *Asclepias fascicularis* Decne. (Asclepiadaceae), narrow-leaf milkweed, in five percent of his walnut study plots at Brea Canyon in the Puente Hills; an area of rolling hills similar in elevation to our site, with a history of cattle grazing. Other California natives found at the Brea Canyon site were *Eremocarpus setigerus* (Hook.) Benth. (Euphorbiaceae), *Urtica holosericea* (Nutt.) Thorne (Urticaceae), *Artemisia californica* Less. (Asteraceae), and *Galium triflorum* Michaux (Rubiaceae). These species mingled with naturalized European species dominated by *Avena fatua* L. (Poaceae). Based on botanical survey work done before and after Swanson's study, *Galium triflorum* may be an incorrect determination of *Galium aparine* L. (Rubiaceae) (S. White, personal communication). Leskinin (1972) found 30 native tree, shrub, and herbaceous species associated with southern California black walnuts at her sites in the Santa Monica Mountains.

Maranon and Bartolome (1994), studying *Quercus agrifolia* woodlands in northern California, found oak woodlands to be refuges for low competitive, shade tolerant, native understory species, while more exposed locations were dominated by Euro-Mediterranean grassland species. It is probable that walnut trees also affect their understories. Swanson (1967) reported allelopathic properties of distilled water extracts of fruit husks of southern California black walnuts. He used the extracts to water carrot, cucumber, radish, and tomato seeds, but unfortunately, not the seeds of woodland plants. He found inhibitions of germination in carrot and tomato, but not cucumber and radish, indicating that at least some plants are susceptible to the allelopathic effects of walnut extracts. This factor could favor natives versus introduced species in walnut woodland understories.

We predicted a priori that position on the slope and seasonal differences in shade from the woodland canopy would affect the composition of the understory species. Both downslope drainage and shade could affect the quantity of water available to shallow-rooted annual plants, as well as affect the period of time that soil moisture is available during the growing season.

STUDY SITE

The Cal Poly, Pomona campus is located in the San Jose Hills of Los Angeles County, which lie between the Transverse and Peninsular Range physiographic provinces (Hill 1984). In the century preceding the urbanization of coastal southern California, these endemic walnut trees dominated north-facing and northeast-facing slopes in the San Jose hills, while other slopes were dominated by annual grasses (Weislander 1934; Quinn 1990). Plants common in coastal sage scrub communities, as well as *Quercus agrifolia*, are components of the local flora (Clark 1990). The climate of Los Angeles County is Mediterranean, with hot, dry summers. In such a climate, most precipitation occurs during the winter months, so seasonal rainfall measured for the period from July through the following June is a better indicator of available moisture and growing conditions than annual calender year totals. The National Weather Service reports average seasonal rainfall at the Los Angeles Civic Center, 48 km from the study site, at 38 cm (range 12.3 – 96.9 cm) for the 120 years from 1878 to 1997 (National Weather Service 1998). The two seasons previous to the study were below average in rainfall totals. The Cal Poly Solar Park weather station, less than 1 km from the study site, recorded 23.4 cm for 1995-1996, compared with 31.6 cm recorded at the Los Angeles Civic Center (Cal Poly Solar Park 1998). The Cal

Poly weather station malfunctioned in late 1996, but the Los Angeles Civic Center recorded 30.5 cm for the 1996-1997 season.

The Cal Poly campus ranges in elevation from 100 m along San Jose Creek to 350 m along the ridge crests. Soil at the study site is mapped as Nacimiento silty clay loam (Pomerening 1990). In addition to the 2.3 ha of walnuts at the Center for Regenerative Studies site, the Cal Poly, Pomona campus contains an additional 164 ha of walnut woodlands and forests. Other nearby stands of walnuts grow throughout the non-urbanized portions of the San Jose Hills, which are approximately 12 km long from northeast to southwest, and up to 6 km wide. Disturbance and fragmentation of the walnut woodlands has occurred, due to two centuries of cattle grazing, and since the mid-twentieth century, by road building and construction. Currently, walnuts enjoy no special protection at Cal Poly, Pomona. Adjacent to the Center for Regenerative Studies site is a parcel of Cal Poly land that was a small, Mexican land grant once known as Rancho Los Nogales, "ranch of the walnuts" (Pomerening 1990). This parcel now includes very few widely scattered walnuts, a housing complex, and an agricultural field. Through successive historic owners, the Center for Regenerative Studies study site was managed as rangeland and wildlife habitat (Pomerening 1990). Fragmentation of this woodland occurred in 1980, when the majority of the mature walnut trees in the area were removed for the construction of a Los Angeles County Sanitary Landfill. In 1993, the remaining woodland was split into two sections by the construction of the Center for Regenerative Studies. Cattle grazing ceased in 1993, but following this study, sheep have been introduced to the site.

METHODS

Study plots were located beneath mature walnut trees on a 0.37 ha site with a northwest-facing slope of 25 to 35 percent, at elevations between approximately 235 and 255 m. The slope is bordered on the south by a dirt road, on the east and west by shallow ravines, and on the north by a wetland. Four 70-m transects, 11 m apart, were extended from the top to the bottom of the hill. Nine 1 m^2 plots were randomly selected along the second transect. In each of these plots, percent cover of each understory species, percent shade, and distance from the top of the hill were recorded. We noted that bare ground was common in the understory, so percent bare ground was recorded for each plot. Percent shade was estimated as the amount of the plot shaded by the overstory walnut trees at mid-day in April. Minimum sample size was estimated using percent cover from the initial nine plots (Zar 1996). Thirty additional plots were then randomly selected along the three remaining transect lines, for a total of 39 plots. Voucher specimens of each plant species encountered were mounted on standard herbarium sheets, and deposited in the Center for Regenerative Studies' Herbarium. Data were gathered in April, 1997, and plots were revisited periodically through July, 1997, to observe and record phenological events of the species present.

A samples-by-species community data matrix was constructed. Species richness was estimated using the jackknife method (Heltshe and Forrester 1983). A distribution curve was constructed by plotting the log of percent cover by species abundance rank (Ludwig and Reynolds 1988). Two-dimensional ordinations of plots and species scores were obtained and related to percent shade, slope position, and percent bare ground (Ter Braak 1991). Eigenvalues were obtained for the three variables (Ter Braak 1986).

RESULTS AND DISCUSSION

Bromus diandrus Roth (Poaceae), ripgut brome, covered 20 to 99 percent of every plot (Table 1). Native to Europe, it is a common California weed in waste places and fields at low elevations (Wilken and Painter 1993). This species has naturalized extensively under the walnut trees of the study area. *Brassica nigra* (L.) Koch (Brassicaceae), black mustard, was found in 56 percent of the plots, with maximum plot cover at 80 percent. In sunny areas of the study site, plant height exceeded 15 dm, while in shady spots *B. nigra* rarely reached 10 dm. *Hordeum murinum* L. (Poaceae), a wild barley, was found in 51 percent of the plots. Cover per plot did not exceed 20 percent, and cover was usually less than 10 percent. *Marrubium vulgare* L. (Lamiaceae), horehound, was found in 15 percent of the plots. It is a widely distributed weed from the kitchen gardens of Europe that was deliberately introduced in many parts of North America (Wilken 1993b). *Urtica urens* L. (Urticaceae), commonly known as dwarf nettle, was found in only eight percent of the plots. However, its cover in those plots was 25, 20, and 15 percent. This species was associated with a high percentage of bare ground; 55, 20, and 45 percent, respectively. Greig-Smith (1946) describes suitable habitat for *U. urens* in the British Isles as croplands that receive several cultivations, implying an ability to rapidly colonize bare ground.

Asclepias fascicularis, narrow-leaf milkweed, was the only native understory species found in the survey. It was found in scattered clumps in two plots at or near the hilltop. Munz (1974) describes this species as a deep-rooted perennial found in dry places below 7000 ft. *Sonchus oleraceus* L. (Asteraceae), common sow thistle, was recorded in two plots. Like *Marrubium vulgare*, it may have been deliberately introduced as a food plant, only later to become a weed (Schoenherr 1992). *Galium aparine*, goose grass, occurred in only 1 plot.

One author (R. Quinn) has been able to monitor walnut seedling establishment since the construction of Center for Regenerative Studies. Only one seedling of the season of *Juglans californica* was encountered in the sample plots. Saplings up to four years old were present on the sunny margins of the stand, however. The age of the saplings corresponds to the amount of time since cattle were removed from the site.

Mean cover per plot varied from 79 percent for *Bromus diandrus* to 0.02 percent for *Galium aparine* (Table 1). The species distribution curve (Figure 1) approximates a log normal distribution. Species richness determined using the sample plots, excluding *Juglans californica*, is 8. The range of species richness estimated by the jackknife method was 7 to 11. The low species richness of the Center for Regenerative Studies site may relate to its fragmented and disturbed nature. Tenbrink (1998) found species richness of 64 along 1000 m of transect at the largest and least disturbed of her southern California black walnut fire sites, but species richness was only 7 along 280 m of transect at the smallest and most disturbed site.

Table 1. Summary of walnut woodland understory vegetation. Data are percent cover from 39, 1-m^2 sample plots.

Species	Range	Mean	SD
Bromus diandrus	20-99	79	20
Brassica nigra	0-80	6	14
Hordeum murinum	0-20	3	5
Marrubium vulgare	0-30	2	6
Urtica urens	0-25	2	6
Asclepias fascicularis	0-30	1	5
Sonchus oleraceus	0-5	0.3	1
Galium aparine	0-1	0.02	0.2
Juglans californica	0-20	0.5	3

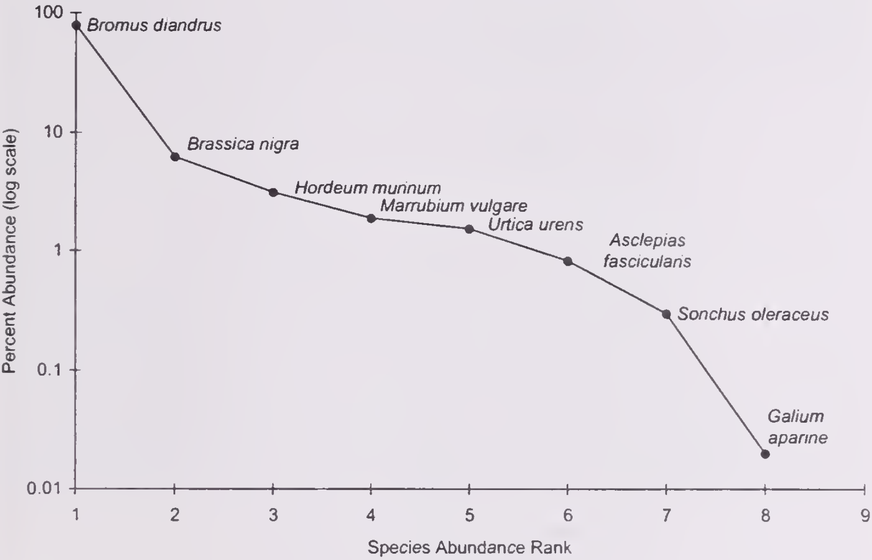

Figure 1. Species distribution curve of relative abundances of understory herbs. Log of percent abundance is plotted against species rank from most abundant to least abundant.

The simultaneous ordination of plots and species is depicted in Figure 2. Plots were densely clustered around the origin, indicating little variation in species makeup. Existing variation in the distribution of sample plots can largely be explained by the presence of one of the rarer species or by above or below average abundance of one of the more common species. For example, plot 1-1, located at the top of the slope and in full sun, had 80 percent coverage of *Brassica nigra*. Plots 1-2 and 1-3 were two of only three plots containing *Urtica urens*.

The sum of eigenvalues for the three independent variables; percent shade, slope position, and percent bare ground, is only 0.279, indicating that they explained only 28 percent of variation among plots. Of the three variables, percent bare ground was the most important, with an eigenvalue of 0.248. Presence of one species, *Urtica urens*, was associated with bare ground. Contrary to our expectation, percent shade appears to have negligible predictive value for the composition of the plots (eigenvalue of only 0.022). More precise estimation of daily and seasonal light levels are recommended for future studies; however, plot composition varied little throughout the understory, regardless of variations in canopy density. An explanation for the lack of species differences occurring in the understory versus outside the canopy may be in the timing of rainfall and winter leaf abscission in this Mediterranean climate. Seeds of annuals, lying dormant since the summer drought, begin to geminate in late winter, when days are warming and lengthening, the surface soil is moist from seasonal rains, but the walnut canopy is still bare. During this phase of the life cycle of annuals, the understory receives nearly as much sunlight as the area outside the woodland. Only in mid-spring, when annuals are established, does the full walnut canopy develop and thereby shade them. Our predicted vegetation gradient from the top to the bottom of the hill was not evident (eigenvalue of 0.009) for slope position). The shallow-rooted annuals received sufficient moisture at all positions on the slope during the winter rains of the study season. Although the native *Asclepias fascicularis* appeared only at the top of the slope, it was so rare that it had little effect on the results of slope analysis.

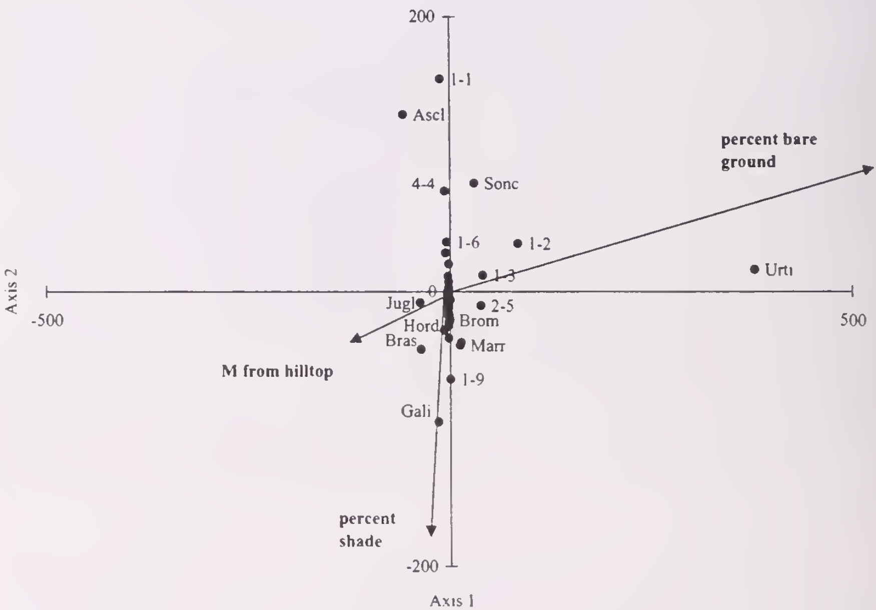

Figure 2. Simultaneous ordination of sample plots (numeric), species (alpha) and environmental variables (arrows) using the first and second principal components axes. Arrows are vectors indicting both magnitude and direction for the variables (Ter Braak 1986; Urbanczyk and Henderson 1994). Species codes: Ascl = *Asclepias fascicularis*, Bras = *Brassica nigra*, Brom = *Bromus diandrus*, Gali = *Galium aparine*, Hord = *Hordeum murinum*, Jugl = *Juglans californica* seedlings, Marr = *Marrubium vulgare*, Urti = *Urtica urens*. Missing and unlabeled sample plots clustered around the origin, and were omitted for clarity.

CONCLUSIONS

Understory vegetation of the walnut woodlands at the Center for Regenerative Studies has been shaped by its history of cattle grazing. The plant species composition consists of naturalized annual grasses, interspersed with naturalized forbs; almost all were introduced from Europe to California in the late 1700's. The understory of the walnut woodlands at the Center for Regenerative Studies surveyed in 1997 consisted entirely of species common to disturbed areas of the coastal lowlands of southern California. The species distribution followed a log normal pattern. The plant community was homogeneous and not separable into subcommunities on the basis of species composition using the environmental variables of percent shade, slope position, and percent bare ground. In terms of cover, the dominant species at the site was *Bromus diandrus*, a weedy grass. Only one plant species native to North America, *Asclepias fascicularis*, was found in the understory sample. This contrasts with Maranon and Bartolome's 1994 results from northern California non-deciduous *Quercus agrifolia* woodlands, where shade-tolerant native species in the understory were able to out-compete Eurasian weeds. Additional studies of the effects of walnut allelopathy on native and introduced species could be informative. Removal of cattle from the site opened the possibility that a different understory community of plants may develop over time, along with renewed recruitment of southern California black walnuts. However, the recent introduction of sheep will affect those outcomes. In addition, *Bromus diandrus* has proved to be a tenacious dominant in the California grasslands where it has become established. Even deliberate efforts to restore grasslands invaded by weedy annual grasses are often unsuccessful (Monsen 1994). We hope that this baseline study will provide a beginning for future studies of the understory of this native walnut community located on the campus of a California university.

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USES OF THE WORLD WIDE WEB IN CONSERVATION BIOLOGY AND ENVIRONMENTAL EDUCATION

PETER A. BOWLER (pabowler@uci.edu) Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697-2525, and
White Mountain Research Station, 3000 E. Line Street, Bishop, CA 93514

ALAN D. THORNHILL (athornhi@rice.edu), Ecology and Evolutionary Biology, MS 170 Rice University, 6100 Main, Houston, TX 77005-1892, and

PETER J. BRYANT (pjbryant@uci.edu) Department of Developmental and Cell Biology, University of California, Irvine, CA 92697-2275

ABSTRACT: World Wide Web (WWW) documents are increasingly being used as support for courses and research in conservation biology and related environmental education programs, as well as in many other areas of plant biology. Examples that have been produced at our institutions include a hierarchically organized set of links to sources of information on conservation biology (a Virtual Library of Biodiversity, Ecology, and the Environment, a conservation hypertext with over a thousand links), the Society for Conservation Biology home page, that is being used in place of, or as a supplement to conventional text books, the Native Americans and the Environment home page, full-text lecture notes, bibliographies, issue guides, and sample exams. Over a dozen related divisions that support environmental education are part of the Center for Conservation Biology Network. The WWW provides authoritative, up-to-date and essentially unlimited materials as well as interactive sites that allow instructors, students, and researchers to both use and contribute to the development of electronic curricula and virtual textbooks. These materials should enhance the quality of environmental education at all levels. For botanists, the Web makes accessible a vast arena of data, including collections and localities of many herbaria, online journals, botanical societies, listservs and topical discussion groups, and lists and costs of native plant material in numerous native plant nurseries throughout the state.

KEYWORDS: botany, conservation biology, environmental education, herbaria, internet, websites, World Wide Web, WWW

INTRODUCTION

By enabling rapid access and exchange of information, the Web has the potential to revolutionize many aspects of education (see Barrie and Presti 1996). It is an especially appropriate resource for conservation biology and environmental education, because it provides convenient access to timely information on rapidly developing environmental issues at both local and global levels, and opportunities for instructors and students, as well as researchers, to explore their interests independently, and to contribute to information sources, as well as benefit from them. Several different kinds of web resources have been developed and are used at our institutions in support of conservation biology and environmental education, as are discussed below.

LECTURE NOTES AND OTHER CLASS DOCUMENTS

As examples of WWW applications for teaching, full-text lecture notes, bibliographies, issue guides and sample exams are provided to the students in Biology 65, Biological Conservation (http://darwin.bio.uci.edu/~sustain/bio65/) and Bioscience 213, Introduction to Ecology and Evolutionary Biology (an introductory laboratory course at Rice University). This replaces the previous system of making hard copy available through a reprographics office or the library, and has several advantages over the previous system:

- It saves paper, it is less costly for students, and it is easier to update the documents.
- The notes contain links to outside information sources that can be used as either required or optional reading for the students.
- The notes contain links to images (photographs, graphs and figures), which can be readily changed, replaced, or updated.
- Students can consult these materials, as well as other internet resources at home, or in the campus computer labs.

THE CONSERVATION HYPERTEXT BOOK

Originally produced for the students in Biology 65, Biological Conservation at UCI, The Conservation Hypertext Book (http://darwin.bio.uci.edu/~sustain/bio65/Titlpage.htm) is an organized set of links to outside information sources covering all topics in biological conservation. The hypertext book contains a core text of 18 chapters covering all topics in biological conservation as well as numerous links to outside information sources that are selected by the instructor for their timeliness and educational value. Biology 65 is the second of three courses needed to fulfill the requirements of the new Interdisciplinary Minor in Global Sustainability at UCI. The sites are selected by the instructor for their educational value. The "book" can be browsed or searched by students or researchers interested in any topic, starting with a multi-level table of contents and proceeding to specific issues, species, habitats, legislation, and so forth. It is designed to replace conventional textbooks as the main information source aside from the lecture notes. The Conservation Hypertext Book has already been adopted by the World Wide Web Consortium as the section of the Virtual Library of Biodiversity, Ecology, and the Environment (http://conbio.rice.edu/vl/).

ISSUE GUIDES

Issue guides have been produced by the instructor as well as the students in our Senior Seminar in Global Sustainability, and posted on the WWW site at UCI (http://darwin.bio.uci.edu/~sustain/global/global.htm). They deal with numerous local and global environmental issues. Each new cohort of students can use the accumulating set of guides and add to the resource as new information becomes available and new issues arise. We find that students are highly motivated to produce a high-quality product when they know it will be made available on the web and will be used by others, rather than just being graded as a report and then discarded. Some of our best Issue Guides are developed by teams of students with different expertise (e.g., Computer Science majors, Graphic Artists, and Biological Science majors).

THE CENTER FOR CONSERVATION BIOLOGY NETWORK

The Center for Conservation Biology Network (CCBN) (http://conbio.rice.edu/) promotes environmental awareness and the development of academic curricula dealing with global environmental issues. It is a series of integrated information servers connected to the internet with the purpose of providing information about conservation biology issues, programs, and opportunities globally, and of helping to develop the technical means for the protection, maintenance, and restoration of biodiversity on this planet.

The CCBN is host to over a dozen separate, but related divisions that support environmental education, including:

- The Society for Conservation Biology home page
- A comprehensive guide to academic programs in conservation biology
- Financial and education resources for students of environmental sciences
- The Virtual Library of Biodiversity, Ecology, and the Environment
- The Native Americans and the Environment home page
- The On-line Center for Higher Education Environmental Programs, produced by the Committee for the National Institute for the Environment (CNIE)
- The National Library of the Environment, also produced by CNIE
- Resources for Instructors of Ecology and Environmental Sciences (under construction). This division will be a clearinghouse of information for teachers working in these topics. The other divisions of the CCBN will be brought together with instructors in mind to facilitate their use of the internet in education. This division will also include a repository for teachers' ideas and suggestions for approaching topics in environmental education.

ADVANTAGES OF THE WWW AS AN INFORMATION SOURCE IN CONSERVATION BIOLOGY AND ENVIRONMENTAL EDUCATION

There are numerous advantages of the WWW over conventional information sources in environmental education. If links are chosen carefully by the instructor, the information sources can be:

- *Inexpensive* — They do not use paper and they are usually free for use by the students.

- *Searchable* — Search engines are readily available and can be incorporated into WWW sites so that the entire resource can be searched by key word or phrase.

- *Authoritative* — Most textbooks are the product of one individual's heroic efforts. They are limited by the author's expertise and time available for research and production, and they are often dated before they are used. In contrast, with the World Wide Web, it is possible for environmental scientists and educators everywhere to collaborate in producing curriculum and vtrtual text books, taking advantage of special scientific, legal and political expertise, as well as local knowledge everywhere. Such a resource could dramatically improve the quality of instruction, wherever it is used.

- *Up to date* — The WWW links provide access to sources of information, analysis, and opinion that are constantly being updated, without the need for instructor involvement. For example, pending legislation is one important type of information that is usually readily available on the Web. The Thomas Home Page (http://thomas.loc.gov/home/thomas.html) provides comprehensive information on bills before Congress, with digests that are usually available within 48 hours of the introduction of the bill. Timely reaction and analysis is provided by many organizations. For example, the Sierra Club (http://lists.sierraclub.org/archives/index.html) publishes electronic action alerts by email and the WWW several times per week. The Natural Resources Defense Council (http://www.nrdc.org/) also publishes legislative analyses on a regular basis. Another timely site is Popclocks (http://www.census.gov/main/www/popclock.html), which shows human population projections by the U.S. Census Bureau, updated every few seconds! It would be impossible for conventional textbooks and information sources to approach the level of thoroughness and timeliness that the WWW provides.

- *Interactive* — Some WWW sites allow various types of interaction with the user. Examples are self-paced tutorials (for example, the tutorial on Geographic Information Systems at http://www.uwsp.edu/acaddept/geog/index.htm, simulations, and virtual field trips (http://www.uwsp.edu/acaddept/geog/), and expeditions (http://www.jasonproject.org/). With our sites, we encourage students to contribute to the sources of information, as well as to use them. For example, they are asked to identify non-functional links, to explore internet resources not already identified in our site, and to propose additional links for evaluation and incorporation into the lecture notes and the hypertext book, if appropriate. By its nature, the internet provides an outstanding opportunity for conservationists in different parts of the world to share information and experience. It also lends itself to the establishment and management of geographic information systems in which numerous sources of local information can be integrated into global databases. Students involved in ecology and conservation courses could be important contributors to such databases. An excellent example is the Nonindigenous Aquatic Species (NAS) information resource (http://nas.er.usgs.gov) provided by the Florida and Caribbean Science Center, which accepts sightings of exotic species from users, and compiles the information into a geographic database that can be viewed at the same web site.

- *Unlimited and Evolving* — Since the information on the WWW is distributed over a huge number of computers, the amount of accessible information is enormous, and rapidly growing. In contrast, conventional textbooks are necessarily limited in scope. Of course, this represents new challenge for the instructor in identifying those links that are of most educational value in the context of a specific course.

- *Available and Accessible* — Web documents can be made available to the world for educational and other purposes without cost or restriction. This makes them ideal information sources for on-line courses. We have started to offer Bio 65, Conservation Biology, as an on-line course using the Hypertext Book. It is also easy for instructors at other institutions to take advantage of remote sources in offering related courses, and for students who use them in learning the subject, and in preparing reports.

California botanists benefit in many ways from use of the WWW, and we have included a selected list of herbaria with strong California collections, as well as agencies, native plant material sources, professional botanical societies, and other useful resources (Table 1). Well-linked botanical web sites are accessible through the New York Botanic Garden and the Missouri Botanic Garden, among others (see Table 1).

USEFUL SOFTWARE

Several Word Processing programs can now "Save as" html, making the generation of web documents possible without any knowledge of html. Microsoft FrontPage is especially convenient, as it allows viewing and editing in both normal and html modes, can add attractive formatting themes to all documents in the collection, and can automatically scan for non-functional links. The latest version also makes it very easy to establish discussion groups, and to generate web-based forms that will capture information from users into a database.

INVITATION

The use of the WWW to deliver materials should enhance the quality of environmental education at all levels. We encourage instructors and students elsewhere to take advantage of the resources that have been developed, to criticize them, and suggest ways of developing them further.

Table 1. Selected URL and Email References. Please note that not all of the herbaria listed below have actual pages themselves, although some have accessions data available electronically.

Barrie and Presti (1996): The World Wide Web as an instructional tool
— http://www.sciencemag.org/science/scripts/display/full/274/5286/371

Biodiversity and Biological Collections Web Server — http://biodiversity.uno.edu/

Biological Conservation course at University of California Irvine
— http://darwin.bio.uci.edu/~sustain/bio65/

Biologists' Field Guide to the Internet — http://www.fsc.usgs.gov/fieldguide.html

Botanical Authors Database — http://www.herbaria.harvard.edu/Data/Author/author.html

California Environmental Resources Evaluation System (CERES) — http://www.ceres.ca.gov/

Center for Conservation Biology Network (CCBN)— http://conbio.rice.edu/
— http://conbio.bio.uci.edu/

California Academy of Sciences California Wildflowers
— http://www.calacademy.org/ (CalPhotos) — http://elib.cs.berkeley.edu/photos/flora/

California Flora (CalFlora) Database — http://www.calflora.org
Frequently Asked Botanical Questions — http://elib.cs.berkeley.edu:80/calflora/faq.html
Occurrence (observations) database — http://elib.cs.berkeley.edu:80/calflora/occ/
California Plant Synonyms — http://elib.cs.berkeley.edu:80/calflora/xwalk

California State University Biological Sciences Web Server (BIOWEB)
— http://arnica.csustan.edu/index.html

California State University Biology Departments — http://arnica.csustan.edu/csubiol.html

California Vascular Plants — http://ucjeps.berkeley.edu/jeps-list.html

Cartographic Links for Botanists — http://www.helsinki.fi/kmus/cartogr.html

Ecology and Evolutionary Biology course at Rice University — http://conbio.rice.edu/bios213/

Flora of North America — http://www.fna.org/fna.html

GIS Tutorial at University of Wisconsin — http://www.uwsp.edu/acaddept/geog/

Gray Card Index — This database currently includes over 325,000 citations of names of New World vascular plants. — http://www.herbaria.harvard.edu/Data/Gray/

Harvard University Herbarium: The Botanical Collectors Database
— http://www.herbaria.harvard.edu/Data/Collectors/collectors.html

Harvard University Herbarium: The Botanical Publications Database
— http://www.herbaria.harvard.edu/Data/Publications/publications.html

Information Center for the Environment (ICE) — http://ice.ucdavis.edu

Interdisciplinary Minor in Global Sustainability at UCI
— http://darwin.bio.uci.edu/~sustain/global/global.htm

Table I. (continued)

International Taxonomic Information System — http://www.itis.usda.gov/itis

Internet Directory for Botany (IDB) — http://www.botany.net/IDB/
— http://www.helsinki.fi/kmus/botmenu.html

National Park Service: Species in Parks Flora and Fauna Database — http://ice.ucdavis.edu/nps/

Natural Resource Defense Council legislative watch — http://www.nrdc.org/field/state.html

New York Botanical Garden Search Index Herbariorum — http://www.nybg.org/bsci/ih/ih.html

Nonindigenous Aquatic Species (NAS) information resource
— http://nas.er.usgs.gov/

North American Association of Environmental Education — http://www.naaee.org

People/Projects/Institutions Module: a compendium of information about people, projects, and institutions. It includes names, addresses, and professional and biographical data about botanical experts, as well as descriptions of institutional projects and of other herbaria.
— http://www.nybg.org/bsci/cass/ppi.html

Popclocks — http://www.census.gov/main/www/popclock.html

Smithsonian Institution Libraries: Internet subject guide: Botany: Organizations, Associations, Botanical Society of America membership list, ASPT membership directory.
— http://www.sil.si.edu/Subject-Guide/botany-04.htm

Synonymized Checklist of the Vascular Flora of the United States, Canada, and Greenland
— http://www.mip.berkeley.edu/bonap/checklist_intro.html

United States Geological Survey (USGS) — http://www.fcsc.usgs.gov

United States Geological Survey Biological Resources Division — http://www.nbs.gov/

United States National Herbarium — http://nmnh.si.edu/departments/botany.html

University of California Irvine's Restoration Ecology web server
— http://darwin.bio.uci.edu/~sustain/EcologicalRestoration/

Texas A&M University Bioinformatics Working Group
Grass Images — http://www.csdl.tamu.edu/FLORA/image/poacr2ba.htm
Cybersedge Carex Images — http://www.csdl.tamu.edu/FLORA/carex/carexout.htm

Thomas Home Page — http://thomas.loc.gov/home/thomas.html

Travel: Tourist Attractions: Botanical Gardens
— http://www.excite.com/guide/travel/tourist_attractions/botanical_gardens

United States Forest Service, Pacific Southwest Region 5 — http://www.r5.fs.fed.us/

USDA, NRCS, National Plant Data Center: a list of plant-related links provided by the National Plant Data Center — http://trident.ftc.nrcs.usda.gov/npdc/10links.html

Virtual Library in Biodiversity, Ecology and the Environment — http://conbio.rice.edu/vl/

Woody Plants of the Central Santa Ynez Mountains (Treebeard's Flora)
— http://www.rain.org/~mkummel/flora/

Table 1. (continued)

Selected California Herbaria and Herbaria with California Collections

Anza-Borrego Desert State Park — http://cal-parks.ca.gov/DISTRICTS/colorado/abdsp622.htm

California Academy of Sciences Herbarium — http://www.calacademy.org/research/botany

California Polytechnic State University San Luis Obispo Hoover Herbarium — http://www.calpoly.edu/%7Ebio/BioSci/Facilities/Collections.html

California State University Chico — http://www.csuchico.edu/biol/Herb/herbarium.html

Carnegie Institution of Washington — http://www.ciw.edu

Farlow Herbarium of Cryptogamic Botany, Harvard University — http://www.bio.umassd.edu/BioDept/resources/farlow.html

Humboldt State University — http://sorrel.humboldt.edu:80/~cnrs/html/collect.htm

Huntington Botanical Gardens — http://www.huntington.org/BotanicalDiv/HEHBotanicalHome.html

Mildred Mathias Botanic Garden, UCLA (herbarium) — http://stratus.lifesci.ucla.edu/botgard/bg-home.htm

Missouri Botanical Garden — http://www.mobot.org/

Natural History Museum of Los Angeles County — http://www.nhm.org

New York Botanical Garden — http://www.nybg.org

Pacific Southwest Forest and Range Experiment Station — http://www.msue.msu.edu/son/mod70/70000016.html

Pomona College — http://www.pomona.edu

Quail Botanical Gardens, Encinitas — http://www.qbgardens.com/

Rancho Santa Ana Botanical Garden — http://www.cgs.edu/inst/rsa/index.html

San Diego Museum of Natural History Herbarium — http://www.sdnhm.org/research/botany/botdept.html

San Diego State University Herbarium — http://www.sci.sdsu.edu/herb/

San Francisco State University Herbarium — http://www.sfsu.edu/tdirect/3248.htm

Santa Barbara Botanic Garden Herbarium — http://www.sbbg.org/herbariu.htm

Santa Barbara Museum of Natural History — http://www.sbnature.org

Sonoma State University North Coast Herbarium of California — http://www.sonoma.edu/biology/catalog/Intro.html

Stanford University — http://www.stanford.edu

University of California, Berkeley, University and Jepson Herbaria — http://ucjeps.berkeley.edu/

Table 1. (continued)

University of California, Davis — http://herbarium.ucdavis.edu//history.htm

University of California, Irvine
— http://www.uci.edu - IRVC is part of the UCI Arboretum, contact: pabowler@uci.edu

University of California, Riverside — http://cnas.ucr.edu/~cnas/facilities/herbarium.html

University of California, Santa Barbara herbarium — http://lifesci.ucsb.edu/~mseweb/coll.html

Selected Non-governmental Organizations

American Bryological and Lichenological Society
— http://ucjeps.herb.berkeley.edu/bryolab/ABLS/aboutABLS.html

American Conifer Society — http://www.pacificrim.net/~bydesign/acs.html

American Fern Society — http://www.visuallink.net/fern/index.html

American Society of Plant Taxonomists http://www.sysbot.org/

Audubon Society — http://www.audubon.org

California Exotic Pest Plant Council (CalEPPC) — http://www.caleppc.org/

California Native Plant Society — http://www.calpoly.edu/~dchippin/cnps_main.html

Defenders of Wildlife — http://www.defenders.org

International Association for Plant Taxonomy — http://www.bgbm.fu-berlin.de/IAPT/

Sierra Club — http://www.sierraclub.org

Society for Conservation Biology — http://conbio.rice.edu/scb/

The Nature Conservancy — http://www.tnc.org

Theodore Payne Foundation — http://www.msue.msu.edu/msue/imp/mod70/70000500.html

Tree of Life Nursery — http://www.habitat-restoration.com/toln.htm

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VEGETATION DESCRIPTIONS, SITE CHARACTERISTICS, AND PLANT ECOLOGY IN SHRUBLANDS OF THE PUENTE HILLS, LOS ANGELES COUNTY, CALIFORNIA[1]

SCOTT D. WHITE
Scott White Biological Consulting
99 East C St., No. 206
Upland, CA 91786

ABSTRACT: Dense shrublands dominated by *Malosma laurina* and *Rhus integrifolia* cannot be unambiguously classified as "coastal sage scrub" or "chaparral." These stands are best termed "Sumac series" and are structurally distinguished from unambiguous coastal sage scrub of the California sagebrush and Purple sage series in adjacent stands. Three hypothetical explanations which might explain the occurrence of these dissimilar shrublands in close proximity are suggested. Implications for California gnatcatcher habitat management and native shrubland restoration are discussed.

KEYWORDS: California gnatcatcher, California sagebrush series, CEQA, chaparral, coastal sage scrub, *Malosma laurina*, Puente Hills, Purple sage series, *Rhus integrifolia*, Sumac series

INTRODUCTION

Shrublands of varying structure and species composition in the Puente Hills illustrate two concerns in vegetation ecology. First, there is a semantic problem that arises in naming plant communities. Second, if dominant species differ in their life histories or habitat requirements, then shrubland composition may be determined by site characteristics. Conservation and management implications of both topics are discussed here.

VEGETATION DESCRIPTIONS

Vegetation classification is intended to identify and name patterns that occur repeatedly, but physical structure and species composition are never identical on any two sites. Named vegetation types represent the most evident vegetation patterns, but they often are segments of continuous structural and floristic gradients, rather than sharply separated, discrete types. The vegetation growing on any particular site might be intermediate between described types, or it may be entirely unique to the site.

Powder Canyon, a 545 acre site in the western Puente Hills, supports shrublands that have been described as "chaparral" and "coastal sage scrub" by Tierra Madre Consultants (1990) on the basis of species composition, physical structure, and comparison with written descriptions of chaparral and coastal sage scrub. Küchler (1977) mapped the potential vegetation of the site as "southern oak forest (*Quercus agrifolia*)" on his 1:1,000,000 scale map of Natural Vegetation of California. At the same scale, Matyas and Parker (1979) mapped existing vegetation as "soft chaparral (*Artemisia, Eriogonum, Salvia, Encelia*)." Both maps were produced using mapping

[1] This paper was originally presented at the symposium, Natural Resources in the Puente Hills - Chino Hills Corridor, 18-19 March 1994, at Whittier College, Whittier, California.

units much larger than the present study site, and therefore, they have only very general application at a more local scale.

Vegetation mapped as "chaparral" (Tierra Madre Consultants 1990) at Powder Canyon is dominated by dense-woody, evergreen, sclerophyllous shrubs, 2 to 4 m tall. *Rhus integrifolia* (Nutt.) Benth. and Hook. (lemonadeberry) and *Malosma laurina* Nutt. ex Abrams (laurel sumac) are most abundant, and *Sambucus mexicana* Presl (Mexican elderberry), *Heteromeles arbutifolia* M. Roem. (toyon), and *Rhamnus ilicifolia* Kell. (holly-leaf redberry) occur commonly. Soft-woody shrubs, especially *Salvia mellifera* Greene (black sage), occur occasionally between larger shrubs. Climbing herbs, especially *Marah macrocarpus* (Greene) Greene (wild cucumber) are common, and *Juglans californica* Wats. (southern California black walnut) occurs occasionally. This vegetation corresponds to Sumac series chaparral described by Paysen et al. (1980), Toyon-sumac chaparral of Gray and Bramlet (1992), and the Sumac series of Sawyer and Keeler-Wolf (1995).

"Coastal sage scrub" mapped at Powder Canyon (Tierra Madre Consultants 1990) is generally dominated by the shorter (about 1 m tall), drought-deciduous, soft-woody shrubs *Artemisia californica* Less. (California sagebrush) and *Salvia leucophylla* Greene (purple sage), growing separately or together. Other commonly occurring soft-woody species include *Baccharis pilularis* DC. (coyote brush), *Encelia californica* Nutt. (California encelia), *Ericameria* sp. (goldenbush), *Isocoma menziesii* (H. and A.) Nesom (coast goldenbush), and *Salvia mellifera*. Taller, dense-woody shrubs, and sometimes *Juglans californica* often emerge above the dominant low shrubs in a scattered pattern. The structure and composition of this vegetation matches Westman's (1983) description of the Venturan II coastal sage scrub association, but some stands include elements of his Diegan association. Individual stands on the study site match coastal sage scrub associations or series described by other authors. For example, some stands match Gray and Bramlet's (1992) descriptions of Purple sage scrub or Sagebrush/coyote brush sage scrub, equivalent to Sawyer and Keeler-Wolf's (1995) Purple sage series and California sagebrush series (in part). Other stands at Powder Canyon are intermediate between "chaparral" and "coastal sage scrub," with roughly equal cover of tall shrubs and lower, soft-woody species. These stands match Kirkpatrick and Hutchinson's (1977) *Salvia mellifera-Rhus laurina* and *Salvia leucophylla-Rhus laurina* coastal sage scrub associations (Sawyer and Keeler-Wolf's [1995] Black sage series and Purple sage series in part).

The simple classification into chaparral and coastal sage scrub was included in an Environmental Impact Report (Cotton Beland Associates 1992) to illustrate anticipated effects of a then-proposed development on the Powder Canyon site. Coastal sage scrub is recognized as a sensitive plant community (O'Leary 1989; California Department of Fish and Game 1991) and it is the habitat of several sensitive animals, including the federally listed threatened California gnatcatcher (Atwood 1993; Salata 1993). Thus, in terms of the California Environmental Quality Act, impacts to coastal sage scrub are more "significant" than to chaparral. Classification of much of the shrubland acreage as "chaparral" was criticized during public review of the EIR because the commenter felt this was (1) inaccurate, and (2) artificially minimized reported impacts by recognizing relatively little shrubland acreage as a "sensitive" plant community. I believe that the disagreement is rooted largely in semantics, and that more precise terminology can prevent this and similar miscommunications in the future.

Most authors (e.g., Munz 1974; Vasek 1983; Wilken 1993) agree that *Rhus integrifolia* and *Malosma laurina* occur in both coastal sage scrub and in chaparral, and stands that they dominate are generally termed chaparral (Paysen et al. 1980; Gray and Bramlet 1992). Mooney (1977) also included *Heteromeles arbutifolia* in this group. In contrast, Axelrod (1983) stated that these sumacs occur almost exclusively in coastal sage scrub. Other authors (Schoenherr 1992, and to a lesser extent, Holland and Keil 1995) have followed Axelrod's interpretation. Criticism of the vegetation classification at Powder Canyon also followed Axelrod's interpretation.

Contradictory terminology evidenced by this example is one reason to closely examine the names that are applied to vegetation. Productive communication relies on accurate, consistently understood terminology. The terms "chaparral" and "coastal sage scrub" are too often used inconsistently, and these terms do not adequately characterize the diversity of the vegetation. In the present Powder Canyon example, more precise classification in the biological analysis (Tierra Madre Consultants 1990) could have avoided or minimized disagreement over accurate vegetation mapping.

Throughout the remainder of this paper, I hope to avoid semantic disagreement by using series names as follows: Purple sage series and California sagebrush series (Sawyer and Keeler-Wolf 1995) make up "coastal sage scrub" as mapped and described at Powder Canyon, and these series also occur in patches within mapped "chaparral." Sumac series (Paysen et al. 1980; Sawyer and Keeler-Wolf 1995) corresponds to "chaparral" as mapped and described at Powder Canyon. Both shrubland types are generally composed of the same species, but the relative abundance of tall, dense-woody species is much greater in the Sumac series than in the Purple sage series and California sagebrush series. Thus, its vertical structure is much taller and denser than the Purple sage and California sagebrush series. More detailed analyses would likely refine this classification. In particular, I believe that more detailed work might support subdividing the Sumac series into two types: one dominated by *Rhus integrifolia*, and the other dominated by *Malosma laurina*, *Heteromeles arbutifolia*, and *Sambucus mexicana*.

Note that this terminology is largely based on interpretation and extrapolation of published descriptions. Quantitative data that were collected at a few sites (Table 1) are insufficient to support a classification, although these few samples may be useful to augment future data sets.

VEGETATION MANAGEMENT: PLANT ECOLOGY AND SITE CHARACTERISTICS

Presuming that conservation of natural diversity is an objective of public land management in the Chino and Puente Hills, then conservation of existing shrublands will be necessary, and restoration of native vegetation in existing non-native grasslands will be desirable. Land managers must consider the influences of their actions on the landscape's natural variation, and they must match their objectives to sites that are likely to favorably respond. Various shrublands may respond differently to fire or recreational use, and sites may vary in their suitability for shrubland restoration.

Sumac, Purple sage, and California sagebrush series at Powder Canyon could provide models for management and restoration elsewhere in the region. Shrubland restoration and long-term management will require an understanding of ecological relationships. Are these series restricted by soils or other characteristics of the physical environment? Do shrubland series develop into other types over time? Do fire or other disturbances convert one series to another? The following hypotheses should be useful in directing further studies of vegetation and habitat in the Puente Hills–Chino Hills corridor.

<u>Hypothesis 1: Shrubland Distribution Is Controlled by Geology or Soils</u>

Geology and soils often correlate with plant distributions, but available mapping for the Powder Canyon site is too general to allow specific conclusions. The San Andreas-San Benito soil association covers most of the site (Soil Conservation Service 1969). San Andreas is a sandy loam soil, and San Benito is a clay-loam. Westman (1981a, 1983) found that *Salvia leucophylla* occurred on finer-textured soils that are relatively poor in phosphate, whereas, *S. mellifera* and *Encelia californica* were on coarser soils where phosphate was not limiting. *Salvia leucophylla* and *Encelia californica* occur together at high cover values at one site described in Table 1, but this is not typical of Purple sage or California sagebrush series at Powder Canyon. A similar distinction between clay loam and sandy loam soils may help explain shrubland distributions at Powder Canyon. *Salvia mellifera* is important in the Sumac series, but *S. leucophylla* occurs only at low cover values. If the dominant *Salvia* is an indicator of soil conditions, then perhaps the Purple sage series occurs primarily on clay loam San Benito soils, while the Sumac and California sagebrush series occur primarily on the sandy loam San Andreas soils. Detailed soil descriptions, maps, and an evaluation of phosphate availability in these soils could test this hypothesis.

Table 1. Estimated average height (m) and cover of woody plants in four subjectively selected 0.1 acre plots at Powder Canyon. Cover codes: 1 = <1%, 2 = 1-3%, 3 = 4-10%, 4 = 11-30%, 5 = >30%.

Series name	Purple Sage		Intermediate		Sumac		Sumac	
	Ht.	Cov.	Ht.	Cov.	Ht.	Cov.	Ht.	Cov.
Artemisia californica			1	1	1	1		
Cercocarpus betuloides			1	1				
Cuscuta sp.			-	1				
Encelia californica	1	4	1	4	1	1		
Galium sp.	1	1						
Heteromeles arbutifolia			3	2	3	4		
Juglans californica							3	1
Keckiella cordifolia			<1	1	1	2		
Malosma laurina	1	2	2	3	3	4		
Marah macrocarpus	-	4	-	3	-	4	-	4
Mimulus aurantiacus					<1	1		
Nicotiana glauca					<1	1		
Rhamnus ilicifolia	2	3			1	3	1	3
Rhus integrifolia	2	1	1	4	2	5	1	5
Salvia leucophylla	1	5	1	3	1	2		
Salvia mellifera	1	1	1	4	1	3	1	3
Sambucus mexicana	3	2	3	2			3	4
Toxicodendron diversilobum			1	1	1	1	1	2

Yerkes (1972) mapped mainly siltstones in the northwestern portion of the Powder Canyon site, and mainly sandstones on the remainder. There is no evident correlation of shrubland series with mapped parent material. Faulting and fracturing may also affect plant distribution, but I know of no bedrock structure descriptions of sufficient detail to test this possibility. Dominant species in the Sumac series (*Rhus integrifolia* and *Malosma laurina*) are broad-leaved, evergreen, and maintain relatively high water potential through summer drought (Miller and Poole 1979), probably indicating that they access deep water sources by rooting deeply into bedrock fractures. In contrast, drought-deciduous plants of California sagebrush and Purple sage series survive summer drought by reducing leaf area (*Artemisia californica, Encelia californica, Salvia leucophylla, S. mellifera*: Westman 1981b), and surviving lower water potentials (*Artemisia californica* and *Salvia mellifera*: Miller and Poole 1979; Kolb and Davis 1994). Root depths are rarely documented, but *Artemisia californica* and *Salvia mellifera* are shallow-rooted (J. Greene, C. Trindle-Smith and M. Blane unpublished data; Hellmers et al. 1955).

Hypothesis 2: Shrubland Distribution Is Controlled by Topography

South-facing slopes receive more intense solar irradiation and tend to support more drought-tolerant plants than north-facing slopes, and this pattern generally affects distributions of the species addressed here (Schoenherr 1992). Surprisingly, there is little evident correlation of north- vs. south-facing slopes at the Powder Canyon site with the three shrubland series addressed here, although north-facing sites do support *Quercus agrifolia* Nee (coast live oak) stands, whereas similar south-facing sites tend to support sumac stands.

Another component of topography is degree of slope. At Powder Canyon, ridgetops tend to be moderately-sloped, and adjacent canyon walls are very steep. Sumac series vegetation occurs mostly on steep slopes. In contrast, ridgetops are mostly covered by non-native annual grassland, with *Salvia leucophylla* and *Artemisia californica* stands in small patches at grassland edges. These grasslands may have originated from grazing or fuelbreak construction, but the ridgetops may once have supported Purple sage and California sagebrush series shrublands. A rigorous analysis might indicate a significant correlation of slope with vegetation. Degree of slope is also likely to correlate with soil texture.

Hypothesis 3: Shrubland Distribution Is Controlled by Fire

One might ask whether these shrubland series are controlled by the long-term effects of differing fire regimes (e.g., average fire interval or season of burning), or by the short-term effects of the most recent fire (i.e., they may be "successional stages" in the post-fire development of otherwise similar vegetation). If differing fire regimes control shrubland series distribution at Powder Canyon, then the patches of Sumac series, California sagebrush series, and Purple sage series described here must have burned in a distinctly different pattern over many fire intervals. Based on historic fire records and computer simulations of long-term fire regimes, Malanson (1984) concluded that fire is probably not responsible for relative dominance of *Salvia leucophylla* and *S. mellifera* in the Santa Monica Mountains. Similarly, it is difficult to envision significantly distinct fire regimes in the various shrublands at Powder Canyon, since they often occur immediately next to one another.

If the most recent fire determines shrubland composition, then one should expect that the California sagebrush series and Purple sage series have burned more recently than Sumac series. Time since burning could be determined by aging the shrubs from growth rings, following Keeley's (1993) methods, or by examining historic aerial photography. Further, if time since the most recent fire differentiates these shrublands, then one should expect sumacs to recruit into the California sagebrush series and Purple sage series (Lloret and Zedler 1991) as these stands develop into the Sumac series. The age of shrubs, determined by growth rings, could also be used to determine whether recruitment is occurring. Again, it is difficult to envision recent fires burning small patches of California sagebrush and Purple sage series on the Powder Canyon site without also burning extensive acreage in the Sumac series.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Structure, species composition, and distribution of shrublands at Powder Canyon have two important implications for vegetation management in the Puente Hills–Chino Hills corridor. First, although the three shrubland series tend to grade into one another, they differ structurally and/or floristically, and provide differing habitats. The California Natural Communities Conservation Program identifies about 100 sensitive species occurring in "coastal sage scrub," but often provides little or nothing more than this vague description of their habitat. The Sumac series, whether or not it is best considered a type of coastal sage scrub, is not primary California gnatcatcher breeding habitat (Bontrager 1991; Fleishman and Murphy 1993; Weaver 1998). Sumacs often occur in gnatcatcher territories, but they are found there as scattered "emergent" tall shrubs within vegetation dominated by lower, soft-woody species (Bontrager 1991; Weaver 1998). California gnatcatchers tend to wander seasonally from strict coastal sage scrub habitats (Campbell et al. 1998), and may well use Sumac series vegetation where it occurs adjacent to their territories.

In contrast, the Purple sage and California sagebrush series *do* match descriptions of California gnatcatcher habitat. If California sagebrush or Purple sage series once covered ridgetops in the Puente Hills–Chino Hills corridor (now type-converted to annual grasslands), then these lands may once have supported California gnatcatchers. Instead, if ridgetops were covered by the Sumac series, these would not have supported gnatcatchers during the breeding season. Management for California gnatcatcher or any particular species must be based on as complete a characterization as possible of that species' habitat. The entrenched terms "chaparral" and "coastal sage scrub" do not provide enough detail for conservation planning.

Second, much of the Puente Hills–Chino Hills area has been partly or entirely converted from native vegetation to non-native grasslands. Natural resource managers in the region should recognize shrubland restoration as a high priority. Westman's descriptions of *Salvia* and *Encelia* habitat differences, along with more detailed studies of soils and parent material should be useful throughout the area. Keeley (1994) has used habitat characteristics to recommend restoration planning strategy for native grasslands. If shrubland restoration is attempted in the Puente and Chino Hills, then a similar effort to correlate series to site characteristics may be useful as a model to predict site capabilities.

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BOOK REVIEWS

Ecology of Fear by Mike Davis. 1998. Los Angeles and the Imagination of Disaster. Metropolitan Books. Henry Holt and Company, New York, New York. 484 pages. Cloth (ISBN: 0-8050-5106-6). $27.50

Mike Davis, author of *City of Quartz*, has produced another southern California classic which is of interest to a broad clientele, including botanists. Like *Cadillac Desert*, this book will be widely used in university classes, and will rapidly become a standard reference in the study of nature and human populations in California. The book is a handsome cloth bound product with numerous illustrations. It is divided into seven topical sections, each with many chapters, an extremely well done annotated footnote segment, acknowledgements, and an index. Although the focus of the book is Los Angeles, the discussion and treatment ranges broadly throughout the southland. Davis' literary digging unearthed many little known references.

The book elegantly demonstrates that "natural disasters" in Los Angeles are the direct consequence of putting people and structures in floodplains, tornado tracks (L.A. has more than Kansas!), high risk earthquake zones, in the paths of inevitable and recurrent wildfires, and in the path of human problems for which nature is blamed. Davis reviews the history and development of Los Angeles beginning with what was before it, its growth through time, the vision of what it might have been through the (rejected) parkland planning of Frederick Law Olmstead, and the broken urban sprawl it has become. All of this is examined in the context of overt greed and nearly blind planning, which followed the dollar of special interests willy-nilly into a patchwork of self created "natural" crises — ridgeline construction in chaparral covered hills requiring subsidized protection from inevitable wildfire, poor construction leading to fire traps in the least wealthy portions of the city, development in the path of debris flows, and so forth. His review of historic bumbling as city planners stumbled into the future makes the city look like a disaster oriented computer game, in which catastrophes arise continuously, and require public subsidy to repair between "attacks."

The book is organized into seven sections, several of which are of particular interest to southern California botanists. "How Eden lost its Garden" describes the rejection of good recommendations by Frederick Law Olmstead and Harlan Bartholomew in 1930 to develop a park and wetland system in the city; the paving and destruction of the Los Angeles River in the 1940s; and another missed opportunity in a study by EDAW of the potential preservation of parkland and biological corridors surviving in 1965. These "lost futures" are engagingly discussed by Davis. "The Case for Letting Malibu Burn" describes the relationship between over-development and fire ecology. In "Maneaters of the Sierra Madre" mountain lion attacks and lion ecology are well discussed, and Davis cites an interview with Paul Beier, as well as many of Beier's publications. Davis chronicles habitat conditions from many obscure references, such as his discussion of the Cienega de las Ranas, a vast former marshland which covered the Tustin plain: "Travelers skirting the edge of the great swamps that once extended southward from Bolsa Chica Mesa to Newport Mesa....encountered even larger populations of migratory wildfowl belonging to 83 species. 'This section of the country, according to a local historian,'...was one of the greatest natural habitats for wildlife and game birds in the world." Other topics among many include bubonic plague with its diversity of vectors, hantavirus, killer bees, and other exotics. An intriguing review is presented of science fiction, other popular, and pulp publications focused on everything from aliens to earthquakes which raze L.A. ("The Literary Destruction of Los Angeles").

Davis chose not to treat a number of subjects which would have been interesting reading, considering his vast perspective. Omitted are the Natural Community Conservation Plan (NCCP) and Habitat Conservation Plan (HCP) processes, which represent the "deal" between developers and state and federal enforcers of the Endangered Species Act(s). Nuclear power plants such as San Onofre are not discussed, and although great and well-documented detail is presented about historic losses of biodiversity, the California gnatcatcher, coastal cactus wren, Pacific pocket mouse and other sensitive species are not discussed, or they are mentioned only in passing. A short section would have been useful that lays-out the actual magnitude of wetland, coastal sage scrub, southern oak woodland, and native grassland losses, as well as an expanded discussion of the scope of rare, endangered, and threatened plants and animals in these communities. Omitted from an otherwise excellent review of the literature are the works of John McPhee (*Controlling Nature*, and *Assembling California*) on debris flows and other southern California disasters, Spence Olin's book on post industrial Orange County, and John Fante's wonderful novels set in southern California. Nonetheless, this book is a masterpiece, which does a fine job of tackling a mammoth topic. Davis' book is exceptional, and I recommend it highly to all.

The reviewer would like to acknowledge the University of California Natural Reserve System's San Joaquin Marsh Reserve for computer support, and a grant from the Transportation Corridor Agencies to the University of California School of Biological Sciences.

— ***Peter A. Bowler**, Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697-2525 and White Mountain Research Station, 3000 E. Line Street, Bishop, CA 93514*

A Manual of California Vegetation, By John Sawyer Jr., and Todd Keeler-Wolf. January 23, 1996. Hardcover $55.00, ISBN 0-943460-25-5; Softcover $39.00, ISBN 0-943460-26-3. California Native Plant Society Press. Includes 471 pages, 32 Color Plates, indices of plant names, NDDB/Holland types, vegetation names and codes, CNPS' community sampling protocol and forms, literature cited. Order from CNPS, 1722 J Street, Suite 17, Sacramento, California 95814; (916) 447-2677; fax: (916) 447-2727.

This publication, from the cover photograph by Tommy Dodson (the man with the tripod) to Frank Balthis' photo of a wildflower display in the Temblor Range east of the Carrizo Plains is well put together. The reader is introduced to the origin of this publication, its main players, and then the philosophy upon which it is based. The introduction also includes sections on the importance of this publication today and in the future for vegetation conservation and management, the history of vegetation classification in California, and a straight forward section titled "How to Use this Manual."

The thirty-two color plates give the reader a visual introduction to 143 of the 240 series, 10 of the 20 stands, all 7 of the habitats, and 3 of the 8 vernal pool vegetation types addressed in this publication. The 240 series described are divided into sections; fifty-two series dominated by herbaceous plants, 107 by shrubs, and 81 by trees. Each section has a key to their specific series. The 20 unique stands, 7 habitats, and 8 vernal pool vegetation types do not have keys, however. Information on each of the vegetation types includes:

— *dominant and characteristic companion species*
— *community architecture or physiognomy*
— *distribution limits*
— *endangerment status*
— *other classification synonyms*
— *discussion of previous studies*

This manual serves to shift conservation emphasis from a single species approach to that of collections of species in quantitatively described vegetation types. Many of these rare or endangered plant communities and their associated fragile species can be better protected from extinction using this method of listing. This manual is the first text to provide those tools, and allow the beginning of further quantification of additional vegetation types using CNPS field sampling protocol and forms. In my opinion, you need this publication whether, you want to define new plant associations, or understand the ones you are already familiar with.

— ***Alan P. Romspert**, Coordinator, California State University Desert Studies Consortium*

A Checklist of the Vascular Plants of Orange County, California, Second Edition by Fred M. Roberts, Jr. 1998. 96 pages. F.M. Roberts Publications, P.O. Box 231176, Encinitas, California 92023. Softcover $7.95 (ISBN 0-9643847-1-X). Order by mail for $10.57 (including shipping and tax) directly from F.M. Roberts Publications. Also available from the California Native Plant Society (see the review above for address information).

Fred Roberts' second checklist of the vascular plants of Orange County has finally appeared, and it is a must for southern California botanists. Attractively bound as a paperback, the list itself is easy to read, with the species names in bold and the common names in capitals. The format is essentially the same as Roberts' first checklist, with a brief introduction followed by the checklist, selected rare plant categories in glossary form, and appendices of excluded taxa, extinct and extirpated species, and nomenclatural cross references. Maps of the County with selected place names in 1920 and 1998, and references conclude the paper. It is interesting to note that despite nomenclatural changes, the number of native species for the county (806) is the same as those reported in the first checklist (Roberts, 1989), while recognized exotic taxa increased from 351 to 387.

Throughout the checklist Roberts maintains independence of taxonomic viewpoint from The Jepson Manual (Hickman, 1993), and frequently uses the nomenclature presented in Munz (1935, 1973, 1974), or others. For example, he rejects *Nassella*, instead retaining *Stipa*. Similarly, species relegated to *Leymus* in The Jepson Manual are treated as *Elymus* here; *Brassica* is retained for species placed in *Sinapis* and *Hirschfeldia* in The Jepson Manual; *Salicornia subterminalis* Parish becomes *Arthrocnemum subterminale* (Parish) Standl., because "*Arthrocnemum* is the [more] widely recognized globally than *Salicornia* for the group (woody succulent perennials...)." Roberts makes many corrections of The Jepson Manual nomenclature, such as retaining *Dichelostemma pulchellum* over *D. capitatum* because of nomenclatural priority, apparently missed in The Jepson Manual. A number of taxa such as *Lupinus agardhianus* not recognized in The Jepson Manual are included in Roberts' checklist. A number of families are not used by Roberts (Adiantaceae=Pteridaceae, Aspidiaceae=Dryptopteridaceae, Salviniaceae=Azollaceae, Orange County members of the Amaryllidaceae are placed in the Alliaceae, and so forth). The second checklist also incorporates nomenclatural changes subsequent to the The Jepson Manual, such as synonymizing *Opuntia parryi* Engelm. var. *parryi* with *Opuntia californica* (Torr. and A. Gray) Cov. var. *parkeri* (J.M. Coult.) D. Pinkava (based on *Haseltonia* 4:103-104, 1996).

Unfortunately, most of these rejections, synonymies, or retentions are made without discussion, which from a local botanist of Roberts' stature would have been useful and interesting. The authors of The Jepson Manual deserve a rebuttal rather than a wordless dismissal of a taxonomic position. These provocative interpretations need elaboration, particularly since the checklist is privately published without peer review; it can only be hoped that Roberts will provide the heart of his interpretations in some other treatment, although the revised checklist would have been an ideal place for such a discussion as a longer, more in depth work. Most southern California botanists use a nomenclatural mixture of Munz, Jepson and others, so Roberts' choices become a particularly important addition in the mix, as do his rationales for name selection. In addition to finding out what can be verified as occurring in the area encompassed by a checklist, botanists also use checklists as quick ways to look up correct species citations, and in this case they must select between Roberts, Munz and Jepson listings for many species. Nomenclatural corrections Roberts noted and might have made (valid publication of several taxa) cannot be accomplished in a privately published work. Roberts shortchanges us, and himself, by pursuing an overly terse approach with little narrative or discussion, which hides his remarkable insight, intuition, and originality.

Just as the first checklist did not align itself with Munz for many common names, the second checklist differs in non-scientific nomenclature from The Jepson Manual. Since common names are not restricted by the Code of Botanical Nomenclature they are fair game for poetic license, but it would nonetheless be helpful to have consistency between major treatments of taxa rather than continuing common name differences between Munz, Jepson, and again here in Roberts' latest checklist.

Including the cover, there are fifteen lovely line drawings by the author, illustrating key characters delineating difficult to separate taxa (*Scirpus robustus* and *S. maritimus*) or showing why a species was so named (the grappling hook of *Harpagonella palmeri*; the large pod of the bigpod lilac, *Ceanothus megacarpus*). None of the figures are numbered or cited in the checklist itself.

Following the checklist is a useful, although very brief glossary of rare plant listings including CNPS and other citations used in the checklist. An expanded list would have been useful, including state "G" designations, and expanding upon Fish and Wildlife Service categories. A revision of Roberts' rare and endangered plant list (1990) would have been a welcome addition. Appendix I ("Excluded Taxa") cites 43 non-native and 24 native taxa which are not considered adequately documented reports. Appendix II ("Extinct and Extirpated Species or Species Not Seen Recorded Since 1937") includes 10 exotic and 53 native taxa, with collection citations following each. It is not clear why the exotic taxa, if extirpated, are retained in the checklist, although the natives clearly should be. Similarly, it would have been useful to have a separate table or appendix presenting the 36 new exotic species reported in the second, but not in the first checklist, with a discussion, their area of origin, and method of introduction (if known) cited. Appendix III ("Nomenclatural Cross Reference") includes 10 pages of Roberts' interpretations (around 289 entries), which are fascinating, original and are based upon Roberts' extensive experience with the Orange County flora. These clear taxonomic judgement calls deserve an expanded discussion. The two maps are useful, but would be more so if development as of 1920 was indicated, as opposed to the present (which should include major park or preserved boundaries).

First reports (since Roberts, 1990) are not cited in the checklist, which would have been useful in a more completely annotated version, whereby the first report could be cited by footnote or author. Also, the bibliography is not comprehensive, in that it does not include all of the references for various new county records since Roberts' first checklist (Bowler and Wolf 1993, for example). New records by Roberts should have been indicated in the checklist, as well. While the overall technical quality of the book is high, nonetheless there are occasional spelling and spacing errors, and inconsistencies in format (italics or bold, etc.).

Most of the documentation, or collections, for the Orange County flora as treated here reside in 14 herbaria, including IRVC, which holds much of the material forming the basis of Roberts' first checklist. With the closure and dismantlement of the University of California's Museum of Systematic Biology in 1991, IRVC is now a part of the University of California, Irvine (UCI) Arboretum, and it will remain there permanently as a resource within the School of Biological Sciences. IRVC may be visited and used by appointment (pabowler@uci.edu) during weekday working hours, and through special arrangement on weekends. Material may be borrowed through standard loan procedures. As Roberts notes, a majority of the recent collections for Orange County reside in the Rancho Santa Ana Botanic Garden collection (RSA).

None of these technical observations should detract from the great value of this truly masterful work that Roberts has again produced. It is a staple that will be cited by southern California botanists until the third checklist appears in the future. Despite the wonderful price and excellent product that Roberts has self-published, I hope that an expanded third checklist will appear in a peer-reviewed forum, so that valid taxonomic changes can be made, and so that gray literature opinions will hold the weight that they deserve. This book is a significant and original interpretation of Orange County's flora by the botanist who knows it best, and it is a bargain that should be on all of our shelves.

The reviewer would like to acknowledge the University of California Natural Reserve System's San Joaquin Marsh Reserve for computer support, and a grant from the Transportation Corridor Agencies to the University of California School of Biological Sciences.

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— ***Peter A. Bowler**, Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697-2525 and White Mountain Research Station, 3000 E. Line Street, Bishop, CA 93514*

Second Review

A Checklist of the Vascular Plants of Orange County, California, Second Edition by Fred M. Roberts, Jr. 1998. (see review above for additional information)

Fred Roberts' updated checklist for Orange County includes all species and subspecies known from Orange County, as well as those documented since the previous checklist, first published in 1989. The checklist incorporates much of the nomenclature used in The Jepson Manual (Hickman 1993), along with authority, synonyms, and a common name. An introduction and brief summary of the flora are followed by three appendices that include: "excluded taxa" (i.e., those reported, but not documented by herbarium specimens); species extirpated or long uncollected in the county; and a comprehensive cross-reference to nomenclature used in The Jepson Manual, and Munz's (1974) A Flora of Southern California. The book also features about a dozen full-page illustrations of meticulous quality that have been prepared by the author.

For students and professionals working from keys in larger floras, the checklist will help with plant identifications by quickly paring down the likely taxa. Field biologists who routinely identify plants for their work will find the Checklist immensely useful. Note, however, that someone using a checklist this way should confirm identifications by comparing the plants to written descriptions in larger floras, or to pressed reference specimens. New species are continually added to regional floras, and collectors should not overlook the possibility that they have discovered a noteworthy addition. The checklist will also be useful to amateur botanists and wildflower enthusiasts, who may normally work from an illustrated field guide rather than a flora. By necessity, illustrated guides do not include all taxa in any region, but generally provide illustrations of representative members of the more showy genera. Amateurs may wish to use an illustrated guide to identify a genus, then refer to Roberts's checklist to learn which species in the genus are known from the local area.

The new Checklist is a convenient quick reference for spelling, common names, and the other memory jogs constantly needed for species lists, herbarium labels, or botanical reports. Its binding seems sturdy enough to withstand the folding and bending that I am likely to give it. It is organized by the system that botanists in California are now well familiar with. It begins with ferns and allies, then gymnosperms, then dicotyledonous angiosperms, and finally, the monocotyledonous angiosperms. Within these large taxa, families are arranged alphabetically, genera are alphabetical within families, and species are alphabetical within genera. Ease of use would be improved if each page had the family in a header. In the few weeks that I have used it, I have found no typographical or spelling errors, although I have made no special effort to search them out.

Roberts has generally followed the family taxonomy of the larger floras, but has not strictly adhered to either the Munz or The Jepson Manual conventions. For example, his treatment of the Liliaceae and allied families is more similar to Munz's than to The Jepson Manual's, but he places the onions in Alliaceae rather than Amaryllidaceae. Roberts has used his own judgement with lower level taxonomy rather than adhering rigidly to earlier works. For example, Roberts retains the genera *Microseris, Brassica*, and *Stipa* (cf. Munz 1974) rather than follow The Jepson Manual, which splits each into three genera. On the other hand, Roberts has not simply held to tradition for its own sake. He accepts the splitting of *Haplopappus* into its segregate genera, and the lumping of two shrubby *Mimulus* species into *M. aurantiacus*. Appendix 3 cross-references names, enabling the reader to quickly find a species, even where Roberts has used an unfamiliar name in the body of the checklist. I generally prefer Roberts' taxonomic judgements to those seen in the larger floras.

The current checklist includes 1193 species (increased by 36 from the 1989 edition). With few exceptions, it includes only species represented by a voucher specimen in a recognized herbarium, although it does not name these vouchers by collector and number. The lists of "excluded taxa" (Appendix 1) and extirpated or long-uncollected taxa (Appendix 2) total about 130 species. Some of these undoubtedly still occur in the county (e.g., *Rorippa curvisiliqua, Loeflingia squarrosa*, and *Opuntia basilaris*). These 130 taxa serve to remind us of the surprisingly poor state of floristic documentation, even in an area as heavily populated as Orange County.

I find the Checklist to be a useful desk reference for Orange County and adjacent cismontane southern California. Due to the absence of keys and descriptions, the Checklist will not be useful as a field reference, except to botanists already experienced and well-familiar with the plants. In the introduction, Roberts lets us know that a more complete flora is in the works, and I look forward to its publication.

— ***Scott D. White****, Scott White Biological Consulting, 99 East C St., No. 206 Upland, California 91786*

Conifers of California by Ronald M. Lanner. 1999. 274 pp. Softcover $24.95 (ISBN 0-9628505-3-5); hardcover $36.95 (ISBN 0-9628505-4-3). SCB members can receive a 10% discount by ordering (sorry, no credit cards) directly from the publisher; Cachuma Press, P.O. Box 560, Los Olivos, California 93341, telephone 805 688-0413 or email cachuma@silcom.com

Most of my friends know that I have always planned to write a book on the conifers of California. I have been known to travel to remote locations such as the Warner Mountains, the New York Mountains, or to Cone Peak in the Santa Lucia Mountains for the sole purpose of photographing and communing with a rare species of conifer. I even approached John Evarts of Cachuma Press with the idea of doing such a book. Wisely, John did not encourage me in this regard. Apparently, Ronald M. Lanner had beaten me to the punch, and he has done such a superior job that I am envious and humbled.

California is a focal point for the evolution of conifers. There are more taxa for this group in California than for any other region of similar size in the world. Simply stated, California would not be blessed with much of its spectacular scenery, were it not for its conifers. With this new volume on conifers by Ronald Lanner, Cachuma Press has produced a fine companion to its superb book on oaks (*Oaks of California* by Pavlik et al. 1991).

Accompanied by beautiful color photographs, many of which are the images of famous photographers, and the watercolor art of the late Otto Walter Murman, this book stands as one of the truly significant contributions to the literature about California plants. Of particular interest about the watercolors is that Murman died in 1962. The original renderings were archived in the biomedical library at UCLA, and many are published here for the first time. Even if the illustrations were not so beautiful, the text alone would make it a worthwhile contribution. Clearly, this is a "must own" volume for botanists and layman interested in California's distinctive flora.

One of the attractive features of this book is that it is not cluttered with taxonomy, yet where it is relevant, the controversies over classification are addressed. Technical aspects of the taxonomy, including a checklist and keys to genera based on cone morphology and characteristics of foliage are included in appendices at the back of the book.

Ronald Lanner is "lumper." He avoids unnecessary splitting of species, but he does not ignore variation. His philosophy, of which I approve, is revealed in the following quotation from the section on White Fir. He writes, "The name *Abies concolor* was first applied to members of what is now regarded as the Rocky Mountain variety of white fir, and that variety is called *Abies concolor* var. *concolor*, referred to as the 'typical' variety. The other variety, whose perceived distinctness triggered this splitting asunder of a species, is the California white fir, *Abies concolor* var. *lowiana*. Some plant scientists think the two are different enough to warrant being considered separate species.... Others think the differences are too slight even to differentiate varieties, and they lump all these firs together simply as *Abies concolor*."

Unlike many books of this type where a reader tends to turn to his favorite species and reads no further, this volume is so loaded with interesting bits of natural history that it begs to be read in its entirety. In the section on Jeffrey Pine we learn which chemical gives the bark its distinctive odor, and how present-day distribution is influenced by episodes of drought, periodic fires, and the activities of various animals that feed upon and cache the seeds.

Regarding the role of fire, Lanner repeatedly emphasizes the beneficial aspects of periodic fires, and he is critical of the well-known policies of fire suppression, as practiced by various public agencies. This is an interesting attitude, especially when one considers that he was once employed by the U.S. Forest Service in California. By the way, it also seems out of character that a man who spent 28 years teaching at Utah State University should write a book about California trees.

If I have a criticism of the book, it is that I would prefer to see more about biogeography. While paleoecology is discussed frequently, Lanner seems not to enjoy the luxury of conjecture about how the trees got where they are. I was particularly anxious to find out if he had any new theories about the peculiar distribution of insular populations of Bishop pine, Monterey Pine, and Torrey pine on the offshore islands of southern and Baja California.

Similarly, many authorities have been curious about the interesting distribution and controversy over classification of various pinyon pines. Lanner previously described a new species (*Pinus juarezensis*) from the Sierra Juarez of northern Baja California, and reduced the Parry pinyon (*Pinus quadrifolia*) to the status of a hybrid between the Sierra Juarez taxon and singleleaf pinyon (*Pinus monophylla*). In this respect, he behaves like a splitter. On the other hand, acting like a lumper, he downplays the work of Stephen Langer who described the southern populations of singleleaf pinyon as *Pinus californiarum*, and further described both single-needle and two-needle subspecies in the New York Mountains of the eastern Mojave.

All of this notwithstanding, I love the book, and consider it to be one of the finest books of its kind ever published. I heartily recommend that everyone who loves California purchase this book, and read it from cover to cover.

—***Allan A. Schoenherr****, Professor of Ecology, Fullerton College, Fullerton, California author of A Natural History of California (Univ. Calif. Press 1992); lead author of Natural History of the Islands of California (Univ. Calif. Press 1999)*

Original line drawing of *Yucca whipplei* by Dr. Jack H. Blok

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By request, the following article has been reprinted as a separate, with covers, and is available for plant collecting workshops:

Reprint. HERBARIUM SPECIMENS AS DOCUMENTS: PURPOSES AND GENERAL COLLECTING TECHNIQUES, by T.S. Ross [from *CROSSOSOMA* 22(1):3–39, 1996]...........................$3.95 each; 10 for $22.50.

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CONTENTS

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EFFECTS OF SCARIFICATION AND STRATIFICATION ON SEED GERMINATION OF *CROTON CALIFORNICUS* (EUPHORBIACEAE)

BRADFORD D. MARTIN, D. RICHARD RAKIJIAN, AND NORMAN L. MITCHELL
Department of Biology
La Sierra University
Riverside, California 92515

AND

JAMES L. SMITH II
Department of Natural Sciences
Loma Linda University
Loma Linda, California 92350

ABSTRACT: *Croton californicus* Muell.-Arg. is a subshrub inhabiting sandy soils of various communities of southwestern North America. The carunculate seeds of this species are difficult to germinate, indicating some form of seed dormancy. This study reports the experimental effects of scarification and stratification on seed germination. Seeds of *Croton californicus* were harvested from three populations in southern California, and collectively divided into three treatment groups, and a control. Seed treatments included scarification, stratification, scarification-stratification, with a non-treatment control. Scarification was accomplished by chemically treating the seeds in hydrochloric acid (pH 2.0) for one hour, and stratification was achieved by exposure to cold temperatures (6° C) for all or the first half of the experiment. All nonstratified seeds were maintained at room temperature, and the experiment was conducted for 90 days, at which point all germination had ceased for at least 12 days. No germination was observed in the stratified or control groups. Germination rates for scarified and scarified-stratified groups were 0.5% and 6.5% respectively. A scarified seed broke dormancy on day 4, with only one seed germinating. Scarified-stratified seed germination ranged from days 25-78, with 46% of these seeds germinating on days 55-56. Although overall germination rates were not high chemical scarification may stimulate seed germination, but cold stratification combined with chemical scarification promotes germination.

KEY WORDS: *Croton californicus*, Euphorbiaceae, seed dormancy, seed germination, scarification, stratification.

INTRODUCTION

Seed germination is an essential process in the ecology of plants in Mediterranean-type climates. Seeds of California native plants exhibit a variety of adaptations that enable them to suitably transition from a quiescent phase into an environment of periodic drought, extreme temperature, and fire (Keeley 1987, 1991; Emery 1995). Seed dormancy is one adaptation that helps plants to avoid activity during harsh environmental periods. This promotes the ability of plants to grow and establish themselves during favorable weather conditions. When conditions are suitable for plant growth, dormancy is broken by an environmental cue, such as temperature (Bell et al. 1993).

In general, there are two types of seed dormancy: seed coat dormancy and internal (embryo) dormancy (Emery 1995). Seed coat dormancy is usually due to seed coat impermeability to oxygen and/or water, but sometimes it is due to inhibiting chemicals in the seed coat. Natural weathering of the seed coat usually allows for the penetration of water, exchange of gases, and removal of inhibitory chemicals. Other methods of breaking seed coat dormancy include scarification, hot water, dry heat, fire, charate (char from burned plant stems), acid and other chemicals (Jones and Schlesinger 1980; Keeley and Pizzorno 1986; Keeley and Keeley 1987; Keeley 1991; Emery 1995). Internal or innate dormancy encompasses many physiological conditions that delay germination, but it is not fully understood, nor is it easy to counteract. After-ripening is a common cause of innate dormancy, whereby ripe seeds require a period of time to mature before they will germinate (Emery 1995). Maturation is often accomplished by subjecting seeds to moisture and high or low temperatures, but sometimes simple dry storage is sufficient to achieve this as well (Bell et al. 1993; Emery 1995). Seeds of plants that grow in high mountains or deserts where environmental extremes in temperature and moisture are encountered often exhibit after-ripening. The most common method for breaking internal dormancy is cold stratification. Almost 35% of the 905 native California plants discussed by Emery (1995) exhibit higher germination rates when stratified by cold temperatures. It is not uncommon for plants to be influenced by both seed coat and internal dormancy, as well as other multiple dormancy factors. Multiple dormancy factors are also exhibited in seeds with two or more distinct internal dormancy factors that unlock sequentially at different temperatures in various fluctuating patterns (Emery 1995). Low germination rates in many studies are often a result of multiple dormancy factors that are not well understood (Keeley 1987, 1991; Keeley and Fotheringham 1998).

Some members of Euphorbiaceae (spurge family) exhibit seed dormancy and require special conditions for seed germination (Lagoa and Pereira 1987; Pacini 1990). The caruncle, an appendage arising from the micropylar region of the seed in many euphorbs (Webster 1994), is often involved in seed dormancy and regulation of seed germination (Lagoa and Pereira 1987; Pacini 1990). This appendage functions in water absorption, and may speed up the germination process. After water is imbibed by the caruncle, enzymes begin to function in the rehydrated seed protoplasm, allowing metabolism and embryonic growth. Some spurges have seeds that do not germinate easily (Lagoa and Pereira 1989; Pacini 1990), which may indicate that multiple seed dormancy factors are inhibiting germination.

Croton californicus Muell.-Arg. is a "subdioecious" (Martin 1998) euphorb subshrub inhabiting sandy soils in various plant communities of southwestern North America. Seeds are hard-coated with smooth seed coats, which are often marbled with shades of brown and gray, resembling the larger seeds of the related spurge, castor bean (*Ricinus communis* L.). Variation in seed coat coloration, with seeds exhibiting polymorphic patterns of black and brown similar to *Croton (Eremocarpus) setigerus* Hook. exists in *C. californicus* (Cook et al. 1971). Caruncles of *Croton californicus* are located near the apex of the seed in the micropylar region, and these become swollen when placed in water. Emery (1995) reported that *Croton californicus* does not require any special treatment for seed germination. However, numerous pilot experiments involving treatments of mechanical scarification, chemical scarification, caruncle removal, leaching, and burning were conducted by the current authors, and not a single seed germinated. Other researchers have had similar difficulties in germinating seeds of *Croton californicus* (Barbieri et al. 1999). Although not reported, Emery and Frey (1971) also had difficulty germinating *Croton californicus* seeds. They found that cold stratification was the most successful treatment for breaking dormancy (Frey, personal comm.). This study reports the experimental effects of scarification and stratification on seed germination and seed dormancy.

METHODS

Seeds of *Croton californicus* were collected from three populations in southern California: 1) Mockingbird Canyon Archeological Site in Riverside, Riverside County; 2) the hills south of Loma Linda, San Bernardino County, and; 3) the Santa Ana River flood plain in East Highlands, San Bernardino County (Figure 1). Collections were made late in the flowering season (October 24-29, 1996) by harvesting mature fruits, just before dehiscence. Fruits were initially maintained in paper bags to allow drying and dehiscence, then seeds were separated from fruit tissues approximately 2-

4 weeks following harvest. Cleaned seeds were randomly mixed from the different populations, and then stored at room temperature in two closed glass bottles prior to the germination experiment.

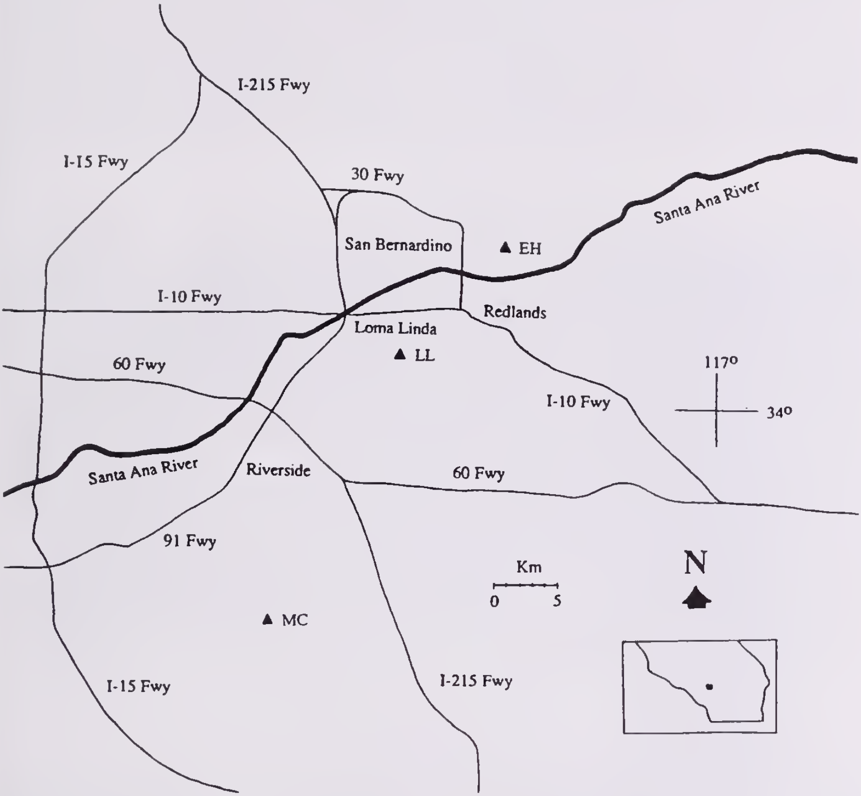

Figure 1. Map of sites where seeds of *Croton californicus* were collected. Sites are indicated by triangles: MC = Mockingbird Canyon; LL = Loma Linda; and EH = East Highlands.

On January 15, 1998, 800 seeds were divided into four groups of 200 seeds each (three treatments and a control), which were further subdivided into eight replicates of 25 seeds each. All seeds were disinfected in a 10% sodium hypochlorite solution for 10 minutes, and the replicates were placed in sterilized petri dishes (90 x 15 mm) lined with filter paper which was saturated using deionized water. Seeds were uniformly spaced in petri dishes, and the filter paper was kept saturated for the duration of the experiment. Treatments included seeds that were scarified, stratified, scarified-stratified, and a control of nonscarified and nonstratified seeds. Scarification was accomplished by chemically treating the seeds in hydrochloric acid (pH 2.0) for one hour, followed by rinsing several times with deionized water. Stratification was achieved by exposure to cold temperatures (6° C) for all or the first half of the experiment, while nonstratified seeds were maintained at room temperature. Half of the stratified and scarified-stratified replicates were removed from the cold treatment on day 54, and then placed in room temperature. Stratification was continued for the other half, because of the positive results obtained in a pilot experiment.

All treatments were maintained in the dark and the experiment was conducted for 90 days, at which point all germination had ceased for at least 12 days. A seed was considered germinated when the radicle initially protruded through the seed coat. Seeds that germinated were not removed from the petri dishes. Chi-square analysis with Yates correction for continuity (Zar 1996) was used to compare differences in patterns of seed germination. However, 2 x 2 contingency analysis could not be used to statistically compare the overall germination rates in the various treatments, due to zero values in two data cells (i.e., stratified and control groups).

RESULTS

There was no germination of *Croton californicus* seeds in the stratified or control groups. Mean germination rates for scarified and scarified-stratified groups were 0.5% (± 0.2% SE) and 6.5% (± 2.3% SE) respectively (Figure 2). Scarified seeds started breaking dormancy on day 4, with only one seed germinating, but which died on day 47 of the experiment. Scarified-stratified seed germination exhibited a delayed sigmoidal growth pattern, ranging from days 25-78, with 46% of these seeds germinating on days 55-56 (Figure 3). Interestingly, this relatively rapid increase in germination occurred within two days after the stratified replicates were removed from cold conditions on day 54, and placed at room temperature. However, there was no significant difference ($p > 0.99$) in the amount of germination between stratified replicates that were removed when compared to replicates that remained in the cold treatment. All germination ceased on day 78, and seeds were observed until day 90, before terminating the experiment.

Immediately after rinsing seeds during the initial setup of the experiment, seeds that were scarified appeared to be larger and more swollen than seeds that were not scarified. Also, caruncles of scarified seeds were white and notably enlarged due to the imbibition of water. This swollen appearance remained for the duration of the experiment, and nonscarified seeds never did enlarge to an equal size. Growth of radicles was much slower in germinated seeds that remained in cold stratified treatment conditions. Fungal contamination was observed at relatively low levels in all treatments until late in the study, at which time the fungal growth appeared to rot seeds. However, there was consistently and noticeably less fungal growth in the cold stratified replicates when compared to room temperature replicates.

DISCUSSION

Although germination rates of this study were not high, our results indicate that chemical scarification stimulates seed germination of *Croton californicus* only when combined with cold stratification. Scarification is an important process in breaking seed coat dormancy in many hard-seeded chaparral and desert plants (Keeley 1987, 1991; Bell et al. 1993; Gutterman 1994). Hydrochloric acid was used to scarify seeds in this experiment, which differs from sulfuric acid, the traditional acid treatment used to stimulate germination (Mirov and Kraebel 1939; Emery 1995). This could possibly influence germination rates because sulfuric acid and nitric acid would be the acids most likely encountered in soils, while hydrochloric acid would simulate a gastric environment of animals possibly ingesting and scarifying seeds. Chemical scarification of seeds by digestion in gophers is suspected to stimulate seed germination in natural populations of *Croton californicus* (Martin 1995). However, other types of scarification, such as fire, may be equally important in breaking seed dormancy (Martin 1995).

Although scarification and stratification stimulate seed germination, the low germination rates obtained in this study may be due to other factors known to inhibit seed germination. For example, caruncles are known to mechanically and/or chemically inhibit seed germination in some euphorbs (Lagoa and Pereira 1987, 1989; Pacini 1990) and other plants (Bullock 1989; Milimo and Hellum 1989). Pacini (1990) reported that caruncle removal of *Mercurialis annua* L. seeds allowed hydration of the endosperm and embryo in only one day, while seeds with intact caruncles did not hydrate even after one month. Caruncles can inhibit germination by physically blocking water and gas exchange.

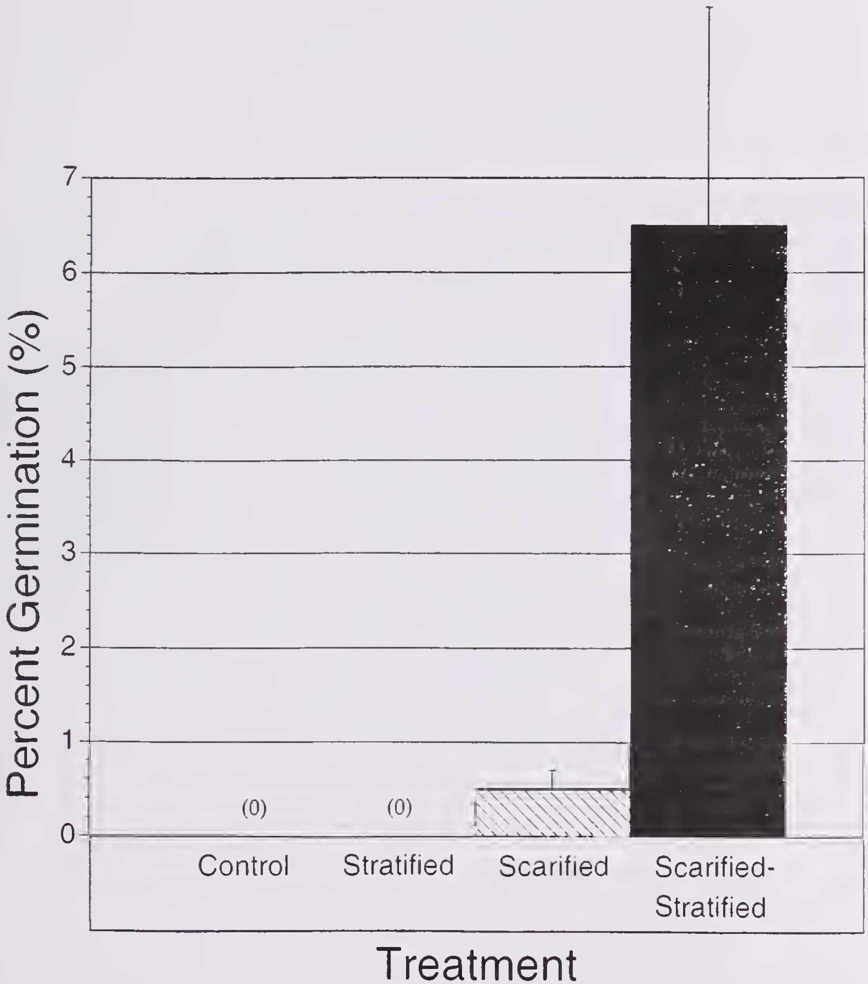

Figure 2. Percent germination for three experimental treatments of *Croton californicus* seeds. Values plotted are mean percents ± one standard error.

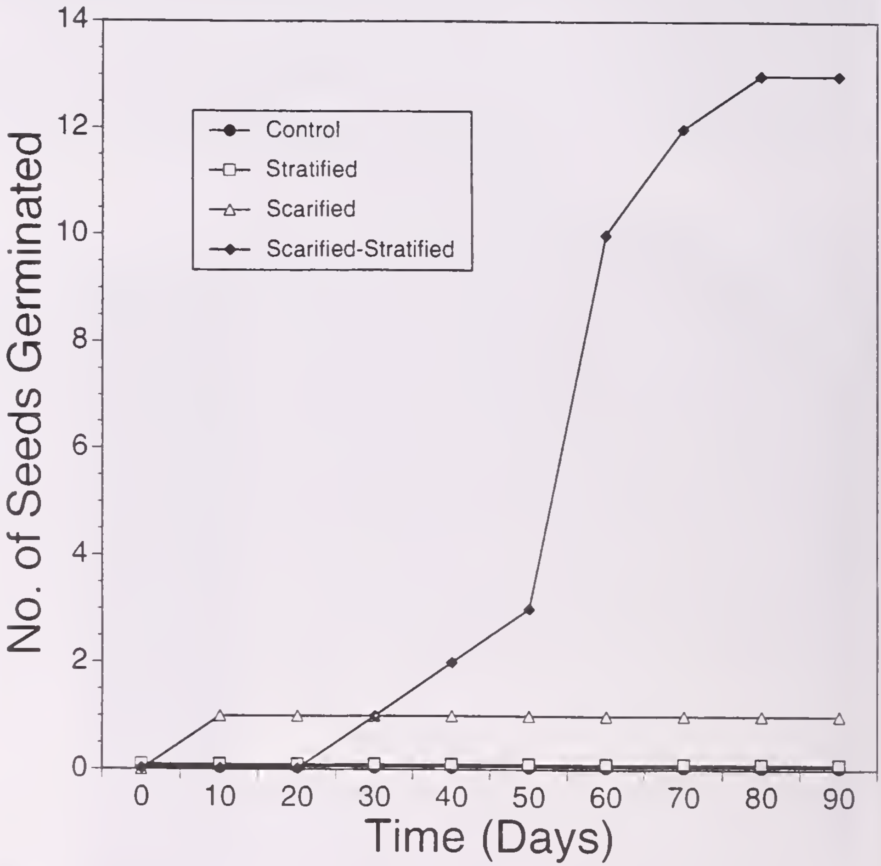

Figure 3. Temporal germination patterns for three experimental treatments of *Croton californicus* seeds.

Leachate of caruncles is also known to chemically inhibit seed germination in *Ricinus communis* (Lagoa and Pereira 1987). Leaching of spurge seeds may either stimulate seed germination by removal of chemical inhibitors (Pacini 1990), or inhibit germination by removing chemical promoters such as gibberellic acid (Lagoa and Pereira 1989). Almeida (1988) discovered that leaching seeds of *Croton glandulosus* L. and *C. lundianus* Muell.-Arg. reduced germination rates, and thus, it may have removed stimulatory chemicals like gibberellic acid. The inhibitory chemicals in caruncles of euphorbs are known to be phenolics (Lagoa and Pereira 1987; Pacini 1990). Phenolic compounds in seed coats increase seed longevity by chemically inhibiting microorganisms, and by physically hardening the seed coat (Mohamed-Yasseen et al. 1994). The higher the phenolic content, the harder the seed coat.

Caruncles of *Croton californicus* were not removed in this study, and this may have inhibited germination. However, pilot studies indicated that caruncle removal by itself was not a significant factor in stimulating seed germination, and therefore, it was not included in the experimental design of the current study. Nonetheless, Lagoa and Pereira (1989) found that the combination of caruncle removal and scarification of *Ricinus communis* seeds significantly increased germination, whereas scarification alone did not. *Croton californicus* may require a combination of factors to allow germination to occur.

Ants are known to disperse seeds of numerous genera of carunculate spurges (Webster 1994), and also remove caruncles (Pacini 1990). Although ants were not observed collecting seeds of *Croton californicus*, seeds are uncommon on the ground below and around female plants that are known to have shed hundreds to thousands of seeds earlier in the season (Martin and Smith unpubl. data). It would seem probable that ants, gophers, and/or birds are harvesting seeds, and either ingesting them and/or storing them in underground nests. Pacini (1990) observed ants harvesting carunculate seeds of three euphorbs and storing these in seed chambers of their nests. Closer observations are needed to confirm if any ants, or other animals, are harvesting and storing seeds of *Croton californicus* underground. Except for recently burned areas, young seedlings in the field are rare, and often found germinating 3-5 cm below the soil surface (Martin and Smith unpubl. data), usually in gopher-disturbed soils (Martin 1995). Explosively-dehiscent schizocarps typically disperse carunculate spurges by hurling seeds up to several meters away from the parent plant, and this mode of dispersal can be further facilitated by ants (Pacini 1990; Webster 1994).

The germination medium (i.e. filter paper or soil) can also inhibit seed germination. Keeley (1987) reported that approximately 30% of the chaparral plants tested exhibited significantly lower germination on filter paper when compared to seeds sown in soil. Seeds sown on filter paper almost always developed fungal growth, which probably inhibited germination. Low germination rates in the current study may be due to the usage of filter paper and resultant fungal contamination, especially in the petri dishes at room temperature.

The dark conditions used in this experiment may have inhibited seed germination of *Croton californicus*. Keeley (1987) found that seed germination of many coastal sage subshrubs was inhibited in the dark. However, the lightweight seeds of most coastal sage subshrubs germinate in the absence of fire (Kirkpatrick and Hutchinson 1980; Keeley and Keeley 1984; Keeley 1987), unlike *Croton californicus*, in which germination is stimulated by fire (Martin 1995). This may be related to the hardness of the seed coats of *Croton californicus*, which is a characteristic associated with fire-stimulated germination (Keeley 1991; Bell et al. 1993). Seeds of most subshrubs of coastal sage scrub do not have hard seed coats, and therefore, they are not stimulated to germinate by fire (Hanes 1971; Keeley and Fotheringham 1998). Hard-seeded shrubs can also be mechanically scarified, as has been observed in many desert shrubs and trees, the seeds of which are tumbled in washes during flooding (Gutterman 1994). In this regard, *Croton californicus* inhabits sandy ravines and floodplains of coastal sage scrub and deserts that are periodically disturbed by flooding.

Another possible explanation for the reduced germination rates observed in this study may be the method of seed storage prior to the experiment. Went (1969) found, for 70% of the 100 species of various California plants tested, that seeds kept in vacuum-sealed glass tubes retained high levels (44-61%) of seed viability for up to 20 years. Seeds of these same species that were left exposed to atmospheric air decreased to 1% viability in 10 years. Seeds of desert species were primarily the only ones that were not affected by open air storage. Seeds of *Croton californicus* used in the current experiment were slightly over a year old. Went (1969) observed a slight reduction in seed viability after one (41% germination rate) and two years (37% germination rate) of open air storage. It would appear that this is not a significant factor in low seed germination rates of the current study, because seeds were kept in sealed glass bottles. Also, seeds that were only a few months old were used in pilot experiments that yielded 0% germination and it was suspected that *Croton californicus* seeds need an after-ripening period. It is possible that *Croton californicus* has innate low rates of seed germination to produce long-lived seed banks in natural populations. Dormancy of seeds and the germination of only a portion of the seed population of many plant species enable seeds to remain in the seed bank for many years (Gutterman 1994). This is particularly important for plants inhabiting small, separate patches, typical of extreme environments such as deserts. Seed coat color variation of *Croton californicus* may indicate differences in seed viability, as observed in *Croton setigerus* (Cook et al. 1971).

Seeds of *Croton californicus* may be under both seed coat dormancy and internal dormancy. Pilot experiments that produced 0% germination were conducted using various treatments (e.g. scarification, caruncle removal, leaching, and burning) applied independently. The current study combined two treatments together which were successful in breaking dormancy in some seeds. Scarification may break seed coat dormancy, while cold stratification may break innate dormancy. However, other environmental factors may also break seed dormancy, in combination with scarification and stratification, to achieve higher rates of germination.

Future experiments should include not only scarification and cold stratification, but also treatments involving seeds sown in soil, different light and temperature regimes, caruncle removal, caruncle leachate, embryos excised from the seed coat, fire, and smoke exposure. Smoke-stimulated seed germination, with rates as high as 100%, have been found in 25 chaparral species, many of which exhibited 0% germination for experimental controls (Keeley and Fotheringham 1998). However, Keeley and Fotheringham (1998) reported that smoke-induced species had seeds that were: 1) small with highly textured seed coats; 2) not hard-seeded, and; 3) not heat-stimulated. In contrast, *Croton californicus* has seeds that are quite different from the smoke-stimulated species studied by Keeley and Fotheringham (1998), and it is not known whether the fire-stimulated germination observed in *Croton californicus* is due to heat, charate, or smoke.

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EDITORIAL: SCB COMMENDS FIELD BOTANISTS FOR SIGNIFICANT DISCOVERIES

Since the publication of The Jepson Manual (Hickman [editor]) in 1993, and the most recent edition of the California Native Plant Society's Inventory (Skinner and Pavlik) in 1994, several species of vascular plants that are new to science have been discovered, and several other plants formerly considered extinct have been rediscovered in southern California. At this year's Symposium held on 23 October 1999, it was our pleasure to award certificates to the following field botanists for these significant discoveries. We hope that by recognizing them and publicizing their contributions, others will be inspired in their continuing exploration and documentation of southern California's flora.

R. Mitchel Beauchamp, James Henrickson, and Carl Wishner, for discovering *Baccharis malibuensis* Beauchamp and Henrickson (Asteraceae). Wishner collected the first specimens of this new species in 1988 and 1991, and recognized it as unusual. It resembled *B. plummerae* Gray, but differed enough to make identification uncertain. Beauchamp and Henrickson independently found it at additional locations. When Wishner brought his specimens to their attention, the three botanists realized they had discovered the same species. Beauchamp and Henrickson published the formal description in *Aliso* 14:197-203 (1996), including citations of specimens and locations and a discussion of affinities with *B. plummerae*. *Baccharis malibuensis* is known only from the Malibu Creek watershed in the Santa Monica Mountains, where it occurs in chaparral, oak woodlands, and grassy openings, on sedimentary and volcanic substrates. The species is included on California Native Plant Society's List 1B.

Steve Boyd and Timothy S. Ross, for discovering and describing *Sibaropsis hammittii* Boyd and Ross (Brassicaceae). Boyd and Ross first collected this plant at Elsinore Peak in the Santa Ana Mountains (Riverside County). The following year, Jeri Hirshberg and Craig Reiser each collected it independently in the Cuyamaca Mountains (San Diego County). Based on the few known occurrences, *Sibaropsis hammittii* is found in *Stipa pulchra* A. Hitchc. grasslands on upland clay soils. The original description published in *Madroño* 44:29-47 (1997) includes a discussion of its taxonomic affinities, habitat, and conservation considerations.

Jerilyn Hirshberg, for discovering *Arabis hirshbergiae* Boyd (Brassicaceae). This new species is closely related to *Arabis johnstonii* Munz and *A. parishii* Watson, narrow endemics of specialized rocky habitats in the San Jacinto and San Bernardino Mountains, respectively. *Arabis hirshbergiae* is known only from similar "pebble plain" habitat in the Cuyamaca Mountains, San Diego County, where Hirshberg discovered it in 1995. The formal description, by Steve Boyd, appears in *Aliso* 17:203-205 (1998).

Ed LaRue, for discovering *Twisselmannia californica* Al-Shehbaz (Brassicaceae). This is a new monotypic genus, probably closely allied to *Tropidocarpum* Hook., of saltbush scrub flats in the San Joaquin Valley. LaRue collected the plant in 1994, and took it to Andy Sanders at the UCR herbarium for identification. Sanders didn't recognize it, and sent the specimen to Reed Rollins. Dr. Rollins recognized it as an undescribed species, but did not formally describe it before he passed away in 1999. The specimen was forwarded to Ihsan Al-Shebaz at Missouri Botanical Garden, who prepared the formal description, published in *Novon* 9:132-135 (1999). The plant is known only from its type locality near Kettleman City (Kings County), where it was collected a second time in 1999 by Dean Taylor and Barbara Ertter.

Rick Riefner, for the rediscovery of *Chorizanthe parryi* Watson var. *fernandina* (Watson) Jepson (Polygonaceae). This spineflower historically occurred in and around the San Fernando Valley of Los Angeles County and coastal drainages of Orange County. Before Riefner's rediscovery, it had been presumed extinct and had not been collected since 1940. His discovery On Laskey Mesa, (proposed, massive Ahmanson Ranch development) is also the first record for the plant in Ventura County. It occurs in xeric openings of annual grassland and adjacent coastal sage scrub.

Andrew Sanders, for the rediscovery of *Hemizonia mohavensis* Keck (Asteraceae) and *Allium marvinii* Davidson (Liliaceae, *s.l.*). Prior to 1994, *Hemizonia mohavensis* was known only from the Mojave River, at the northern foot of the San Bernardino Mountains, and reportedly also from chaparral in the San Jacinto Mountains. It had not been collected since 1933, and was presumed extinct. Sanders rediscovered it in the San Jacinto Mountains in 1994, and since then, he, Jeri Hirshberg, Darin Banks, and Steve Boyd have collected it at several sites in southern Riverside, and northern San Diego Counties. It has not been rediscovered in San Bernardino County. Sanders, Banks, and Boyd published an account of its known distribution in Madroño 44:197-200 (1997). Subsequently, it has been discovered in Short Canyon, Kern County. An herbarium specimen collected near Jawbone Canyon, also in Kern County, has been determined as this species. *Hemizonia mohavensis* flowers late in the summer, and occurs in swales, intermittent channels, and around seeps in rolling eroded granitic substrates. The wide gap in its geographic distribution suggests that additional occurrences might be found in the San Gabriel and Tehachapi Mountains.

Allium marvinii was originally described by A. Davidson in 1921 (*Bull. Southern Calif. Academy of Sciences* 20:49) based on material collected by J.C. Marvin in 1921. Marvin described it as "abundant on a hill east of Beaumont." LeRoy Abrams, in the first volume of his Illustrated flora of the Pacific states (1923), synonymized *A. marvinii* with the common and widespread *A. haematochiton* Watson. Phillip Munz and David Keck (1959), and subsequent authors have followed Abrams' synonymy. Sanders collected *A. marvinii* in 1993 near Yucaipa, and recognized it as a distinctive species not treated in local or regional floras. It was only by digging through historic herbarium specimens that he was able to identify the plant. The only known collections are from the San Bernardino Mountain foothills, near Yucaipa and Beaumont. *Allium marvinii* is distinguished from *A. haematochiton* by differences in fruit shape, and the absence of red pigment in bulb coats. It will be included in the next edition of the CNPS Inventory on List 1B.

Kate Symonds, for the rediscovery of *Astragalus pycnostachyus* Gray var. *lanosissimus* (Rydb.) Munz & McBurn. (Fabaceae). This milk vetch was historically known from coastal salt marsh habitat in Orange, Los Angeles, and Ventura Counties, which largely have been lost to development. Prior to Symonds' discovery, it had not been collected since 1967, and was presumed extinct. The new occurrence, and still the only known extant occurrence, is on a former industrial site now *approved* by the City of Oxnard for residential development.

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— ***Scott White, President, Southern California Botanists***

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— ***Alan P. Romspert**, Treasurer, Southern California Botanists*

PLANTS OF SYCAMORE CANYON PARK, RIVERSIDE, CALIFORNIA

PATRICK J. TEMPLE
U.S. Forest Service
PSW Experiment Station
4955 Canyon Crest Drive
Riverside, CA 92507

ABSTRACT: Sycamore Canyon Park (SC) is an area of approximately 567 ha (1,400 acres) in the southeast quadrant of the city of Riverside, California, that was set aside as a preserve for Stephens' Kangaroo Rat (*Dipodomys stephensi* Merriam) and other endangered animals. The vegetation of SC consists primarily of annual grasslands, dominated by weedy grasses and mustards of European origin, and Coastal Sage Scrub species, primarily *Encelia farinosa*, *Eriogonum fasciculatum*, *Salvia mellifera*, and *Artemisia californica*. Small areas of riparian habitat support *Platanus racemosa*, *Populus fremontii*, and several species of *Salix*. Although the area has been greatly disturbed by grazing, agriculture, and invasion of weedy species, 201 native plant species were recorded in SC in surveys conducted from 1993 to 1998. An additional 84 introduced plant species were also recorded. The largest plant families included Asteraceae (56 spp.), Poaceae (35 spp.), Fabaceae (16 spp.), Scrophulariaceae (15 spp.), and Brassicaceae (12 spp.). Although few of the species found in SC are listed as threatened or endangered *per se*, over 23 per cent of the plants were found only as a few isolated individuals or small colonies, threatened with local extinction. This flora of Sycamore Canyon Park provides a record of plants currently growing in an area of interior Coastal Sage Scrub vegetation that is rapidly disappearing because of development, or that is undergoing profound changes because of conversion of shrubland to annual grassland.

KEY WORDS: Coastal Sage Scrub, Riverside, shrubland conversion, Stephens' kangaroo rat, Sycamore Canyon Park.

INTRODUCTION

The native vegetation of southern California's Coastal Sage Scrub (CSS) communities is being drastically altered by the combined forces of urban development, fire and other disturbances, and invasion by weedy plants. Coastal Sage Scrub has the unfortunate distinction of being located in one of the most rapidly developing and urbanizing areas of the country, and within this area, it is found on highly desirable lowland flats and foothill slopes. Earlier disturbances of CSS by grazing and agriculture have now been overtaken by wholesale conversion to urban and suburban development. Quantitative estimates of the amount of original CSS habitat that has already been lost vary from 66 percent (Brandman 1991, quoted in O'Leary 1995) to the frighteningly high figure of 90 percent (Westman 1981). Whatever the present amount of conversion, it is obvious that in the not too distant future, CSS in southern California will be reduced to a few, isolated, embattled remnants in an ocean of urban sprawl.

Recently, a new threat to CSS habitats has been recognized: invasion by weedy annual plants, primarily annual grasses and mustards, and consequent conversion of shrublands to annual grasslands. The number of alien plant species invading California's habitats has increased exponentially from the relative handful introduced at the time of the Spanish colonization, to well over 1,000 today (Hickman 1993). The South Coast has the highest percentage of alien plant species of any area in the state (Randall et al. 1998), no doubt associated with the long history of disturbance and enormous human population increases in this region. Curiously, although many of the annual weeds invading CSS, particularly annuals in the genera of *Bromus*, *Avena*, *Brassica*, *Hordeum*, and *Erodium* have been in southern California since before the 20th Century, it is only within the last 30 years or so that wholesale conversions of relatively undisturbed CSS to annual grasslands has been observed in western Riverside County (Minnich and Dezzani 1998). This conversion has been accompanied by significant losses in plant species diversity, as native annuals, perennials, and shrubs are out-competed by aggressive weedy grasses and mustards.

The dramatic loss of CSS habitat and rapid changes in community structure and species composition make it imperative that a contemporary record of current plant species be compiled in the remaining areas of CSS. The objective of this research is to provide an inventory of plant species growing in one of those CSS remnants, namely, Sycamore Canyon Park (SC), located in the southeastern quadrant of the city of Riverside, California.

SHRUBLAND CONVERSION

The mechanisms through which shrublands are converted to annual grasslands are under active investigation (Minnich and Dezzani 1998). The process may begin with some disturbance such as grazing and/or increased frequency of fire that favors the growth of annual grasses over that of native perennial grasses, herbaceous plants, or shrubs (D'Antonio and Vitousek 1992). The weedy annual grasses germinate earlier in the spring and grow faster than most native plants, out-competing native annuals, shrubs, and tree seedlings for light, and for water stored in the soil (O'Leary and Westman 1988). In addition, annual grasslands are inherently more fire-prone than native shrub vegetation and native perennial bunch grasses, because of the high flammability of the desiccated grass stalks. Furthermore, increased frequency of fires favors the growth of annual grasses (D'Antonio and Vitousek 1992). As population densities of annual grasses increase, a dense thatch layer develops at the soil surface, preventing the germination and growth of shrub seedlings. The shrubs of CSS communities are relatively short-lived, and maintenance of intact CSS stands may require continual recruitment of shrub seedlings under the relatively open canopies, rather than vigorous re-sprouting after fire, as is more frequent in chaparral communities (O'Leary 1990). This may be particularly true of "riversidian" CSS (Westman 1983), as some studies have shown very limited resprouting of CSS shrubs on xeric, interior plots (Myers 1984; Westman and O'Leary 1986) compared with CSS shrubs from immediate coastal habitats. Deprived of seedling establishment because of competition from the annual grasses, CSS declines and is converted to annual grassland.

Air pollution is another environmental stress that may play a significant role in altering CSS habitats, particularly in Riverside. Westman (1979) measured the frequency and density of shrubs at 67 sites throughout the range of CSS in southern California, and correlated these data with a suite of climatic and edaphic variables measured at each plot. Using data on ambient ozone concentrations extrapolated from the closest available air quality monitoring stations, he reported that the highest correlation between shrub density and any environmental variable was with ozone concentration, with lowest percent shrub cover and lowest species diversity on plots located in areas with the highest ozone concentrations, specifically, Riverside. He concluded that ozone had played a role in altering species density and composition in CSS plots in Riverside. However, subsequent experimental exposures of common CSS shrubs; e.g. *Encelia farinosa* and *Artemisia californica*, to ozone showed that these species were resistant to ozone, except at the earliest seedling stages of development (Stolte 1982; Preston 1986; Temple unpubl.). In addition, ambient ozone concentrations are generally low in winter and spring, when the plants of the CSS community are most physiologically active. Also, peak ozone concentrations have declined significantly in southern California in recent years (Davidson 1993), yet the pace of conversion of CSS to annual grasslands has apparently increased. This suggests that other factors beside or in addition to ozone may account for the low shrub frequency and density in Riverside reported by Westman (1979). For example, increased nitrogen deposition in native shrublands close to urban areas may favor the growth of annual weedy grasses or depress growth of CSS shrubs (Allen et al. 1996). Atmospheric nitrogen deposition in Riverside, where CSS habitats have shown severe declines, is up to four times greater than at Lake Skinner, 45 km SSE of Riverside, where the CSS is relatively intact. Surface soil nitrate concentrations were also significantly greater in CSS plots in Riverside compared with those at Lake Skinner (Padgett et al. 1998). Further research is needed to assess the role that atmospheric deposition of nitrogen compounds and other air pollutants play in the decline of native shrublands in southern California.

PHYSICAL DESCRIPTION

Sycamore Canyon Wilderness Preserve (SC), is an area of approximately 567 ha in the southeastern quadrant of Riverside, California [33° 55-57' N latitude; 117° 17-20' W longitude], as shown on Figure 1. The area is approximately 4.5 km long, from its northern border on Central Avenue to just north of Allesandro Blvd. on the south, and 0.5 to 2 km wide. The east and west boundaries of SC are highly irregular, generally following the 485 m (1,600') contour on both sides of the main ravine. The elevation at the northern edge of SC is approximately 360 m, rising rapidly to 450 m in the south, and to over 485 m along the ridgetops. The highest point in the park is approximately 515 m. The area is bisected by a stream that originates in the Box Springs Mountains located 6 km to the northeast. The stream flows south from the mountains, then curves northwest through SC, and eventually reaches the Santa Ana River through Tequesquite Arroyo. As it enters SC, the stream flows through relatively flat terrain composed of Quarternary alluvial deposits on the Perris block. To the north, the permanently-flowing stream tumbles down through the eponymous steep-walled canyon, over large granitic boulders weathered from the Southern California Batholith (Rogers 1965). At its steepest, the walls of Sycamore Canyon rise 75 m or more from the stream bed, and the steep, shaded northeast-facing slope provides a mesic environment for plants not found elsewhere in the park. On either side of the stream are a series of ridges, the highest of which rise steeply to over 485 m. The SE-NW direction of these ridges reflects the northwest-striking faults of the San Jacinto Fault Zone (Allen 1957). The highest ridge crests consist of exposed, highly eroded quartz diorite and granodiorite rocks of the Southern California batholith (Morton and Gray 1971), skirted by scree slopes of decomposed granite. In general, the topography of SC is gently to steeply rolling hillsides, with numerous granitic outcrops and steep ridges dissected by deep, narrow ravines. Soils of SC are primarily in the Cieneba-Rockland-Fallbrook association, consisting of well-drained, undulating to steep, very shallow to moderately deep soils, with surface layers of sandy loam, developed on granitic rock (Knecht 1971).

The climate of SC is typically Southern California Mediterranean, with long, hot, dry summers and cool winters, with highly variable amounts of precipitation. In a typical year, no rain will fall from April until November (NOAA 1997). Annual precipitation at a meteorological station less than 2 km to the NE averaged 264 mm (1949-1998), but this long-term mean included a few years with extraordinarily high precipitation, and many years with annual precipitation of 200 mm, or less. A prolonged series of dry years from 1984 through 1990, in which annual precipitation averaged less than 175 mm (NOAA 1999), may have contributed to the recent conversion of CSS to annual grasslands.

PARK HISTORY

Historically, the hills and gentle slopes of SC were used for grazing and for dryland agriculture, until relatively recently. Evidence for agricultural usage include remnants of barbed wire fences, and a large grove of olive (*Olea europaea*) trees that still persists in the southeast corner of SC. The entire area was grazed by sheep (*Ovis ovis*) until the early 1990's, when the practice was stopped. In June, 1998, a major fire consumed about 280 ha in the northeastern section of SC. That same area had also burned in 1980. Otherwise, no major fires have been noted in the park for at least the last 20 years.

Figure 1. Sycamore Canyon Park, Riverside, California.

0 1 KILOMETER

Sycamore Canyon was originally set aside by the city of Riverside to preserve the deep canyon and Native American artifacts. The park was greatly expanded in the 1980's, when the area was included in habitat to preserve the endangered Stephens' Kangaroo Rat (SKR) (*Dipodomys stephensi* Merriam). This species prefers open herbaceous to shrubby habitat, with relatively low grass cover. Seeds of *Artemisia californica, Eriogonum fasciculatum*, and various other shrubs in the Asteraceae form the major part of its diet (Jameson and Peeters 1988), but it also forages on seeds of *Erodium cicutarium*. Stephens' Kangaroo Rat avoids areas of dense *Bromus*, *Avena*, or mustard cover. Two or three pairs of the endangered California Gnatcatcher (*Polioptila californica* Brewster) also breed in the area. This bird prefers dense *Encelia* and *Eriogonum* shrubland for breeding, so SC presently provides sub-optimal habitat for this species. A small population of the San Diego (Coast) Horned Lizard (*Phrynosoma coronatum* Blainville ssp. *blainvillii* Gray) can still be found in SC on arid, open hillsides. This species is severely threatened in southern California because of habitat destruction. Thus, although SC habitats have been disturbed over the years, the area plays an increasingly important role in the preservation of these endangered species.

The Riverside area has been botanized extensively, but no systematic study of the vegetation of SC has recently been published. The first list of plants of the Riverside area was compiled by Reed (1909), who listed 1,245 species growing in a wide area centered around Riverside. Many plant species listed therein as common in "foothills around Riverside," or in "Arroyo Tequisquite," whose upper drainage includes parts of SC, can still be found in SC. Many other conspicuous species listed as "common on foothills" have long since disappeared from SC; e.g. *Paeonia californica*, *Dodecatheon clevelandii*, and *Centaurium venustum*. A slightly later list of plants from an area centered around Riverside contains many species that can still be found in SC (Reed 1916). Boyd (1983) compiled a list of 430 plant species from the Gavilan Hills, an area 15 km to the south of SC. Although some grassland and CSS habitats surveyed by Boyd (1983) are similar to those of SC, the Gavilan Hills contain a much wider variety of habitats than can be found in SC. However, over 90 percent of the plant species found in SC were also reported by Boyd (1983) for the Gavilan Hills. An effort to compile a flora of the Box Springs Mountains, just north of SC, is also in progress (A.C. Sanders pers. communication).

Plant Communities

Annual Grasslands

Annual grasses, primarily of Mediterranean origin, occupy about 60 percent of the area of SC, on flats, gently to moderately rolling hills and slopes, and low ridge tops. Principal species are *Avena barbata*, *A. fatua*, *Bromus madritensis* ssp. *rubens*, *B. hordeaceus*, *B. diandrus*, *Hordeum murinum* ssp. *leporinum*, *Vulpia myuros* (incl. var. *hirsuta*), and *Schismus barbatus*. Other weedy species dominate on the edges of clearings and along dirt roads, particularly, *Erodium cicutarium* and *Hirschfeldia incana* (*Brassica geniculata*). In June, the tall, wiry fruiting stems of *Hirschfeldia incana* are so dense along the paths as to make it difficult to walk through them. Few native annuals or perennials can compete directly with these weedy species. Among the few that can compete are *Amsinckia menziesii* var. *intermedia* and *Dichelostemma pulchellum*, perhaps because their early germination and growth, and their vertical growth habit allows them to capture soil water and light among the grass stems. In areas where grass cover is less dense, and in clearings, many native spring annuals and perennials can still commonly be found, including *Lasthenia californica*, *Gnaphalium bicolor*, *G. californicum*, *Daucus pusillus*, *Cryptantha intermedia*, *Pectocarya* spp., *Plagiobothrys canescens*, *Lotus hamatus*, *L. strigosus*, *Lupinus bicolor*, *L. hirsutissimus*, *L. truncatus*, *Eucrypta chrysanthemifolia*, *Nemophila menziesii*, *Phacelia* spp., *Platystemon californica*, *Gilia angelensis*, *Calandrinia ciliata*, and *Allium peninsulare*. Other prominent and attractive elements of the native spring flora have been reduced to a few isolated colonies. These include *Delphinium parryi*, *Viola pedunculata*, *Clarkia purpurea* ssp. *quadrivulnera*, *Linaria canadensis* var. *texana*, *Bloomeria crocea*, and *Calochortus splendens*. A few other common to abundant native annuals of the grasslands grow and set seed in mid to late summer, after the annual grasses have turned to straw. These include *Hemizonia kelloggii*, *H. paniculata*, *Heterotheca grandiflora*, *Stephanomeria exigua* ssp. *deanei*, *S. virgata* ssp. *pleurocarpa*, *Eremocarpus setigerus*, and *Trichostema lanceolatum*. Isolated individuals or small colonies of grassland shrubs still persist, including *Artemisia dracunculus*, *Ericameria palmeri* var. *pachylepis*, *Gutierrezia californica*, *Isocoma menziesii* var. *vernonioides*, and *Tetradymia comosa*.

Native annual and perennial grasses have become uncommon in SC, and these are generally confined to isolated clumps on boulders, or in the shelter of rock outcrops. The bunchgrasses *Stipa lepida* and *S. speciosa* can occasionally be found, along with *Poa secunda* and *Melica imperfecta*. Large clumps of *Elymus condensatus* are common along the borders of riparian areas, and *Elymus triticoides* is locally common on sandy, alkali flats. *Muhlenbergia rigens* is uncommon in shaded, rocky stream banks. The native annual grasses *Muhlenbergia microsperma* and *Vulpia octoflora* var. *hirtella* are both uncommon on dry rocky slopes. The annual *Bromus trinii*, reported as "common in foothills" around Riverside (Reed 1916) apparently has been extirpated from the area.

COASTAL SAGE SCRUB

Shrublands in SC are confined to more mesic habitats than grasslands, typically occupying east or north-facing slopes, and borders of riparian areas. The CSS of SC is typical of the "riversidian" phase of CSS, which develops on dry, interior sites (Axelrod 1978; Westman 1983). This phase is characterized by the dominance of *Encelia farinosa*, and the absence of coastal elements, such as *Salvia leucophylla*. Although "riversidian" CSS has been sub-divided into a number of "series," primarily based on species dominance (Sawyer and Keeler-Wolf 1995; White and Pedley 1997), such classification schemes do not appear to be useful in describing the CSS vegetation in the relatively small area of SC. The most abundant CSS species are *Encelia farinosa*, *Artemisia californica*, *Eriogonum fasciculatum* (vars. *foliolosum* and *polifolium*), and *Salvia mellifera*. Although these species can occur in mixed stands, particularly with mixtures of *Eriogonum fasciculatum*, they are typically found in stands dominated by one species. *Encelia farinosa* is primarily found on the most xeric sites, such as hill tops and upper east and west-facing slopes. *Artemisia californica* usually occurs in clumps or in bands downslope from *Encelia farinosa*. *Salvia mellifera* dominates the most mesic, lower north-facing slopes and sides of ravines. It is likely that *Salvia apiana* was more common in CSS habitats in the recent past, judging by the many dead individuals scattered across the landscape. At present, *Salvia apiana* does not appear to be reproducing successfully in SC, so its future there is in doubt. However, populations of *Encelia farinosa*, *Artemisia californica*, *Eriogonum fasciculatum*, and *Salvia mellifera* appear to be self-sustaining at the present time, and continuing to reproduce on exposed, mineral soil. Other shrubs and suffrutescent perennials common in CSS habitats include *Acourtia microcephala*, *Bebbia juncea*, *Eriophyllum confertiflorum*, *Corethrogyne filaginifolia*, *Clematis pauciflora*, *Lotus scoparius*, *Galium angustifolium*, *Keckiella antirrhinoides*, and *Solanum xanti*. The perennial vine *Marah macrocarpus* is abundant in spring, straggling between and over shrubs. Many of the spring annuals already mentioned are also common in the shrublands.

No characteristic chaparral shrubs grow in SC, although *Adenostoma fasciculatum* Hook. & Arn. can be found growing 4 km to the NE, near the top of the Box Springs Mountains, at an elevation of about 800 m. However, a few species more commonly associated with chaparral can be found in SC, growing in sheltered, mesic microsites, such as semi-shaded east-facing ravine walls and shaded rock grottos. These include *Heteromeles arbutifolia*, *Prunus ilicifolia*, *Rhus trilobata*, *Ribes malvaceum* var. *viridifolium*, *R. quercetorum*, and *Penstemon spectabilis*. Large individuals of *Juniperus californica* grow scattered or as small groves in SC, at elevations above 450 m. Large, tree-like individuals of *Sambucus mexicana* are also common in drainages, or emerging from sheltered rock outcrops.

RIPARIAN

The main stream channel, and a few smaller side drainages support well-developed riparian plant communities. Southern Willow Riparian Forest is found on sandy/silty substrates deposited on flats and gradual slopes. This forest is characterized by large individuals of *Populus fremontii*, with an understory of *Salix lasiolepis*, *S. gooddingii*, *S. lucida* var. *lasiandra*, and *S. exigua*. A large specimen of *Juglans californica* can be found among the willows and cottonwoods in a flat along the main stream channel. Southern Sycamore Woodland is found in the bottom of deep ravines on rocky substrates, presumably where water is available throughout the year. *Platanus racemosa* is the dominant tree, associated with *Salix lasiolepis*. The understory and ground cover is often a dense tangle of *Toxicodendron diversilobum*, *Vitis girdiana*, *Artemisia douglasiana*, *Helianthus annuus*, *Baccharis salicifolia*, *Urtica dioica* ssp. *holosericea*, and *Solanum douglasii*. Herbaceous plants of the riparian woodlands include *Mimulus guttatus*, *Stachys ajugoides* var. *rigida*, *Cyperus eragrostis*, *Scirpus acutus*, *S. robustus*, *Juncus bufonius*, *J. mexicanus*, *J. xiphioides*, and *Muhlenbergia rigens*. Riparian zones in SC have recently been invaded by *Arundo donax*, a large, highly aggressive colonizer of wet habitats. *Arundo* has the potential to severely reduce plant diversity in the riparian zones. Attempts to eradicate it from SC ravines have thus far been unsuccessful.

A specialized association of riparian vegetation that is adapted to disturbance has developed along a sandy wash on the western edge of SC. Sandy benches along this drainage are subject to periodic flooding and severe erosion, producing cycles of deposition and erosion of unconsolidated decomposed granite. The damp sands and sandy banks of the stream channel have been colonized by dense thickets of *Lepidospartum squamatum*, a characteristic species of this floodplain disturbance regime (Smith 1980). Shrub species associated with *Lepidospartum squamatum* on raised sandy benches include *Eriogonum fasciculatum*, *Artemisia californica*, *Salvia apiana*, and tree-like *Nicotiana glauca*. Other species found on this sandy substrate but uncommon or absent elsewhere in SC include *Croton californicus*, *Stillingia linearifolia*, *Sarcostemma cynanchoides* var. *hartwegii*, *Stylocline gnaphaloides*, *Eriogonum gracile*, *Rumex hymenosepalus*, and *Nicotiana quadrivalvis*. The damp, sandy stream bottom supports dense thickets of *Salix lasiolepis*, *S. gooddingii*, and *Baccharis salicifolia*. Dense colonies of *Mimulus cardinalis* develop during wet years, when the sandy wash remains damp throughout the summer.

ALKALI FLATS

An extensive area of alkali flats vegetation has developed on sandy soils in a shallow depression along the main stream channel, near the center of SC. The characteristic species on these saline soils are *Distichlis spicata*, *Frankenia salina*, and *Atriplex serenana*. Several large colonies of *Hemizonia pungens* ssp. *laevis* are conspicuous here in mid-summer. This species is uncommon elsewhere in the Riverside area. Other species found in this alkaline area, but rare or absent elsewhere in SC include *Heliotropium curassavicum*, *Atriplex canescens*, *A. lentiformis*, *Elymus triticoides*, and *Sporobolus airoides*. *Anemopsis californica*, a species often found on damp, alkali soils, does not occur here, but it is found elsewhere in SC, in a damp, shaded drainage.

ROCK OUTCROPS

A number of plants in SC are found exclusively growing in crevices, or in the shelter of boulders and rock outcrops. The rocks would appear to provide a more mesic environment, particularly by reducing evapotranspiration in the root zone, permitting these plants to become established and to continue growth later in the summer than would otherwise be possible. Ferns whose rhizomes grow in the shelter of rock outcrops include *Dryopteris arguta*, *Polypodium californicum*, *Cheilanthes newberryi*, *Pellaea andromedifolia*, *P. mucronata*, *and Pentagramma triangularis*. Other plants with similar requirements for damp, shaded environments are *Bowlesia incana*, *Hesperocnide tenella*, and *Parietaria hespera* var. *californica*. Shrubs that grow almost exclusively in SC in the crevices of boulders or rocky ledges and cliff faces include *Bebbia juncea*, *Brickellia desertorum, Epilobium canum,* and *Mimulus aurantiacus.* Other plants found almost exclusively in crevices or on rock ledges in SC are *Lotus argophyllus* and *Antirrhinum nuttallianum,* while *Phacelia ramosissima* var. *latifolia* and *Scrophularia californica* ssp. *floribunda* are usually found growing among tumbled boulders of rock outcrops.

FLORISTICS

During fieldwork for this inventory conducted primarily in 1993 and 1994, with occasional additions through the spring of 1998, a total of 285 plant species, subspecies, and two hybrids were recorded as growing in Sycamore Canyon Park, or immediately adjacent to it (borders of the park preserve were, and still remain, ill-defined). Sixteen of these were trees, 40 shrubs, 61 herbaceous perennials, 126 herbaceous annuals, 35 grasses, and 7 ferns and allies (Table 1). The largest families of plants were the Asteraceae, with 56 species in 40 genera, Poaceae (35/24), Fabaceae (16/6), Scrophulariaceae (15/9), and Brassicaceae (12/10). Annuals, including both native and introduced grasses and herbaceous weeds comprise 50 percent of the flora, generally higher than that reported for other southern California floras (Boyd et al. 1995), but similar to the flora of the Gavilan Hills south of Riverside (Boyd 1983). The percent of native annual plants in the flora is 42 percent, again higher than other local mainland southern California floras, but similar to the percentage of native annuals in the flora of Santa Catalina Island (Thorne 1967). Non-natives comprise twenty-nine percent of the flora, significantly higher than the 18 percent non-native reported by Boyd (1983) for the Gavilan Hills, but similar to the proportion of non-natives recorded for Orange County (Roberts 1989), and for the Santa Monica Mountains (Raven et al. 1986) in Los Angeles and Ventura counties.

Table 1. Summary statistics for the plants of Sycamore Canyon Park, Riverside, California.

Form	Native	Introduced	Percent of Total
Trees	8	8	5.6
Shrubs	37	3	14.0
Perennial Herbs	55	6	21.4
Annual Herbs	82	44	44.2
Perennial Grasses	9	5	4.9
Annual Grasses	3	18	7.4
Pteridophytes	7	0	2.5
Total	201	84	100.0

SENSITIVE SPECIES

Two of the plant species growing in SC are listed in the California Native Plant Society (CNPS) inventory of rare and endangered plants of California (Skinner and Pavlik 1994). *Hemizonia pungens* ssp. *laevis* is included on list 1B: plants rare, threatened, or endangered in California and elsewhere. This annual grows on seasonally damp, alkaline soils in grasslands, or in other areas with low shrub cover. Suitable habitat for this species in the region has been destroyed by flood control projects, channelization of drainages, and development. The closest, known population to the one in SC is along the San Jacinto River drainage near Lake Perris, approximately 20 km east. The population in SC appears to be robust, and has reproduced successfully for many years. *Juglans californica* is included on CNPS list 4: plants of limited distribution — a watch list. This species formerly occurred as extensive groves in suitable riparian habitat, principally in foothill oak communities. Lowland walnut groves in riparian areas have been severely impacted by channelization, flood control, and urban development. Although the species *per se* is not threatened, the California walnut woodland is an endangered plant community (Quinn 1990). *Juglans californica* at SC does not appear to reproducing successfully.

Many other species of native plants in SC are present only in very small numbers, and in some cases, they are represented by only a single individual. Some are locally common only in limited areas with specific habitat requirements. These species are listed in Table 2. Specific threats to the conservation of these species are discussed in the annotated list of plants.

Table 2. Sensitive plant species in Sycamore Canyon Park, Riverside, California. These native plants are either present in very low numbers (<10) or have been found growing only in a single location within the park.

Anemopsis californica
Atriplex canescens
Atriplex lentiformis
Calochortus splendens
Chorizanthe staticoides
Clarkia epilobioides
Clarkia purpurea var. *quadrivulnera*
Delphinium parryi
Dryopteris arguta
Elymus triticoides
Encelia californica
Frankenia salina
Hemizonia pungens ssp. laevis
Heteromeles arbutifolia
Isocoma menziesii var. *vernonioides*
Juglans californica
Juncus xiphioides
Lasthenia coronaria
Layia playtglossa (presumed extirpated)
Lotus purshianus
Lycium andersonii
Malacothamnus fasciculatus
Mimulus pilosus
Muhlenbergia microsperma
Muhlenbergia rigens
Muilla maritima
Navarretia atractyloides
Nicotiana quadrivalvis
Oenothera elata ssp. *hirsutissima*
Penstemon spectabilis
Poa secunda
Polypodium californicum
Rhus trilobata
Ribes indecorum
Ribes malvaceum var. *viridifolium*
Ribes quercetorum
Rumex hymenosepalus
Scirpus robustus
Sporobolus airoides
Stillingia linearifolia
Stipa lepida
Stipa speciosa
Stylomecon heterophylla
Trifolium gracilentum
Veronica peregrina ssp. *xalapensis*
Vulpia octoflora var. *hirtella*
Yucca whipplei

ANNOTATED LIST OF PLANTS OF SYCAMORE CANYON, RIVERSIDE

The following list includes all vascular plants observed by the author in Sycamore Canyon Park during surveys from 1993 until 1998. The majority of these surveys were conducted in 1993 and 1994. No attempt has been made to search public herbaria or private collections to record species collected in SC in the past, so this list represents (except one extirpated taxon) the contemporary flora of this remnant of "riversidian" coastal sage scrub. Voucher specimens were collected for most, but not all, plant species encountered in SC. In the case of *Layia platyglossa*, the species was seen routinely on dry grassy slopes up until the late 1980's, but it has not been observed in recent years, and may be extirpated from the park. In a few other cases, no voucher specimens were collected from large, easily identified and conspicuous plant species, such as *Phoenix canariensis* and *Washingtonia filifera*. No voucher specimens were collected from species found growing in SC only as single small individuals, or from some ubiquitous, weedy species. Voucher specimens for all other taxa are deposited in the herbarium of the University of California, Riverside (UCR). Nomenclature for individual taxa and for most family relationships follows The Jepson Manual (Hickman [ed.] 1993), with a few exceptions. In these cases, The Jepson Manual equivalent is given in brackets. Non-native plant species are preceded by an asterisk (*). I used the following descriptors of relative abundance:

Abundant —likely to be encountered in the appropriate habitat, often forming dense stands.
Common — usually encountered in appropriate habitat.
Fairly common — may be widely scattered or locally common, but not forming dense stands.
Occasional — widely scattered individuals or small stands.
Uncommon — not likely to be encountered; may be missing from appropriate habitat.
Rare — very unlikely to be encountered; usually <10 individuals or < 5 small populations in the park.

FERNS AND ALLIES

Dryopteridaceae

Dryopteris arguta (Kaulfuss) Maxon — rare, only two stations known, both in deep rock shelters next to permanent underground streams; rhizomes deeply shaded, fronds exposed to several hours of direct sun (Temple 1262).

Polypodiaceae

Polypodium californicum Kaulfuss — rare, one colony, on rock face in deep, shaded, east-facing ravine (Temple 1332).

Pteridaceae

Cheilanthes newberryi (D. Eaton) Domin — fairly common, under rock outcrops and on boulders, where rhizomes shaded, but fronds exposed to sun (Temple 1171).
Pellaea andromedifolia (Kaulfuss) Fee — fairly common, under rock outcrops, in sun or shade (Temple 1151).
Pellaea mucronata (D. Eaton) D. Eaton var. *mucronata* — occasional, seasonally damp, shaded ravines (Temple 1143).
Pentagramma triangularis (Kaulfuss) G. Yatskievych, M.D. Windham, & E. Wollenweber — fairly common, under rock outcrops and on seasonally damp slopes (Temple 1157).

Selaginellaceae

Selaginella bigelovii L. Underwood — fairly common, exposed damp banks, rocks, sometimes forming large colonies (Temple 1009).

GYMNOSPERMS

Cupressaceae

Juniperus californica Carrière — widely scattered at elevations above ca 450m, usually on rocky to open grassy slopes, often on silty soils; occasionally forming small groves. These trees appear to be of considerable age, and no seedlings or young trees have been found (Temple 1160).

ANGIOSPERMS
Dicotyledones

Amaranthaceae

**Amaranthus albus* L. — common, sandy, disturbed areas; annual (Temple 1372).

Anacardiaceae

Rhus trilobata Torrey & Gray — rare, two or three small shrubs in sheltered east-facing slope at ca 400 m. These plants correspond to the var. *anisophylla* (Greene) Jepson; shrub (Temple 1241).
**Schinus molle* L. — uncommon, persisting after cultivation near olive grove and naturalized in ravines.
Toxicodendron diversilobum (Torrey & Gray) Greene — common to abundant in damp, shaded to sunny ravines, especially along the main stream channel; occasional patches also on dry brushy slopes; shrub.

Apiaceae

Bowlesia incana Ruíz López & Pavón — fairly common, damp, shaded bases of trees, under rock outcrops; early spring annual (Temple 1117).
Daucus pusillus Michaux — locally abundant on dry open slopes, especially on loose decomposed granite; spring annual (Temple 1341).

Apocynaceae

**Nerium oleander* L. — one red-flowered shrub in sunny clearing in sandy stream channel near S edge of SC. Although *Nerium oleander* is not listed in Hickman (1993) or Munz (1974) as a permanent element in the California flora, this oleander is growing in a location where it appears to have naturalized. It may have originated as yard waste in an upstream community and was transported into Sycamore Canyon following a rainstorm, along with other debris that often gets swept along Sycamore Creek with the storm surge; shrub (Temple 1388).

Asclepidaceae

Sarcostemma cynanchoides Decaisne ssp. *hartwegii* (Vail) Holm — locally common, especially in dry sandy washes, covering *Bebbia*, *Lepidospartum*, etc.; perennial vine (Temple 1140).

Asteraceae

Acourtia microcephala DC. — fairly common, especially on steep, rocky E or N-facing slopes; large perennial (Temple 1309).

Ambrosia acanthicarpa Hooker — common, disturbed sandy areas; fall annual (Temple 1186).

**Anthemis cotula* L. — uncommon, damp sandy washes; common in industrial area E of SC; annual (Temple 1260).

Artemisia californica Lessing — common to abundant on rocky slopes, ridge tops. One of the dominant shrubs defining the coastal sage scrub community. Produces abundant seedlings, but these appear to be successful only on bare mineral soil.

Artemisia douglasiana Besser — locally abundant, forming large colonies on damp sandy soils in stream channels, ravines; perennial.

Artemisia dracunculus L. — common, dry open grassy slopes; shrubby perennial (Temple 1293).

Aster subulatus Michaux var. *ligulatus* Shinners — uncommon, damp ditches, seeps; fall flowering annual (Temple 1318).

Baccharis emoryi Gray — uncommon, steep slopes near streams and stream banks; shrub (Temple 1180).

Baccharis salicifolia (Ruíz López & Pavón) Persoon — common, damp sandy bottoms, stream banks, seeps; large (2-3 m tall) shrub (Temple 1272).

Bebbia juncea (Bentham) E. Greene var. *aspera* E. Greene — fairly common, rocky slopes, ledges, overhangs, usually growing in or around large rocks, boulders; shrub, flowering mainly June-July (Temple 1152).

Brickellia desertorum Coville — fairly common on rocky ledges, often growing on or out of cracks in boulders; flowering mid-summer; small shrub (Temple 1024).

**Centaurea melitensis* L. — common, dry disturbed areas, often along trails; annual (Temple 1242).

**Chamomilla suaveolens* (Pursh) Rydberg — locally common, sandy to silty disturbed soils; annual (Temple 1274).

Cirsium occidentale (Nuttall) Jepson var. *occidentale* — uncommon, scattered on sandy flats and dry grassy slopes; large biennial (Temple 1226).

**Cirsium vulgare* (Savi) Tenore — uncommon, disturbed soils, usually shaded; biennial (Temple 1316).

**Conyza bonariensis* (L.) Cronquist — common, dry, disturbed soils, especially along trails; annual (Temple 1366).

**Conyza canadensis* (L.) Cronquist — common, sandy areas along trails; annual (Temple 1187).

Corethrogyne filaginifolia (Hooker & Arnott) Nuttall [*Lessingia filaginifolia* (H. & A.) Lane] — common, grassy or rocky slopes; highly variable, ligules various shades of white, pale pink to blue or purple; flowers conspicuous on dry slopes mid-summer to winter; perennial.

**Cotula australis* (Sieber) Hooker f. — fairly common, wet depressions along trails; spring annual (Temple 1125).

**Dimorphotheca sinuata* DC. — uncommon, dry open slopes and flats, spreading from extensive use along near-by highways; annual (Temple 1334).

Encelia californica Nuttall — rare, only a few shrubs on open, E-facing grassy slope near W edge of SC. *E. californica* was formerly common in the SE Riverside area. It has greatly declined in recent years, along with many other species of native shrubs, perhaps as a consequence of competition with weedy annual grasses. Subtle climatic changes including higher temperatures and recent episodes of drought may also have contributed to reduced survival of this and other species on the eastern edge of their natural range (Temple 1385).

Encelia farinosa Torrey & Gray — common, dominant shrub on open rocky slopes and ridge tops; flowering January to May. *E. farinosa* appears to be one of the few native shrubs able to reproduce in competition with annual weedy grasses. A few shrubs, especially in SE part of the park, have dark brown to purple central disk flowers, suggesting some introgression with *E. californica*. *Encelia* is frequently attacked and often nearly completely defoliated in spring by the larvae and adults of the herbivorous beetle *Trirhabda geminata* (Chrysomelidae) (Temple 1276).

Ericameria palmeri (Gray) Hall var. *pachylepis* (Hall) Nesom — uncommon, grassy or rocky slopes, especially on silty soils, flowering summer to fall; low-growing shrub, conspicuous when flowering in summer (Temple 1185).

Erigeron foliosus Nuttall var. *foliosus* — uncommon, steep open grassy to rocky E-facing slopes, often among *Salvia mellifera*; perennial (Temple 1298).

Eriophyllum confertiflorum (DC.) Gray var. *confertiflorum* — common, grassy to rocky slopes, drainages and ravines, flowering conspicuously May-June; perennial (Temple 1239 and 1265).

Filago californica Nuttall — fairly common, dry bare soils, especially along trails; spring annual (Temple 1330).

**Filago gallica* L. — fairly common, dry disturbed soil along trails and roads; annual (Temple 1256 and 1270).

Gnaphalium bicolor Bioletti — common, dry slopes; perennial (Temple 1162).

Gnaphalium californicum DC. — fairly common, damp banks, ravines; white involucres conspicuous November-April; biennial (Temple 1179).

**Gnaphalium luteo-album* L. — uncommon, damp sandy wash; annual (Temple 1394).

Gnaphalium purpureum L. — uncommon, scattered on dry sandy soils, especially in washes; annual (Temple 1354).

Gutierrezia californica (DC.) Torrey & Gray — fairly common, grassy slopes; low rounded shrub; flowering mid-summer (Temple 1150).

Helianthus annuus L. — common, dry disturbed slopes, roadsides; flowering year-round; annual (Temple 1383).

Hemizonia kelloggii Greene — fairly common, dry grassy flats and gentle slopes; flowering May-June, annual (Temple 1368).

Hemizonia paniculata Gray — common, dry grassy flats and slopes, growing and flowering summer to fall; individuals vary enormously in size, number of heads; annual (Temple1314).

Hemizonia pungens (Hooker & Arnott) Torrey & Gray. ssp. *laevis* Keck — a few small to large colonies, sandy flats along main channel, with other alkali species; e.g. *Distichlis*, *Atriplex*, *Heliotropium*; large summer annual; CNPS list 1B (Temple 1007).

Heterotheca grandiflora Nuttall — common, dry disturbed areas; large annual.

**Hypochaeris glabra* L. — uncommon, disturbed soil along trails; annual (Temple 1103).

Isocoma menziesii (Hooker & Arnott) Nesom var. *vernonioides* (Nuttall) Nesom — uncommon, scattered on dry grassy flats and gentle slopes, especially on sandy soils; low shrub, flowering summer to fall. *Isocoma* is another native shrub whose numbers in this area appear to have declined greatly in recent years (Temple 1190).

**Lactuca serriola* L. — fairly common weed of sandy soils; annual.

Lasthenia californica Lindley — locally abundant, densely crowding open grassy slopes or hill tops, especially on silty soils; spring annual. Massed plants emit a delicate, pleasant odor, noticeable on warm sunny days (Temple 1149).

Lasthenia coronaria (Nuttall) Ornduff — uncommon, scattered in small groups on damp open grassy slopes and silty ridge tops, spring annual. *L. coronaria* is uncommon in the Riverside area (Temple 1100).

Layia platyglossa (Fischer & Meyer) Gray — rare, probably extirpated; has not been seen or collected in several years, since the prolonged drought of the late 1980's. Formerly found on grassy slopes now dominated by *Avena*, *Bromus*; spring annual.

Lepidospartum squamatum (Gray) Gray — locally common, damp to dry sandy wash; flowering sporadically summer-fall; large shrub (Temple 1025).

Rafinesquia californica Nuttall — fairly common, steep grassy slopes; tall spring annual (Temple 1232).

Senecio flaccidus Lessing var. *douglasii* (DC.) Turner & Barkley — uncommon, sandy disturbed soils near SE edge of SC; shrubby perennial (Temple 1177).

**Senecio vulgaris* L. — uncommon, widely scattered along trails; annual (Temple 1105).

**Sonchus asper* (L.) Hill ssp. *asper* — uncommon, damp sandy soils; annual (Temple 1289).

**Sonchus oleraceus* L. — common weed, disturbed damp soils; annual.
Stephanomeria exigua Nuttall ssp. *deanei* (Macbride) Gottleib — common to abundant, dry grassy slopes; summer to fall flowering annual. Most plants have ligules white above, purple-pink beneath; a few scattered plants have ligules creamy-pink above, with two brown streaks beneath (Temple 1397).
Stephanomeria virgata Bentham ssp. *pleurocarpa* (Greene) Gottleib — fairly common, grassy slopes, flowering mid-summer to late fall, sometimes all year, annual.
Stylocline gnaphaloides Nuttall — common to locally abundant, bare sandy to silty soils; early spring annual (Temple 1218).
Tetradymia comosa Gray — fairly common, scattered in small groups on open rocky to grassy slopes; low shrub; yellow flowers conspicuous in mid-summer (Temple 1406).
Uropappus lindleyi (DC.) Nuttall — common, grassy slopes; spring annual (Temple 1235).
Venegasia carpesioides DC. — locally common in ravines, along drainages, and near seeps, mainly below 400 m; large shrub, fl throughout year.
**Xanthium strumarium* L. — fairly common, open disturbed stream beds, damp sands; annual.

Boraginaceae

Amsinckia menziesii (Lehmann) Nelson & Macbride var. *intermedia* (Fischer & Meyer) Ganders — abundant on grassy slopes, one of the few native annuals that competes successfully with weedy annual grasses, perhaps by its very early spring growth (Temple 1273)
Cryptantha intermedia (Gray) Greene — abundant, open grassy slopes; spring annual (Temple 1109).
Heliotropium curassavicum L. — uncommon, alkaline seeps and sandy flats; perennial (Temple 1280).
Pectocarya linearis (Ruíz López & Pavón) DC. ssp. *ferocula* (I.M. Johnston) Thorne — common to abundant, open grassy slopes; spring annual (Temple 1215).
Pectocarya penicillata (Hooker & Arnott) DC. — common to abundant, especially on bare disturbed sandy to silty soils, often growing intermixed with *P. linearis*; spring annual (Temple 1333).
Plagiobothrys canescens Bentham — abundant, open grassy slopes; spring annual (Temple 1108).

Brassicaceae

Athysanus pusillus (Hooker) Greene — fairly common, damp grassy E and N-facing slopes, especially under *Salvia*; spring annual (Temple 1209).
**Brassica tournefortii* Gouan — fairly common, but spreading rapidly, disturbed soils; early spring annual (Temple 1147).
**Capsella bursa-pastoris* (L.) Medikus — uncommon, along trails; annual (Temple 1319).
Guillenia lasiophylla (Hooker & Arnott) Greene (*Caulanthus lasiophyllus* (Hooker & Arnott) Payson) — uncommon, seasonally damp open grassy to rocky slopes; spring annual (Temple 1225).
**Hirschfeldia incana* (L.) Lagrèze-Fossat [*Brassica geniculata* (Desfontaines) Ball] — common to abundant throughout; weedy perennial.
Lepidium lasiocarpum Torrey & Gray — fairly common, scattered in dry sandy soil; spring annual (Temple 1375).
Lepidium nitidum Torrey & Gray — fairly common, open grassy slopes; spring annual (Temple 1120a).
**Lobularia maritima* (L.) Desvaux — uncommon garden escape, damp sands; perennial, not persisting (Temple 1141).
**Raphanus sativus* L. — fairly common, grassy slopes, especially along trails; spring annual (Temple 1227).
**Sisymbrium irio* L. — fairly common, disturbed soils; spring annual (Temple 1115).
**Sisymbrium orientale* L. — fairly common, scattered along trails; spring annual (Temple 1352).

Tropidocarpum gracile Hooker — common, especially on seasonally damp E and N-facing grassy slopes; spring annual (Temple 1133).

Cactaceae

Opuntia parryi Engelmann — widely scattered on dry slopes throughout; flowering in May.
Opuntia X *vaseyi* (Coulter) Britton & Rose — a few large clumps on dry grassy to rocky slopes, in heavier soils near S edge of SC; highly variable.

Caprifoliaceae

Sambucus mexicana C. Presl — common, small tree of rocky slopes, drainages, and ravines.

Caryophyllaceae

Loeflingia squarrosa Nuttall var. *squarrosa* — uncommon, disturbed silty soils along roads, trails; spring annual (Temple 1336).
**Silene gallica* L. — uncommon, disturbed soils along trails; annual (Temple 1338).
Spergularia marina (L.) Grisebach — locally common, but confined to one location, at the edges of seasonal pools along a silty trail at the south-eastern edge of SC; spring annual (Temple 1325).
**Stellaria media* (L.) Villars — fairly common, damp soil under rock overhangs; spring annual (Temple 1234).

Chenopodiaceae

Atriplex canescens (Pursh) Nuttall ssp. *canescens* — uncommon, a few large shrubs on dry rocky slope near and along dirt access road through the center of SC; conspicuous in fruit in late summer and fall (Temple 1198).
Atriplex lentiformis (Torrey) Watson ssp. *lentiformis* — uncommon, especially on disturbed sandy soils near drainages; low shrub, fruiting in late summer (Temple 1183).
**Atriplex semibaccata* R. Brown — locally common, dry disturbed soils near industrial area at SE edge of SC; low shrub (Temple 1172).
Atriplex serenana Nelson — locally common, dry sandy flats near main stream channel, with *Distichlis* and other alkaline species; summer annual (Temple 1312).
**Chenopodium album* L. — uncommon weed in sandy soils; annual (Temple 1192).
**Chenopodium ambrosioides* L. — locally common, damp sandy soils; large summer annual (Temple 1173).
Chenopodium californicum (Watson) Watson — uncommon, low grassy slopes and flats; perennial (Temple 1136).
**Chenopodium murale* L. — uncommon weed, damp sands; annual.
**Salsola tragus* L. — occasional to locally common, disturbed sandy to silty soils; summer annual (Temple 1197).

Convolvulaceae

Calystegia macrostegia (Greene) Brummitt ssp. *intermedia* (Abrams) Brummitt — common, highly variable; flowers conspicuous March-May; perennial vine (Temple 1135).
**Convolvulus arvensis* L. — uncommon, disturbed soils along trails; perennial (Temple 1258).

Crassulaceae

Crassula connata (Ruíz López & Pavón) Berger — locally abundant, bare soil; tiny early spring annual (Temple 1144).
Dudleya lanceolata (Nuttall) Britton & Rose — fairly common, sheltered rock outcrops and overhangs, damp banks of shaded ravines; flowering in May; perennial (Temple 1268).

Cucurbitaceae

Cucurbita foetidissima Kunth — locally common, flat sandy areas, forming large patches mid to late summer; perennial vine (Temple 1013).

Marah macrocarpus (Greene) Greene — common, rocky slopes; occasionally suffocating *Encelia*, *Artemisia* with dense foliage; flowering early spring (January-February), fruiting April-June; perennial vine (Temple 1142).

Cuscutaceae

Cuscuta californica Hooker & Arnott var. *californica* — fairly common, parasitic vine on *Encelia*, *Eriogonum* etc., flowering April-May; annual (Temple 1278).

Euphorbiaceae

Chamaesyce albomarginata (Torrey & Gray) Small — common, sandy or silty disturbed soils, often on roads or trails; flowering mostly April-May; perennial (Temple 1370).

Chamaesyce polycarpa (Bentham) Millspaugh — common, bare soils; flowering mostly April-June; perennial (Temple 1382).

Croton californicus Mueller-Aargau — locally common, dry banks of sandy wash; perennial (Temple 1300).

Eremocarpus setigerus (Hooker) Bentham — locally abundant, bare disturbed soils; growing in dry soils during hottest time of year; annual.

**Ricinus communis* L. — uncommon, in drainages, ravines; weedy shrub.

Stillingia linearifolia Watson — uncommon, scattered on low rocky slopes near sandy wash; spring perennial (Temple 1015).

Fabaceae

Astragalus pomonensis Jones — common, grassy or bare flats and gentle slopes; conspicuous January-June; perennial (Temple 1164).

Lotus argophyllus (Gray) Greene var. *argophyllus* — fairly common, prostrate on boulders, rocky ledges; bright yellow flowers in January-March; perennial (Temple 1165).

Lotus hamatus Greene — fairly common, scattered on open dry grassy slopes; spring annual (Temple 1356).

Lotus purshianus (Bentham) Clements & Clements — rare, small colony on shaded grassy slope near main stream channel; large annual, pinkish-white flowers in June (Temple 1374).

Lotus scoparius (Nuttall) Ottley — common, grassy or rocky slopes; shrubby perennial (Temple 1279).

Lotus strigosus (Nuttall) Greene — common, scattered on grassy slopes; spring annual (Temple 1207).

Lupinus bicolor Lindley— locally abundant, open grassy slopes, disturbed sandy soils; spring annual (Temple 1101).

Lupinus hirsutissimus Bentham — fairly common, scattered on open rocky slopes; spring annual (Temple 1342).

Lupinus sparsiflorus Bentham — fairly common, scattered on steep, grassy slopes; spring annual (Temple 1335).

Lupinus succulentus Koch — uncommon, sandy disturbed soils; spring annual (Temple 1343).

Lupinus truncatus Nuttall ex Hooker & Arnott — fairly common, open grassy slopes; spring annual (Temple 1137).

**Medicago polymorpha* L. — locally common, damp, disturbed soils; annual (Temple 1345).

**Melilotus alba* Medikus — uncommon, disturbed soils; annual (Temple 1030).

**Melilotus indica* (L.) Allioni — uncommon, damp disturbed soils; annual (Temple 1244).

Trifolium gracilentum Torrey & Gray — uncommon, scattered among annual grasses in low, damp spots; spring annual (Temple 1346).
Trifolium willdenovii Sprengel — fairly common, damp grassy slopes; spring annual (Temple 1340).

Frankeniaceae

Frankenia salina (Molina) I.M. Johnston — rare, one colony on open sandy flats near main stream channel, with *Distichlis* and other alkali plants; leaves blue-white, covered with salt; flowers pink-purple, in July (Temple 1396).

Geraniaceae

**Erodium botrys* (Cavanilles) Bertoloni — common, especially on heavy, silty soils; spring annual (Temple 1148).
**Erodium brachycarpum* (Godron) Thellung — fairly common, open grassy slopes, banks; annual (Temple 1118).
**Erodium cicutarium* (L.) L'Héritier — abundant, bare soils, open grassy slopes; ubiquitous annual.

Grossulariaceae

Ribes indecorum Eastwood — rare, one large shrub, W side of main stream, beneath willows; characters variable, may have introgressed with *R. malvaceum* (Temple 1347).
Ribes malvaceum J.E. Smith var. *viridifolium* Abrams — uncommon, large shrub, widely scattered on rocky slopes in shelter of large boulders; pink flowers in February-March (Temple 1114).
Ribes quercetorum Greene — rare, one large colony in sheltered rocky slope along main stream channel, elevation ca 450 m; flowering January, leaves deciduous by June (Temple 1166).

Hydrophyllaceae

Emmenanthe penduliflora Bentham — uncommon to locally common, numbers vary widely from year to year; open grassy slopes usually on bare soils; spring annual (Temple 1357).
Eucrypta chrysanthemifolia (Bentham) Greene var. *chrysanthemifolia* — common, shaded to open grassy slopes especially on loose granitic soils; spring annual (Temple 1213).
Nemophila menziesii Hooker & Arnott — common to abundant, grassy slopes; spring annual.
Phacelia distans Bentham — common, open grassy or disturbed soils; spring annual (Temple 1119).
Phacelia minor (Harvey) Thellung — locally common, especially on open, loose decomposed granite slopes; spring annual (Temple 1132).
Phacelia ramosissima Lehmann var. *latifolia* (Torrey) Cronquist — common, grassy or rocky slopes, often on or about rock outcrops; perennial (Temple 1286).

Juglandaceae

Juglans californica Watson var. *californica* — one large fruiting tree, riparian zone of main stream channel, with *Populus*, *Salix* spp. (Temple 1021).

Lamiaceae

**Lamium amplexicaule* L. — locally common, shaded riparian areas; annual (Temple 1329).
**Marrubium vulgare* L. — common, open disturbed soils; shrubby perennial (Temple 1269).
Salvia apiana Jepson — common, but declining; scattered over dry grassy to rocky slopes; one of the defining species of the coastal sage scrub community. Reproduction seems to be unsuccessful; the seedlings may not be able to compete with annual grasses.

Salvia apiana X *S. mellifera* — uncommon, small shrubs, scattered wherever parents co-occur (Temple 1121).

Salvia columbariae Bentham — locally common, especially on loose decomposed granite slopes; spring annual (Temple 1131).

Salvia mellifera Greene — common, forming dense stands on dry grassy to rocky especially on E or N-facing slopes. Numbers appear to have increased in recent years, since the drought of the late 1980's.

Stachys ajugoides Bentham var. *rigida* Jepson & Hoover — common, damp soils, stream channels; very strong-smelling annual, flowering summer to fall in damp sandy washes (Temple 1029).

Trichostema lanceolatum Bentham — common on open, disturbed soils, strong-smelling annual, flowering mid-summer to fall (Temple 1006).

Malvaceae

Malacothamnus fasciculatus (Torrey & Gray) Greene var. *fasciculatus* — uncommon, small shrub scattered on rocky slopes, often in shelter of large boulders; flowering March-June; numbers appear to have declined in recent years (Temple 1120).

**Malva parviflora* L. — occasional weed along trails, annual (Temple 1208).

Myrtaceae

**Eucalyptus globulus* Labillardière. — one large tree and several seedlings, scattered in riparian zone along main stream channel, with *Populus, Salix*, etc. (Temple 1389).

Nyctaginaceae

Mirabilis californica Gray — common, rocky slopes; spring perennial; occasional plants have white flowers (Temple 1245).

Oleaceae

**Olea europaea* L. — large grove, persisting after cultivation, SE side of park.

Onagraceae

Camissonia bistorta (Torrey & Gray) Raven — fairly common, open sandy flats and slopes; spring annual (Temple 1255).

Clarkia epilobioides (Nuttall) Nelson & Macbride — locally common, damp, shaded grassy slopes; spring annual (Temple 1353).

Clarkia purpurea (Curtis) Nelson & Macbride var. *quadrivulnera* (Douglas) H. Lewis & M. Lewis — uncommon to locally common, sandy flats, grassy slopes; spring annual. Both Clarkia species vary in abundance from year to year; they are locally common only in wet years (Temple 1358).

Epilobium canum (Greene) Raven ssp. *canum* — locally common, dry to damp rocky drainages, cliff faces; summer perennial; often flowering through the fall and winter (Temple 1020).

Epilobium ciliatum Rafinesque ssp. *ciliatum* — fairly common, damp soils, shaded stream channels; tall summer annual (Temple 1369).

Oenothera elata Kunth ssp. *hirsutissima* (Watson) Dietrich — rare, open damp, sandy wash; biennial (Temple 1408).

Papaveraceae

Eschscholzia caespitosa Bentham — fairly common over open grassy slopes, widely scattered; spring annual (Temple 1362).

Eschscholzia californica Chamisso — uncommon to fairly common, especially in rainy years, open grassy slopes. Both *E. caespitosa* and *E. californica* are yellow-flowered annuals on grassy slopes, often growing side-by-side. Flowers of *E. caespitosa* are usually noticeably smaller than those of *E. californica*, and lack receptacle rim. Large, orange-petaled *E. californica* in disturbed areas on the edges of Sycamore Canyon are probably garden escapes (Temple 1348).

Platystemon californicus Bentham — fairly common, especially in rainy years, open E-facing grassy slopes and semi-shaded flats; petals usually creamy-white to white with yellow spots at base, occasionally all yellow; spring annual (Temple 1277).

Stylomecon heterophylla (Bentham) Taylor — rare, a few plants on sheltered E-facing rocky slope; spring annual (Temple 1384).

Plantaginaceae

Plantago erecta Morris — locally abundant on open grassy slopes especially on silty soils near SE edge of SC; spring annual (Temple 1324).

Platanaceae

Platanus racemosa Nuttall — locally common along streams, especially on rocky substrates in ravines, indicative of permanent running surface or sub-surface water; main stream channels. The largest individual in SC has a circumference of ca 16 m, and is probably of great age.

Polemoniaceae

Eriastrum sapphirinum (Eastwood) Mason — uncommon, scattered on open gravelly or rocky slopes; flowering May-June, annual (Temple 1301).

Gilia angelensis V. Grant — common to locally abundant, open grassy slopes; spring annual (Temple 1104).

Navarretia atractyloides (Bentham) Hooker & Arnott — uncommon, scattered on dry open knolls; flowering May-June (Temple 1371).

Polygonaceae

Chorizanthe staticoides Bentham — uncommon, scattered on dry, open ridgetops; spring annual (Temple 1411).

Eriogonum elongatum Bentham var. *elongatum* — fairly common, open grassy slopes, flowering summer to fall; perennial (Temple 1189).

Eriogonum fasciculatum Bentham var. *foliolosum* (Nuttall) Abrams — common to abundant, open grassy to rocky slopes; one of the characteristic shrubs of the coastal sage scrub community.

Eriogonum fasciculatum Bentham var. *polifolium* (DC.) Torrey & Gray — widely scattered on grassy or rocky slopes, growing contiguously with var. *foliolosum*, and nearly as common; shrub (Temple 1287).

Eriogonum gracile Bentham var. *gracile* — locally common, sandy disturbed soils; flowering summer to fall; annual (Temple 1175).

**Polygonum arenastrum* Boreau — uncommon to locally common, bare disturbed soils; annual (Temple 1310).

Polygonum lapathifolium L. — uncommon, wet soils in stream channels; large summer annual (Temple 1018).

**Rumex crispus* L. — uncommon to locally common, damp disturbed soils; weedy perennial.

Rumex hymenosepalus Torrey — rare, open sandy flats; large perennial (Temple 1350).

Rumex salicifolius Weinmann var. *salicifolius* — uncommon, seasonally wet soils in drainages and seeps; large perennial (Temple 1361).

Portulacaceae

Calandrinia ciliata (Ruíz López & Pavón) DC. — common, damp open bare to grassy slopes, most common on heavy silty soils; spring annual. Plants with white flowers are rare, widely scattered among red-flowered forms (Temple 1240).

Calyptridium monandrum Nuttall — fairly common, bare, loose disturbed soil; annual (Temple 1251).

Claytonia perfoliata Willdenow ssp. *perfoliata* — common, damp shaded banks, E-facing slopes, seeps; spring annual (Temple 1224).

**Portulaca oleracea* L. — uncommon, damp sandy washes, drying stream channels; annual.

Primulaceae

**Anagallis arvensis* L. — uncommon, damp disturbed soils; annual (Temple 1243).

Ranunculaceae

Clematis pauciflora Nuttall — common, sheltered grassy or rocky slopes, often on boulders; woody vine; flowering January to March (Temple 1134).

Delphinium parryi Gray ssp. *parryi* — uncommon to locally common, widely scattered small colonies in open grasslands; threatened by competition from annual grasses; perennial, flowering May (Temple 1363).

Rosaceae

Heteromeles arbutifolia (Lindley) Roemer — rare, 4 or 5 shrubs, steep NE-facing shaded slope of deep ravine, main stream channel (Temple 1168).

Prunus ilicifolia (Nuttall) Walpers ssp. *ilicifolia* — uncommon, usually in small groves, sheltered rocky E-facing slopes or ravines, small tree (Temple 1022).

Rubiaceae

Galium angustifolium Nuttall ssp. *angustifolium* — common, often straggling over boulders; woody-stemmed perennial (Temple 1247).

**Galium aparine* L. — fairly common, sheltered damp grassy slopes; spring annual (Temple 1263).

Salicaceae

Populus fremontii Watson ssp. *fremontii* — common, seedlings to large trees, riparian zone along the larger stream channels, usually on sandy substrates. Large cottonwoods are important nesting sites for red-tailed hawks, Cooper's hawks, great-horned owls, and common ravens.

Salix exigua Nuttall — fairly common, sandy flats along main stream channel; small tree (Temple 1281).

Salix gooddingii Ball — common, large stream channels; small tree (Temple 1174).

Salix lasiolepis Bentham — common, large stream channels; large shrub (Temple 1182).

Salix lucida Muhlenberg ssp. *lasiandra* (Bentham) Murray — occasional, large stream channels; small tree (Temple 1008).

Saururaceae

Anemopsis californica (Nuttall) Hooker & Arnott — rare, one colony, in damp shaded arroyo off main stream channel, near SW edge of SC; perennial (Temple 1412).

Scrophulariaceae

Antirrhinum nuttallianum Bentham ssp. *nuttallianum* — common, rock ledges, boulders; flowering January to May, occasionally all year; annual (Temple 1229); a few, white-flowered plants scattered throughout (Temple 1230).

Collinsia concolor Greene — fairly common, damp grassy slopes or banks; spring annual (Temple 1129).

Collinsia heterophylla Graham — occasional to locally common, damp shaded ravines, often on bare banks or steep slopes; spring annual (Temple 1201)

Keckiella antirrhinoides (Bentham) Straw var. *antirrhinoides* — occasional to locally common, edges of rocky ravines, E-facing slopes; shrub, flowering April (Temple 1211).

Linaria canadensis (L.) Dumont de Courset var. *texana* (Scheele) Pennell — widely scattered on open, disturbed grassy slopes; spring annual (Temple 1337).

Mimulus aurantiacus Curtis — common, on rocks, boulders; low shrub, flowering January to June; flower color highly variable, from pale creamy yellow to dark red; pale-flowered forms appear to dominate early in the year, darker-flowered forms later in the summer (Temple 1253).

Mimulus brevipes Bentham — uncommon to locally common, dry sandy soils; spring annual (Temple 1359).

Mimulus cardinalis Bentham — numbers highly variable, locally common to abundant in rainy years, absent in dry years; damp sandy washes; large perennial (Temple 1003).

Mimulus guttatus DC. — common, sunny wet silty to sandy soils in drainages; annual.

Mimulus pilosus (Bentham) Watson — uncommon, damp sandy banks, main stream channel; annual (Temple 1005).

Orthocarpus purpurascens Bentham var. *purpurascens* [*Castilleja exserta* (Heller) Chuang & Heckard var. *exserta*] — widely scattered to common (in rainy years), grassy fields, especially on heavy soils in S half of SC; spring annual. Numbers appear reduced in recent years, apparently from competition with annual grasses, especially *Hordeum murinum* (Temple 1327).

Penstemon spectabilis Thurber var. *spectabilis* — uncommon, scattered on E-facing grassy to rocky slopes: large, shrubby perennial; flowering January to May (Temple 1249).

Scrophularia californica Chamisso & Schlechtendal ssp. *floribunda* (Greene) Shaw — common, rock outcrops, boulders: spring perennial (Temple 1223).

**Veronica anagallis-aquatica* L. — occasional, damp sandy washes; mostly annual (Temple 1002).

Veronica peregrina L. ssp. *xalapensis* (Kunth) Pennell — locally common on seasonally damp silty or clay soils near SE edge of SC; spring annual (Temple 1339).

Simaroubaceae

**Ailanthus altissima* (Miller) Swingle — occasional seedlings, disturbed sandy bank of main stream channel; tree (Temple 1399).

Solanaceae

Datura wrightii Regel — common, open sandy to rocky slopes; long-lived annual, flowering all year.

Lycium andersonii Gray — uncommon, rocky W-facing slopes; large shrub flowering January to March (Temple 1320).

**Nicotiana glauca* Graham — common, disturbed sandy soils, washes, seeps; weedy tree flowering all year.

Nicotiana quadrivalvis Pursh — uncommon, disturbed, sandy soils; annual, flowering all year (Temple 1170).

**Physalis philadelphica* Lamarck — uncommon, a few plants in disturbed, damp sandy soils; annual (Temple 1392).

Solanum douglasii Dunal — fairly common, damp soils, ravines; large perennial, flowering all year (Temple 1026).

Solanum xanti Gray — common, grassy or rocky slopes; small shrub, flowering November through spring (Temple 1264).

Tamaricaceae

**Tamarix ramosissima* Ledebour — uncommon, seedlings and small trees scattered along stream channels (Temple 1231).

Urticaceae

Hesperocnide tenella Torrey — uncommon, damp, shaded base of boulders; spring annual (Temple 1252).
Parietaria hespera Hinton var. *californica* Hinton — fairly common, damp rock shelters, shaded banks; spring annual (Temple 1204).
Urtica dioica L. ssp. *holosericea* (Nuttall) Thorne — abundant, damp sunny to shady areas, streams, seeps, springs; perennial.

Verbenaceae

Verbena lasiostachys Link var. *scabrida* Moldenke — fairly common, scattered on damp soil, sunny stream banks; perennial (Temple 1294).

Violaceae

Viola pedunculata Torrey & Gray — locally common, in scattered colonies, open seasonally damp grassy flats; perennial (Temple 1344).

Vitaceae

Vitis girdiana Munson — locally abundant, riparian zone of main stream channel; liana, climbing on trees and spreading over the ground (Temple 1297).

ANGIOSPERMS
Monocotyledones

Agavaceae [Liliaceae (part)]

Yucca whipplei Torrey ssp. *whipplei* — rare, a few plants on steep, W-facing rocky slope; perennial (Temple 1355).

Alliaceae [Liliaceae (part)]

Allium peninsulare Lemmon — common, seasonally damp grassy slopes; perennial, flowering March-April (Temple 1138).
Bloomeria crocea (Torrey) Coville var. *crocea* — occasional to locally common, damp grassy slopes; perennial, flowering late April-May (Temple 1299).
Dichelostemma capitatum Wood — common, grassy slopes; perennial, flowering February-April (Temple 1236).
Muilla maritima (Torrey) Watson — rare, one plant on damp, partly-shaded bank, flowering March, perennial (Temple 1410).

Arecaceae

**Phoenix canariensis* Chabaud — rare, one large tree in narrow ravine, facing Central Avenue, persisting from cultivation or escaped (?).
**Washingtonia filifera* (Linden) Wendland — uncommon, naturalized in a few deep ravines; small to medium-sized trees.

Calochortaceae [Liliaceae (part)]

Calochortus splendens Bentham — uncommon, small colonies scattered over dense grasslands, in heavy soils above 450 m; perennial, flowering May (Temple 1288).

Cyperaceae

Cyperus eragrostis Lamarck — common, scattered along streams; large perennial (Temple 1292).
Scirpus acutus Bigelow var. *occidentalis* (Watson) Beetle — occasional, small colonies in damp soils along main stream channel; large perennial (Temple 1238)
Scirpus robustus Pursh — uncommon, muddy soils, main stream channel; large perennial (Temple 1365).

Juncaceae

Juncus balticus Willdenow — occasional, in sunny seasonally wet soils along main stream channel; perennial (Temple 1387).
Juncus bufonius L. var. *bufonius* — occasional, damp shaded stream banks; small annual (Temple 1254).
Juncus mexicanus Willdenow — occasional to locally common, damp banks and adjacent grassy flats along main channel; large perennial (Temple 1302) or (Temple 1161).
Juncus xiphioides E. Meyer — occasional, small colonies in damp shaded banks along main stream channel; large perennial (Temple 1380).

Lemnaceae

Lemna minuta Kunth[1] — locally common in quiet sunny pools along streams; habitat available only in wet years; tiny perennial (Temple 1393)

Poaceae

**Agrostis viridis* Gouan — occasional, scattered on sandy stream bottoms; perennial (Temple 1364a).
**Arundo donax* L. — common, choking main stream channel; large perennial spreading throughout riparian zone.
**Avena barbata* Link — common, grassy slopes; spring annual (Temple 1156).
**Avena fatua* L. — common to locally abundant, grassy slopes, spring annual (Temple 1106).
**Bromus diandrus* Roth — common to locally abundant, open grasslands; annual.
**Bromus hordeaceus* L. — common, disturbed soils; annual (Temple 1102).
**Bromus madritensis* L. ssp. *rubens* (L.) Husnot — ubiquitous weedy annual.
**Bromus tectorum* L. — common, scattered throughout; annual (Temple 1107).
Distichlis spicata (L.) Greene — locally common, low alkaline sandy flats along main stream channel; perennial (Temple 1307).
**Echinochloa crus-galli* (L.) Palisot de Beauvois — occasional, scattered on open, damp disturbed soils; annual (Temple 1377).

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[1]This is the correct name for *Lemna minuscula* Herter, as given in The Jepson Manual (Hickman [editor] 1993); see *The Jepson Globe* Vol. 8 No. 3, December, 1997.

Elymus condensatus C. Presl [*Leymus condensatus* (C. Presl) Love] — fairly common, large clumps on open flats and slopes bordering riparian zones; large perennial (Temple 1296).

Elymus triticoides Buckley [*Leymus triticoides* (Buckley) Pilger] — locally common, low alkaline sandy flats along main stream channel, often shaded by willows, cottonwoods; large tufted perennial (Temple 1306).

**Eragrostis mexicana* (Hornemann) Link ssp. *virescens* (J. Presl) S.D. Koch & Sánchez — rare, a few plants in damp disturbed sandy wash; annual (Temple 1390).

**Festuca pratensis* Hudson — occasional, wet mud flats along stream; perennial (Temple1305).

**Hordeum murinum* L. var. *leporinum* (Link) Arcangeli — locally common, especially along trails, roads; annual (Temple 1124).

**Hordeum vulgare* L. — one large clump, on loose sandy soil, near main stream channel; annual (Temple 1409).

**Lamarckia aurea* (L.) Moench — fairly common, disturbed areas, often in soil pockets on boulders; annual (Temple 1145).

Leptochloa uninervia (J. Presl) Hitchcock & Chase — occasional, damp ditches; summer annual (Temple 1317).

**Lolium perenne* L. ssp. *multiflorum* (Lamarck) Husnot [*L. multiflorum* Lamarck] — occasional, disturbed soils, especially in riparian areas; large annual (Temple 1246).

Melica imperfecta Trinius — occasional, scattered over rocky mostly E-facing grassy slopes; perennial (Temple 1219).

Muhlenbergia microsperma (DC.) Kunth — rare, crevices in rocks on open, xeric slope; spring annual (Temple 1116).

Muhlenbergia rigens (Bentham) Hitchcock — rare, a few large clumps in shaded riparian zone at base of cliff in main stream channel; perennial (Temple 1351).

**Paspalum dilatatum* Poiret — occasional, damp, disturbed sandy stream bottoms; perennial (Temple 1376).

**Pennisetum setaceum* (Forsskål) Chiovenda — uncommon, naturalized at base of boulder on dry W-facing slope, spreading from cultivation; perennial (Temple 1112).

**Poa annua* L. — occasional, damp spots along trails; annual (Temple 1275).

Poa secunda J. Presl ssp. *secunda* — uncommon, scattered on E-facing rocky, grassy slopes, near seeps; tufted perennial (Temple 1123).

**Polypogon monspeliensis* (L.) Desfontaines — common, damp soils along streams; annual (Temple 1228).

**Schismus barbatus* (L.) Thellung — common, open grasslands, open sandy soils; spring, annual (Temple 1146).

**Setaria pumila* (Poiret) Roemer & Schultes — occasional, damp disturbed soils, muddy banks of streams; annual (Temple 1367).

Sporobolus airoides (Torrey) Torrey — locally common, alkaline sandy flats; tufted perennial (Temple 1023).

Stipa lepida Hitchcock [*Nassella lepida* (Hitchcock) Barkworth] — occasional, scattered over dry rocky to open grassy W-facing slopes; perennial (Temple 1303).

Stipa speciosa Trinius & Ruprecht [*Achnatherum speciosum* (Trinius & Ruprecht) Barkworth] — rare, a few clumps at base of boulder on dry, rocky E-facing slope, ca. 400 m; perennial (Temple 1248).

**Vulpia myuros* (L.) Gmelin var. *myuros* — fairly common, along trails, disturbed soils; annual (Temple 1261).

**Vulpia myuros* var. *hirsuta* Hackel[2] — common, open grasslands; annual (Temple 1266).

Vulpia octoflora (Walter) Rydberg var. *hirtella* (Piper) Henrard — occasional, scattered in openings on dry W-facing slopes, annual (Temple 1414).

[2]Subspecies authority corrected in *The Jepson Globe* Vol. 9 No. 1 (1998).

Typhaceae

Typha latifolia L. — occasional to locally common, open, sandy stream channels, seeps, springs; perennial.

Acknowledgments

Many thanks to Andrew C. Sanders, UCR Herbarium, for his encouragement, and for correcting my many mistakes in plant identification. However, any errors or omissions are entirely my own. Thanks also to Oscar Clarke for his enthusiastic example how to keep the fun in field work. The Friends of Sycamore Canyon, the Park and Recreation Department, and the people of Riverside also deserve thanks for preserving a part of our natural heritage for future generations.

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BOOK REVIEWS

Plant life in the world's Mediterranean climates: California, Chile, South Africa, Australia, and the Mediterranean Basin by P. R. Dallman, with a preface by Robert Ornduff. 1998. California Native Plant Society and University of California Press, Berkeley, California. 255 p. Cloth, alkaline paper (ISBN 0-520-20808-0) $50.00; paperback, alkaline paper (ISBN 0-520-20809-9) $29.95.

This is a superbly constructed book for botanists interested in shared and different characteristics of the five Mediterranean type ecosystems, which occur between roughly 30 and 40 degrees North and South latitude on the western sides of five continents. The book is organized in ten chapters, with the first four describing the climate, plant and climate origins, plant adaptations, and plant communities, followed by chapters dedicated to California, central Chile, the Western Cape of South Africa, Australia, and the Mediterranean Basin. The final chapter recommends routes for trips by visiting botanists to the five MTEs. The tables are of high quality and provide ready comparisons of the MTEs in a diversity of areas ranging from plant adaptations to alpha and beta diversity to specific climate data. There are good scanning electron micrographs of sclerophyll and drought deciduous leaves, as well as of stomata. Plant adaptations and communities are particularly well treated, with parallels and differences in the MTEs clearly shown. Drought-evading strategies include drought deciduousness, geophytes, and annual life histories. The two water seeking strategies of roots, i.e., thick, deep roots and a mat of finer roots near the soil surface, are illustrated with figures from Kummerow (1981). The book is clearly written, with the well described plant communities of each MTE displayed in excellent photographs, and also in illustrative drawings.

Correcting the common misconception that MTEs are community-poor, in each MTE there are many plant communities besides those frequently compared with chaparral and coastal sage scrub. One learns in reading this book that "each Mediterranean climate area has an unusual degree of plant diversity with a high percent endemics," surpassed only in density by the tropical rainforests of the western hemisphere and southeast Asia. Comparing the MTE regions, California has 4,400 species with an endemism of 48%; Chile has 2400 species with 50% endemics; the Cape Region has 8550 species and 68% endemism; SW Australia has 8000 species of which 75% are endemic; and the Mediterranean basin has 25000 with 50% endemic. There are some issues of importance here in California such as restoration and mitigation of coastal sage scrub losses which are not addressed, but there is ample data for comparison of many other characteristics of the plant communities in the MTEs, and there is a strong discussion of the need to conserve these habitats. There ten pages of references which are an excellent entrance to the literature, and a useful index at the back of the book.

This book would be a natural for a text in a course on Mediterranean type ecosystems, and is an invaluable resource for botanists from any of these areas. I highly recommend this book to all. Well done in all regards, it provides a readable, concise, and highly informative synopsis, and modern basis for our better understanding of the botany of our North American MTE, as well as for that of the other four.

This reviewer would like to acknowledge the University of California Natural Reserve System's San Joaquin Marsh Reserve for computer support, and a grant from the Transportation Corridor Agencies to the University of California School of Biological Sciences.

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— ***Peter A. Bowler****, Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697-2525 and White Mountain Research Station, 3000 E. Line Street, Bishop, CA 93514*

Natural History of the Islands of California by Allan A. Schoenherr, C. Robert Feldmeth, and Michael J. Emerson; illustrations by David Mooney, and Michael J. Emerson. 1999. California Natural History Guides, 61. University of California Press, Berkeley and Los Angeles, California. 502 pages. Cloth (ISBN 0-520-21197-9) $45.00.

Natural History of the Islands of California is a wonderful, well-organized, and enlightening book by Allan Schoenherr, Robert Feldmeth and Michael Emerson. Schoenherr is the lead author of this book begun by the late Robert Feldmeth, and it is a joy to read, just as was Schoenherr's "Natural History of California," also a University of California Press Natural History Guide. The book is organized into ten chapters, an epilogue, eleven pages of selected references, and an index. There are sixteen color plates and 207 black and white plates, comprising a mixture of photographs and masterful line drawings. The twenty-seven tables are superb anthologies of information comparing everything from island size to plant and animal endemism and species richness in all of California's islands, with individual tables for each island. I was delighted to see an excellent drawing of *Helminthoglypta ayresiana*, one the California islands' many endemic landsnails. The book does not limit itself to terrestrial fauna, but does a commendable job of presenting the ocean environment from the intertidal to marine fishes and marine mammals. The geology is particularly well treated, as is the history of Native American habitation of the islands. The book is thorough, with both the scientific and common names of organisms presented from robber flies to the endemic mammals and plants. Besides engaging discussions of conditions on each island, general principles are also clearly explained, often with attractive photographs or line drawings. Key words for each community are italicized and defined. In addition to the Channel Islands, this book also addresses the Farallon Islands and the islands of San Francisco Bay.

For those who teach biology, this book is a particularly superb tool, with each chapter falling into a gracefully organized topical sequence, naturally fitted to a lecture (you can see my special pleasure in this!). The excellent compilation of facts and figures makes this a valuable vehicle for teaching island ecology. This book complements and goes far beyond other treatments of the California islands.

I will never again visit any of the Channel Islands without this book. I give it my highest recommendation for anyone interested in the California islands, on any level. This is one of the best contributions to California biology in years, and I am learning more with every re-read. This book should be in all of our libraries, and it is truly one of the best books I have read about California biology – it is another magnificent contribution.

This reviewer would like to acknowledge the University of California Natural Reserve System's San Joaquin Marsh Reserve for computer support, and a grant from the Transportation Corridor Agencies to the University of California School of Biological Sciences.

— ***Peter A. Bowler**, Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697-2525 and White Mountain Research Station, 3000 E. Line Street, Bishop, CA 93514*

Native and Non-native Vascular Plant Congeners: Sympatric Without a (Natural) Cause

Peter A. Bowler (pabowler@uci.edu) Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92697-2525, and
White Mountain Research Station, 3000 E. Line Street, Bishop, CA 93514

"*...that grand subject, that almost keystone of the laws of creation, Geographical Distribution.*"

—Charles Darwin in a letter to Joseph Dalton Hooker, 1845

A graduate student recently asked me to recommend a local exotic-native congener pair to use as a system comparing a weedy species and a related native. As I began looking through Roberts' (1998) checklist for Orange County, it was surprising how many such pairs existed, and it was of further interest to note those families which do or do not have both native and exotic taxa established in this Mediterranean type ecosystem. According to Roberts (1998), there are 1,193 species, and an additional 76 infraspecific taxa (subspecies and varieties) in Orange County, for a total of 1,269 taxa, of which 387 species (32.4%) are non-native. This is significantly greater than the percentage of exotics (1,023 taxa; 17.4%) within the California flora (5,867 species) as reported in The Jepson Manual (Hickman [editor] 1993).

Following Roberts' nomenclature, which differs in part (Bowler 1999a; White 1999) from both The Jepson Manual, and that of Munz (1973; 1974), there are 129 families of vascular plants in Orange County. Of these, 53 families have no genera with exotic taxa, and the other 76 have non-natives established in Orange County. Thirty-one families have genera with at least one native and non-native species, with great variation between them (Table 1). These include the Cupressaceae (*Juniperus*) and Pinaceae (*Pinus*) in the Gymnospermae, 25 familes in the Dicotyledones, and four families of Monocotyledones. Seventeen families have only one such genus.

The families with the greatest number of native-exotic congeners are Asteraceae (16 genera), Poaceae (13 genera), Fabaceae (4 genera) and Brassicaceae (4 genera), which also are among the ten largest families in Orange County (Asteraceae - 186 species, 123 natives, 63 non-native; Poaceae - 124 species, 50 native, 74 non-native; Fabaceae - 84 species, 49 native, 35 non-native, and; Brassicaceae - 47 species, 22 native, 25 non-native [Roberts 1998]). The 149 non-native species that have native congeners comprise 42.7% of the 351 exotic vascular plant species reported for Orange County, and 13% of the total flora (1,157 species).

Plant distributions have fascinated biologists for centuries, a topic well reviewed in classic studies such as Goods' (1953) "The Geography of the Flowering Plants," Cain's (1994) "Foundations of Plant Geography," Raven and Axelrod (1995), as well as in many more recent studies such as Sauer's (1988) "Plant Migration." The history of introductions has been well described in many studies, particularly Robbins (1940) for southern California, and exotics are a familiar problem in the management of southern California natural areas (Natural Communities Conservation Planning [NCCP] Core Group 1997; Luken and Thieret 1997; Bowler 1992).

Human-caused introductions have placed many plant communities in a new evolutionary context, and there have been a few cases of new genotypes arising within invading species, although, I know of no example of well-documented genetic changes within native species, in the face of invasive species. Several studies comparing native and non-native wetland species in Orange County show that among wetland indicator species, non-native taxa have broad temperate distributions, while upland exotic species are more limited in their ranges outside the area of their native occurrence (Bowler and Wolf 1994; Bowler, Wolf, and Bradley 1995). It was hypothesized that the commonality of wetland conditions ameliorates restrictive climate or edaphic factors, which upland exotic species' distributions reflect more closely. Previously, a perennial life history predominated among exotic wetland species in Orange County, while most of the non-native flora are now annuals.

The study of native and non-native congeners can lead to a better understanding of genetic distance between them, and can also provide insight into why some species are invasive, and other closely related taxa are not. It is hoped that this list of Orange County native and non-native congeners will be useful to those seeking congeneric pairs for their research.

Table 1. A summary of the families and genera for Orange County which have native and non-native congeners in them, based on the nomenclatural interpretation of Roberts (1998). This list includes varietal and subspecific taxa, not just species. Roberts accepts *Achillea millefolium* var. *californica* (Pollard) Jepson, which Meredith Lane in The Jepson Manual does not. As treated here, var. *californica* and the non-native var. *millefolium* comprise the only two native and exotic varietal or subspecies pairs in the list.

Family / *Genus*	(All Genera) Native Taxa	Non-Native Taxa
GYMNOSPERMAE		
Cupressaceae	(3)	
Juniperus	1	1
Pinaceae	(2)	
Pinus	2	1
ANGIOSPERMAE – DICOTYLEDONES		
Amaranthaceae	(1)	
Amaranthus	3	5
Apiaceae	(20)	
Daucus	1	1
Asteraceae	(94)	
Achillea	1	1
Ambrosia	4	1
Artemisia	4	1
Bidens	2	1
Chamomilla	1	1
Cirsium	3	2
Conyza	2	1
Coreopsis	1	1
Filago	1	1
Gnaphalium	8	1
Helianthus	3	2
Hemizonia	5	1
Lasthenia	3	1
Senecio	3	2
Solidago	2	1
Verbesina	1	2
Brassicaceae	(26)	
Cakile	1	1
Cardamine	1	1
Lepidium	4	3
Rorippa	3	1
Cactaceae	(1)	
Opuntia	6	1
Caprifoliaceae	(2)	
Lonicera	1	1
Caryophyllaceae	(10)	
Polycarpon	1	1
Silene	5	2
Spergularia	2	2
Stellaria	1	1
Chenopodiaceae	(12)	
Atriplex	12	5
Chenopodium	2	8
Convolvulaceae	(6)	
Convolvulus	1	1
Dichondra	1	1
Euphorbiaceae	(8)	
Chamaesyce	3	4
Euphorbia	3	3
Fabaceae	(19)	
Lathyrus	2	3
Lotus	12	1
Trifolium	11	5
Vicia	3	5
Geraniaceae	(3)	
Geranium	1	1
Hypericaceae	(1)	
Hypericum	1	1
Lythraceae	(2)	
Lythrum	1	2
Nyctaginaceae	(3)	
Mirabilis	1	1
Onagraceae	(6)	
Oenothera	2	1
Oxalidaceae	(1)	
Oxalis	1	2
Plantaginaceae	(1)	
Plantago	2	5
Plumbaginaceae	(2)	
Limonium	1	2
Polygonaceae	(9)	
Polygonum	4	3
Rumex	4	3

Table 1. (continued)

Family (All Genera) / *Genus*	Native Taxa	Non-Native Taxa
Rubiaceae	**(2)**	
Galium	3	1
Scrophulariaceae	**(15)**	
Linaria	1	3
Veronica	1	2
Solanaceae	**(9)**	
Datura	1	1
Nicotiana	3	1
Solanum	4	6
Urticaceae	**(3)**	
Urtica	1	1
Verbenaceae	**(2)**	
Phyla	1	1
Verbena	5	1
ANGIOSPERMAE – MONOTYLEDONES		
Alliaceae	**(6)**	
Allium	3	1

Family (All Genera) / *Genus*	Native Taxa	Non-Native Taxa
Cyperaceae	**(5)**	
Cyperus	9	2
Poaceae	**(60)**	
Agrostis	2	2
Aristida	4	1
Bromus	7	7
Chloris	1	1
Eragrostis	2	2
Festuca	1	1
Hordeum	4	2
Paspalum	1	1
Phalaris	1	3
Poa	3	2
Setaria	1	3
Sporobolus	2	1
Vulpia	4	3
Potamogetonaceae	**(2)**	
Potamogeton	1	1

NATIVE AND NON-NATIVE CONGENERS OF ORANGE COUNTY, CALIFORNIA

GYMNOSPERMAE

Cupressaceae

Juniperus californica Carrière
**J. monosperma* (Engelmann) Sargent[1]

Pinaceae

P. attenuata Lemmon
Pinus coulteri D. Don
**P. radiata* D. Don

ANGIOSPERMAE – DICOTYLEDONES

Amaranthaceae

Amaranthus blitoides S.Watson
A. *palmeri* S.Watson
A. powellii S.Watson
**A. albus* L.
**A. deflexus* L.
**A. hybridus* L.
**A. retroflexus* L.

Apiaceae

Daucus pusillus Michaux
**D. carota* L.

[1] Not included in The Jepson Manual.

Asteraceae

Achillea millefolium L. var. *californica* (Pollard) Jepson
**A. millefolium* L. var. *millefolium*
Ambrosia chamissonis Lessing
A. chenopodiifolia (Bentham) Payne[2]
A. confertiflora DC.
A. psilostachya DC. var. *californica* (Rydberg) Blake
**A. trifida* L.

Artemisia californica Lessing
A. douglasiana Besser
A. dracunulus L.
A. tridentata Nuttall
**A. biennis* Willdenow

Bidens cernua L. var *cernua*
B. laevis (L.) Britton, Sterns & Poggenburg
**B. pilosa* L.

[2] Roberts treats as non-native, The Jepson Manual as native.

Chamomilla occidentalis (Greene) Rydberg
**C. suaveolens* (Pursh) Rydberg

Cirsium brevistylum Cronquist
C. californicum A. Gray
C. occidentale (Nuttall) Jepson
**C. arvense* (L.) Scopoli
**C. vulgare* (Savi) Tenore

Conyza canadensis (L.) Cronquist
C. coulteri A.Gray
**C. bonariensis* (L.) Cronquist

Coreopsis californica (Nuttall) H.K. Sharsmith var. *californica*
**C. gigantea* (Kellogg) H.M. Hall

Filago californica Nuttall
**F. gallica* L.

Gnaphalium beneolens Davidson
G. bicolor Bioletti
G. californicum DC.
G. leucocephalum A. Gray
G. microcephalum Nuttall
G. palustre Nuttall
G. ramosissimum Nuttall
G. stramineum Humboldt, Bonpland & Kunth
**G. luteo-album* L.

Helianthus annuus L.
H. gracilentus A. Gray
H. nuttallii Torrey & A. Gray ssp. *parishii* (A. Gray) Heiser
**H. ciliaris* DC.
**H. petiolaris* Nuttall ssp. *petiolaris*

Hemizonia fasciculata (DC.) Torrey & A. Gray
H. fitchii A. Gray[3]
H. kelloggii Greene
H. paniculata A. Gray
H. parryi Greene ssp. *australis* Keck
**H. pungens* (Hooker & Arnott) Torrey & A. Gray ssp. *pungens*

Lasthenia californica DC. ex Lindley
L. coronaria (Nuttall) Ornduff
L. glabrata Lindley ssp. *coulteri* (A. Gray) Ordnuff

[3] Roberts indicates this taxon is non-native, probably in error.

**Lasthenia glabrata* Lindley ssp. *glabrata*[4]

Senecio aphanactis Greene
S. californicus DC.
S. flaccidus Lessing var. *douglasii* (DC.) Turner & Barkley
**S. mikanioides* Otto ex Walpers
**S. vulgaris* L.

Solidago californica Nuttall
S. confinis A. Gray[5]
**S. altissisma* L. var. *altissima*

Verbesina dissita A. Gray
**V. encelioides* (Cavanilles) Bentham & Hooker var. *encelioides*
**V. encelioides* var. *exauriculata* Robinson & Greenman

Brassicaceae
Cakile edentula (Bigelow) Hooker[6]
**C. maritima* Scopoli

Cardamine californica (Nuttall)[7] Greene var. *californica*
**C. oligosperma* Nuttall[8]

Lepidium lasiocarpum Nuttall[9]
L. nitidum Nuttall[10] var. *nitidum*
L. virginicum L. var. *pubescens* (Greene) Thellung
L. virginicum L. var. *robinsonii* (Thellung) C.L. Hitchcock
**L. latifoliuim* L.
**L. perfoliatum* L.
**L. pinnatifidum* Ledebour

Rorippa curvisiliqua (Hooker) Bessey ex Britton
R. gambellii (S.Watson) Rollins & Al-Shehbaz

[4] Roberts treats as non-native, The Jepson Manual as native?
[5] The Jepson Manual gives the authority as Nuttall.
[6] The Jepson Manual treats this as a non-native taxon.
[7] The Jepson Manual gives the authority as Torrey and A. Gray.
[8] Roberts treats as non-native, The Jepson Manual as native?
[9] The Jepson Manual gives the authority as Torrey and A. Gray.
[10] The Jepson Manual gives the authority as Torrey and A. Gray.

Rorippa palustris (L.) Besser ssp. *occidentalis* (S.Watson in A. Gray) Abrams
**R. nasturtium-aquaticum* (L.) Hayek[11]

Cactaceae
Opuntia californica (Torrey & A. Gray) Coville var. *parkeri* (Coulter) D. Pinkava[12]
O. "demissa" Griffiths[13]
O. littoralis (Engelmann) Cockerell.
O. littoralis x *vaseyi* (Coulter) Britton & Rose
O. oricola Philbrick
O. prolifera Engelmann
**O. ficus-indica* (L.) P. Miller

Caprifoliaceae
Lonicera subspicata Hooker & Arnott var. *denudata* Rehder
**L. japonica* Thunberg

Caryophyllaceae
Polycarpon depressum Nuttall
**P. tetraphyllum* (L.) L.

Silene antirrhina L.
S. laciniata Cavanilles ssp. *major* C.L. Hitchcock & Maguire
S. lemmonii S.Watson
S. multinervia S.Watson
S. verecunda S.Watson ssp. *platyota* (S.Watson) C.L. Hitchcock & Maguire
**S. gallica* L.
**S. vulgaris* (Moench) Garcke

Spergularia macrotheca (Hornemann) Heynhold var. *macrotheca*
S. marina (L.) Grisebach
**S. bocconei* (Scheele) Foucaud ex Merino
**S. villosa* (Persoon) Cambessèdes

Stellaria nitens Nuttall
**S. media* (L.) Villars

[11] The Jepson Manual treats this as a native taxon.
[12] Considered a synonym of *Opuntia parryi* Engelmann in The Jepson Manual. Kartesz (1994) places *O. californica* in *O. tetracantha* Toumey.
[13] The Jepson Manual indicates "could be a hybrid with *O. oricola* Philbr. as one parent," whereas Munz (1974) indicates that it is "related to *O. ficus-indica* (L.) P. Miller."

Chenopodiaceae
Atriplex argentea Nuttall var. *mohavensis* M.E. Jones
A. californica Moquin-Tandon in DC.
A. canescens (Pursh) Nuttall ssp. *canescens*
A. coulteri (Moquin-Tandon) D. Dietrich
A. davidsonii Standley
A. lentiformis (Torrey) S.Watson ssp. *breweri* (S.Watson) H.M. Hall & F.E. Clements
A. leucophylla (Moquin-Tandon) D. Dietrich
A. pacifica A. Nelson
A. parishii S.Watson
A. patula L. ssp. *patula*
A. serenana A. Nelson
A. watsonii A. Nelson
**A. glauca* L.[14]
**A. lindleyi* DC.[15]
**A. polycarpa* (Torrey) S.Watson
**A. rosea* L.
**A. semibaccata* R. Brown

Chenopodium berlandieri Moquin-Tandon
C. californicum (S.Watson) S.Watson
**C. album* L.
**C. ambrosioides* L.
**C. botrys* L.
**C. macrospermum* Hooker f. var. *halophilum* (Phillippi) Standley[16]
**C. multifidum* L.
**C. murale* L.
**C. pumilio* R. Brown
**C. rubrum* L.

Convolvulaceae
Convolvulus simulans L.M. Perry
**C. arvensis* L.

Dichondra occidentalis House
**D. repens* Forster & Forster f.[17]

Euphorbiaceae
Chamaesyce albomarginata (Torrey & A. Gray) Small
C. polycarpa (Bentham) Millspaugh var. *polycarpa*

[14] Not included in The Jepson Manual, or Kartesz (1994).
[15] Roberts indicates native, The Jepson Manual states native to Australia
[16] Roberts treats as native, The Jepson Manual indicates "probably native to South America "
[17] Not included in The Jepson Manual.

Chamaesyce serpyllifolia (Persoon) Small ssp. *hirtula* (S.Watson) Koutnik
**C. prostrata* (Aiton) Small[18]
**C. maculata* L.
**C. nutans* (Lagasca) Small
**C. serpens* (Kunth) Small

Euphorbia crenulata Engelmann
E. misera Bentham
E. spathulata Lamarck
**E. lathyris* L.
**E. peplus* L.
**E. tirucalli* L.[19]

Fabaceae
Lathyrus vestitus Nuttall ssp. *alefeldii* (T. White) Broich[20]
L. vestitus Nuttall ssp. *laevicarpus* Broich[21]
**L. latifolius* L.
**L. odoratus* L.
**L. tingitanus* L.

Lotus argophyllus (A. Gray) Greene ssp. *argophyllus*
L. crassifolius (Bentham) Greene var. *crassifolius*
L. hamatus Greene
L. heermannii (Durand & Hilgard) Greene var. *orbicularis* (A. Gray) Isely
L. heermannii (Durand & Hilgard) Greene var. *heermannii*
L. humistratus Greene
L. micranthus Bentham
L. salsuginosus Greene ssp. *salsuginosus*
L. scoparius (Nuttall in Torrey & A. Gray) Ottley var. *scoparius*
L. strigosus (Nuttall in Torrey & A. Gray) Greene var. *strigosus*
L. unifoliolatus (Hooker) Bentham[22]
L. wrangelianus Fischer & C. Meyer
**L. corniculatus* L.

Trifolium albopurpureum Torrey & A. Gray
T. ciliolatum Bentham
Trifolium depauperatum Desvaux var. *amplectens* (Torrey & A. Gray) L.F. McDermott
T. depauperatum Desvaux var *truncatum* (Greene) Martin ex Isely.
T. gracilentum Torrey & A. Gray var. *gracilentum*
T. macraei Hooker & Arnott
T. microcephalum Pursh
T. obtusiflorum Hooker
T. variegatum Nuttall
T. willdenovii Sprengel
T. wormskioldii Lehmann
**T. fragiferum* L.
**T. hirtum* Allioni
**T. incarnatum* L.
**T. pratenese* L.
**T. repens* L.

Vicia americana Muhlenberg ex Willdenow var. *americana*
V. hassei S.Watson
V. ludoviciana Nuttall var. *ludoviciana*[23]
**V. benghalensis* L.
**V. cracca* L.
**V. sativa* L. ssp. *nigra* (L.) Ehrhart
**V. sativa* L. ssp. *sativa*
**V. villosa* Roth

Geraniaceae
Geranium carolinianum L.
**G. dissectum* L.

Hypericaceae
Hypericum formosum Humboldt, Bonpland & Kunth ssp. *scouleri* (Hooker) C.L. Hitchcock[24]
**H. canariense* L.

Lythraceae
Lythrum californicum Torrey & A. Gray
**L. hyssopifolia* L.
**L. tribracteatum* Sprengel

Nyctaginaceae
Mirabilis californica A. Gray
**M. jalapa* L.

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[18] Roberts treats as native, The Jepson Manual "indicates " native West Indies and South America."
[19] Not included in The Jepson Manual or Kartesz (1994).
[20] The Jepson Manual gives Isely as the second author.
[21] Not included in The Jepson Manual.
[22] Not included in The Jepson Manual.
[23] Roberts gives as non-native, The Jepson Manual treats as native.
[24] Treated as *Hypericum formosum* var. *scouleri* (Hooker) J. Coulter in The Jepson Manual.

Onagraceae
Oenothera californica (S. Watson) S.Watson ssp. *californica*
O. elata Kunth ssp. *hirsutissima* (A. Gray ex S. Watson) W. Dietrich
**O. speciosa* Nuttall

Oxalidaceae
Oxalis albicans Humboldt, Bonpland & Kunth ssp. *californica* (Abrams) Eiten
**O. corniculata* L.
**O. pes-caprae* L.

Plantaginaceae
Plantago erecta Morris ssp. *erecta*
P. subnuda Pilger
**P. indica* L.
**P. lanceolata* L.
**P. major* L.
**P. ovata* Forsskål
**P. virginica* L.

Plumbaginaceae
Limonium californicum (Boissier) Heller
**L. perezii* (Stapf) F.T. Hubbard
**L. sinuatum* (L.) P. Miller

Polygonaceae
Polygonum amphibium L. var. *emersum* Michaux
P. hydropiperoides Michaux
P. lapathifolium L.
P. punctatum Elliot
**P. arenastrum* Boreau
**P. argyrocoleon* Steudel ex Kunze
**P. persicaria* L.

Rumex hymenosepalus Torrey
R. maritimus L.
R. salicifolius Weinmann var. *denticulatus* Torrey
R. salicifolius Weinmann var. *salicifolius*
**R. acetosella* L.
**R. conglomeratus* J. Murray
**R. crispus* L.

Rubiaceae
Galium angustifolium Nuttall ssp. *angustifolium*
G. nuttallii A. Gray ssp. *nuttallii*
G. porrigens Dempster var. *porrigens*
**G. aparine* L.[25]

[25] Origin uncertain.

Scrophulariaceae
Linaria canadensis (L.) Dumont de Courset var. *texana* (Scheele) Pennell
**L. bipartita* Willdenow
**L. maroccana* Hooker f.
**L. reticulata* Curtis[26]

Veronica peregrina L. ssp. *xalapensis* (Humboldt, Bonpland & Kunth) Pennell
**V. anagallis-aquatica* L.
**V. persica* Poiret

Solanaceae
Nicotiana attenuata Torrey
N. quadrivalvis Pursh
N. clevelandii A. Gray
**N. glauca* Graham

Solanum douglasii Dunal in DC.
S. parishii Heller
S. umbelliferum Eschscholtz var *glabrescens* Torrey
S. xanti A. Gray
**S. americanum* P. Miller[27]
**S. elaeagnifolium* Cavanilles
**S. lanceolatum* Cavanilles
**S. nigrum* L.
**S. rostratum* Dunal
**S. sarrachoides* Sendtner ex Martius

Urticaceae
Urtica dioca L. ssp. *holosericea* (Nuttall) Thorne
**U. urens* L.

Verbenaceae
Phyla lanceolata (Michaux) Greene
**P. nodiflora* (L.) Greene var. *nodiflora*[28]

Verbena bracteata Lagasca & Rodriguez
V. lasiostachys Link var. *lasiostachys*
V. lasiostachys var. *scabrida* Moldenke
V. menthifolia Bentham
V. scabra Vahl
**V. tenuisecta* Briquet

[26] Not included in The Jepson Manual. Given as *L.* *r*. (Sm.) Desf. in Kartesz (1994).
[27] The Jepson Manual treats as native, but then states "may be early introduction from South America."
[28] The Jepson Manual treats as native, but states "densely matted plants with lvs < 1 cm, widely naturalized from South America have been called *L. n.* var. *rosea* (D. Don) Munz."

MONOCOTYLEDONES

Alliaceae
Allium haematochiton S.Watson
A. monticola Davidson
A. praecox Brandegee
**A. neopolitanum* Cirillo

Cyperaceae
Cyperus acuminatus Torrey & Hooker
C. eragostis Lamarck
C. erythrorhizos Muhlenberg
C. esculentus L.
C. laevigatus L.
C. niger Ruíz López & Pavón var. *capitatus* (Britton) O'Neill
C. niger Ruíz López & Pavón var. *castaneus* (Pursh) Kükenthal
C. odoratus L.
C. squarrosus L.
**C. involucratus* Rottboel
**C. rotundus* L.

Poaceae
Agrostis diegoensis Vasey
A. exarata Trinius
**A. stolonifera* L.
**A. viridis* Gouan

Aristida divaricata Humboldt & Bonpland ex Willdenow
A. ternipes Cavanilles var. *hamulosa* (Henrard) J.S. Trent
A. purpurea Nuttall var. *parishii* (A. Hitchcock) Allred
A. purpurea Nuttall var. *purpurea*
**A. adscensionis* L.

Bromus arizonicus (Shear) Stebbins
B. carinatus Hooker & Arnott var. *californicus* Shear[29]
B. carinatus Hooker & Arnott var. *carinatus*
B. carinatus Hooker & Arnott var. *hookerianus* (Thurber) Shear
B. grandis (Shear) A. Hitchcock
B. catharticus Vahl
B. laevipes Shear
**B. diandrus* Roth
**B. hordeaceus* L. ssp. *hordeaceus*
**B. inermis* Leysser
**B. madritensis* L. ssp. *rubens* (L.) Husnot
**Bromus secalinus* L.
**B. sterilis* L.
**B. tectorum* L.

Chloris virgata Swartz[30]
**C. gayana* Kunth

Eragrostis mexicana (Hornemann) Link ssp. *mexicana*
E. mexicana (Hornemann) Link ssp. *virescens* (C. Presl) S.D. Koch
**E. cilianensis* (Allioni) Janchen
**E. pilosa* (L.) Palisot de Beauvois

Festuca rubra L.
**F. arundinacea* Schreber

Hordeum brachyantherum Nevski ssp. *brachyantherum*
H. brachyantherum ssp. *californicum* (Covas & Stebbins) von Bothmer, Jacobsen, & Seberg
H. depressum (Scribner & J.G. Smith) Rydberg
H. intercedens Nevski
**H. murinum* ssp. *leporinum* (Link) Arcangeli
**H. vulgare* L.[31]

Paspalum distichum L.
**P. dilatatum* Poiret

Phalaris lemmonii Vasey
**P. aquatica* L.
**P. minor* Retzius
**P. paradoxa* L.

Poa fendleriana (Steudel) Vasey ssp. *longiligula* (Scribner & Williams) R. Soreng
P. howellii Vasey & Scribner
P. secunda J.S. Presl
**P. annua* L.
**P. pratensis* L. ssp. *pratensis*[32]

Setaria gracilis Kunth
**S. pumila* (Poiret) Roemer & Schultes

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[29] Described as "plants with smooth sheaths" in Munz (1974).

[30] Treated as non-native in The Jepson Manual, but stating "native to warm temperate regions worldwide."

[31] Not included in The Jepson Manual.

[32] Roberts treats as native, The Jepson Manual treats as non-native, indicating native to Europe.

**Setaria sphacelata* (Schumacher) Stapf & C.E. Hubbard[33]
**S. verticillata* (L.) Palisot de Beauvois

Sporobolus airoides (Torrey) Torrey
S. flexuosus (Thurber ex Vasey) Rydberg
**S. indicus* (L.) R. Brown

Vulpia microstachys (Nuttall) Munro ex Bentham var. *ciliata* (Beal) Lonard & Gould
V. microstachys (Nuttall) Munro ex Benth var. *pauciflora* (Beal) Lonard & Gould

Vulpia octoflora (Walter) Rydberg var. *hirtella* (Piper) Henrard
V. octoflora (Walter) Rydberg var. *octoflora*
**V. bromoides* (L.) S.F. Gray[34]
**V. myuros* (L.) K.C. Gmelin var. *hirsuta* Hackel
**V. myuros* (L.) K.C. Gmelin var. *myuros*

Potamogetonaceae
Potamogeton nodosus Poiret
P. pectinatus L.
**P. crispus* L.

[33] The Jepson Manual gives the second author as Moss.

[34] Roberts gives the author as A. Gray, in error.

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NOTEWORTHY COLLECTION-CALIFORNIA

RICHARD E. RIEFNER, JR., Harmsworth Associates, 17554 Vandenberg-14, Tustin, CA 92780; **JOHN TISZLER**, National Park Service, 401 West Hillcrest Drive, Thousand Oaks, CA 91360-4207; and **STEVE BOYD**, Rancho Santa Ana Botanic Garden, 1500 North College Avenue, Claremont, CA 91711.

NAVARRETIA MELLITA E. Greene (POLEMONIACEAE) - Ventura Co., Santa Monica Mountains National Recreation Area, Circle "X" Ranch: open-soil habitats along the Mishe Mokwa Trail, Sandstone Peak region, USGS 15' Quadrangle Triunfo Pass, UTM 323170, 3776300; T1S, R20W, Section 35; 7 June 1998, elevation ca. 701 m, *Riefner & Tiszler 98-352* (RSA).

Previous Knowledge. Navarretia mellita is not well known in southern California, and has been omitted from treatments of the Polemoniaceae in major floras (Munz 1974, A flora of Southern California, University of California Press). Previously, its range has been commonly cited as occurring from Humboldt County south to San Luis Obispo County in the inner coast ranges, and in the foothills of Sierra Nevada, mostly between 300-1200 m elevation (Munz and Keck, 1959, A California flora and supplement, University of California Press; Day 1993, *Navarretia*, pp. 84-849 *in* Hickman, ed., The Jepson manual: higher plants of California, University of California Press). This species also was not included in various floras of the Santa Monica Mountains (Raven et al., 1986, Flora of the Santa Monica Mountains, California, Southern California Botanists Special Publ. No. 2, University of California, Los Angeles; Wishner, 1997, Crossosoma 23:3-63). Throughout its range, *Navarretia mellita* is found in a number of plant communities including mixed evergreen, pine, and oak forests (Munz and Keck, loc. cit.). Characteristically, however, this species is found in open, wet sandy or gravelly areas in chaparral (Day, loc. cit.). *Navarretia hamata* E. Greene ssp. *hamata* and *N. pubescens* (Bentham) Hook. & Arn. have been recorded previously from the Santa Monica Mountains (Wishner, loc. cit.). *Navarretia mellita* is easily separated from these taxa: the tips of the outer bracts of *N. mellita* are neither three-lobed nor hooked, which easily separates it from *N. hamata*, and its calyx ribs are tapered and narrower at the base than the membrane, which separates the species from *N. pubescens* (section *Mitracarpium*). Also, *N. mellita* does not produce the strong skunk-like odor of *N. hamata*, and its stem and branches are heavily glandular-hairy, noticeably sticky to the touch, which is not characteristic of the retrorsely-puberulent *N. pubescens*.

Significance. This collection represents only the second known record for *Navarretia mellita* in Ventura County, and is the first for the Santa Monica Mountains in the Transverse Ranges of southern California. This population is approximately 65 km southeast of the only other reported population in Ventura County, near Council Rock, Ortega Hill Trail, Ventura River Basin: *Navarretia mellita*, 29 July 1949, *Pollard s.n.* (UC), elev. ca. 1,220 m. (Distribution data from University and Jepson Herbaria specimens, University of California, Berkeley, CalFlora Data Base: Ann Dennis, Ginger Ogle, and Tony Morosco [accessed 9 January 2000]),[1] and represents a disjunction of approximately 200 km from the next closest location in San Luis Obispo County, at the Cuesta Ridge Botanic Area in the Santa Lucia Mountains.

This new Ventura County collection is near the 948 m-tall Sandstone Peak, located at the western edge of the Transverse Ranges. Sandstone Peak is the highest point in the Santa Monica Mountains, and is approximately 3.5 km from the Los Angeles County line. This region is characterized by steep cliffs and boulder-strewn hillsides, vegetated mostly with mixed chaparral

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[1] See the web address - http://elib.cs.Berkeley.edu/cgi/calflora_query?where-taxon=Navarretia+mellita.

dominated by *Adenostoma fasciculatum* Hook. & Arn. and *Ceanothus* spp., deep stream-cut canyons dominated by riparian forest species, and large post-burn successional habitats that support locally dense growth of *Venegasia carpesioides* DC. and *Lepechinia fragrans* (E. Greene) Epling. The soil survey (USDA Soil Survey: Ventura Area, 1970) mapping unit for the region is Igneous Rock Land (IrG) which is steep mountainous terrain consisting of basalt, andesite, and volcanic breccia outcroppings. This landform supports a relatively thin mantle of stable soils, and it is typically nearly barren, or has sparse shrub cover due to the shallow depth to bedrock. In the Sandstone Peak region, *Navarretia mellita* grows in open-soil habitats associated with rocky and clay loam soils in chaparral clearings and on open colluvial benches dominated by *Dudleya lanceolata* (Nutt.) Britt. & Rose, *Selaginella bieglovii* Underw., and geophytes such as *Allium peninsulare* Lemmon. These open-soil areas are frequently covered with a conspicuous cryptogamic crust, dominated by lichens.

Navarretia mellita, at least during the unusually wet spring following the 1997/1998 El Niño event, favored slightly moist micro-depressions near the head of Mishe Mokwa Trail (elev. ca. 701 m) and on the 823 m-high plateau below Sandstone Peak. It was uncommon at each of these two sites. Small-scale topographic relief such as these micro-depressions can be important in determining spatial structure and variation in plant density, and in influencing the formation of irregular mosaics in vegetation patterns in semiarid ecosystems (Klausmeier, 1999, Science 284:1826-1828). These 1-3 cm deep micro-depressions apparently provide annual plants with the benefit of improved moisture regimes in these generally well-drained loams, which in-turn, also promote the growth of cyanobacteria (*Microcoleus* sp. and *Nostoc* spp.) and bryophytes (*Riccia* spp.) that are becoming scarce where dense growth of exotic grasses dominate deep, organic soil habitats. The invasion of these exotic grasses has displaced many native annual plants, and forever altered several of California's vegetation communities (McClintock 1986, *in* Elias and Nelson, eds., Conservation and Management of Rare and Endangered Plants, California Native Plant Society).

Navarretia mellita is but one of a diverse group of annual vascular plants, invertebrates, and cryptogams that depend upon open-soil micro-sites that are free of shade and competing exotic grasses to successfully complete their life cycle. A few examples of the rarest of these species include the federally-listed endangered *Pentachaeta lyonii* A. Gray (U.S. Fish and Wildlife Service, 1998, Draft Recovery Plan for six plants from the mountains surrounding the Los Angeles Basin, California), the federally-listed threatened *Eriastrum hooveri* (Jepson) H. Mason (Holmstead & Anderson, 1998, Madroño 45:295-300), the federally-listed endangered quino checkerspot butterfly, *Euphydryas editha quino* (Behr) (Mattoni et al., 1997, Jour. Res. Lepidoptera 34:99-118), and the rare soil lichen, *Texosporium sancti-jacobi* (Tuck.) Nadv. (McCune & Rosentreter, 1992, The Bryologist 95:329-333) These open-soil communities have often been overlooked as a refuge for rare or unusual organisms, and they should be routinely included in field surveys and restoration projects, in order to conserve southern California's vanishing arid-land resources.

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Southern California Botanists
Department of Biology
California State University
Fullerton, California 92834 U.S.A.

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