

\$10.00 (Free to Members)

VOL. 39, NO. 2 AND VOL. 39, NO. 3 • MAY 2011 AND SEPTEMBER 2011

FREMONTIA

JOURNAL OF THE CALIFORNIA NATIVE PLANT SOCIETY

CALIFORNIA'S PRAIRIES
AND GRASSLANDS

FREMONTIA

VOL. 39, NO. 2, MAY 2011 AND
VOL. 39, NO. 3, SEPTEMBER 2011

Copyright © 2011

California Native Plant Society

Bob Hass, Editor

Glen Holstein, Contributing Editor

Beth Hansen-Winter, Designer

Brad Jenkins and Cynthia Roye,
Proofreaders

CALIFORNIA NATIVE PLANT SOCIETY

*Dedicated to the Preservation of
the California Native Flora*

The California Native Plant Society (CNPS) is a statewide nonprofit organization dedicated to increasing the understanding and appreciation of California's native plants, and to preserving them and their natural habitats for future generations.

CNPS carries out its mission through science, conservation advocacy, education, and horticulture at the local, state, and federal levels. It monitors rare and endangered plants and habitats; acts to save endangered areas through publicity, persuasion, and on occasion, legal action; provides expert testimony to government bodies; supports the establishment of native plant preserves; sponsors workdays to remove invasive plants; and offers a range of educational activities including speaker programs, field trips, native plant sales, horticultural workshops, and demonstration gardens.

Since its founding in 1965, the traditional strength of CNPS has been its dedicated volunteers. CNPS activities are organized at the local chapter level where members' varied interests influence what is done. Volunteers from the 33 CNPS chapters annually contribute in excess of 97,000 hours (equivalent to 46.5 full-time employees).

CNPS membership is open to all. Members receive the quarterly journal, *Fremontia*, the quarterly statewide *Bulletin*, and newsletters from their local CNPS chapter.

Disclaimer:

The views expressed by authors published in this journal do not necessarily reflect established policy or procedure of CNPS, and their publication in this journal should not be interpreted as an organizational endorsement—in part or in whole—of their ideas, statements, or opinions.

CALIFORNIA NATIVE PLANT SOCIETY

CNPS, 2707 K Street, Suite 1; Sacramento, CA 95816-5113

Phone: (916) 447-CNPS (2677) Fax: (916) 447-2727

Web site: www.cnps.org Email: cnps@cnps.org

MEMBERSHIP

Membership form located on inside back cover;
dues include subscriptions to *Fremontia* and the *CNPS Bulletin*

Mariposa Lily	\$1,500	Family or Group	\$75
Benefactor	\$600	International or Library	\$75
Patron	\$300	Individual	\$45
Plant Lover	\$100	Student/Retired/Limited Income	\$25

CORPORATE/ORGANIZATIONAL

10+ Employees	\$2,500	4-6 Employees	\$500
7-10 Employees	\$1,000	1-3 Employees	\$150

STAFF (SACRAMENTO)

Executive Director . Dan Gluesenkamp
Finance & Administration Manager .
Cari Porter
Membership & Development Coordi-
nator Stacey Flowerdew
Conservation Program Director
Greg Suba
Rare Plant Botanist . . . Aaron Sims
Vegetation Program Director . . . Julie
Evans
Vegetation Ecologists Jennifer
Buck-Diaz, Kendra Sikes
Education Program Director . . . Josie
Crawford
Administrative Asst. . . . Marcy Millett
Office Asst. Caroline Garland

STAFF (AT LARGE)

Fremontia and *CNPS Bulletin* Editor . .
Bob Hass
Legislative Consultant . Vern Goehring
East Bay Conservation Analyst
Mack Casterman
Website Coordinator . . Mark Naftzger

PROGRAM ADVISORS

Rare Plant Program Senior Advisor . . .
Jim Andre
Vegetation Program Senior Advisor . .
Todd Keeler-Wolf
Horticulture Committee Chair
Laura Camp
CNPS Press Director . . . Nancy Morin
Poster Program . . . Bertha McKinley,
Wilma Follette

BOARD OF DIRECTORS

Brett Hall (President); Lauren Brown
(Vice President); Carol Witham (Trea-
surer); Laura Camp (Secretary); At
Large: Ellen Dean, Arvind Kumar, Brian
LeNeve, Nancy Morin, Vince Scheidt,
Alison Shilling; Chapter Council
Representatives: Orchid Black, Steve
Hartman

CHAPTER COUNCIL

David Magney (Chair); Larry Levine
(Vice Chair); Marty Foltyn (Secretary)
Alta Peak (Tulare) Joan Stewart
Bristlecone (Inyo-Mono)
Steve McLaughlin
Channel Islands David Magney
Dorothy King Young (Mendocino/
Sonoma Coast) Nancy Morin
East Bay Bill J. Hunt
El Dorado Susan Britting
Kern County Dorie Giragosian
Los Angeles/Santa Monica Mtns . . .
Betsey Landis
Marin County . . Carolyn Longstreth
Milo Baker (Sonoma County)
Liz Parsons
Mojave Desert Tim Thomas
Monterey Bay Rosemary Foster
Mount Lassen Catie Bishop
Napa Valley Gerald Tomboc
North Coast Larry Levine
North San Joaquin Alan Miller
Orange County Nancy Heuler
Redbud (Grass Valley/Auburn)
Joan A. Jernegan
Riverside/San Bernardino counties . .
Katie Barrows
Sacramento Valley . . Glen Holstein
San Diego David Varner
San Gabriel Mtns Orchid Black
San Luis Obispo Kristie Haydu
Sanhedrin (Ukiah) Geri
Hulse-Stephens
Santa Clara Valley Judy Fenerty
Santa Cruz County . Deanna Giuliano
Sequoia (Fresno) Paul Mitchell
Shasta Ken S. Kilborn
Sierra Foothills (Tuolumne, Cala-
veras, Mariposa) . . Robert W. Brown
South Coast (Palos Verdes)
David Berman
Tahoe Michael Hogan
Willis L. Jepson (Solano)
Mary Frances Kelly Poh
Yerba Buena (San Francisco)
Ellen Edelson

MATERIALS FOR PUBLICATION

CNPS members and others are welcome to contribute materials for publication in *Fremontia*. See the inside back cover for submission instructions.

Staff and board listings are as of October 2012.

Printed by Premier Graphics: www.premiergraphics.biz

CONTENTS

PRAIRIES AND GRASSLANDS: WHAT'S IN A NAME? <i>by Glen Holstein</i>	2
The accepted name for California's prairie/grassland landscapes has changed back and forth and may significantly impact its conservation.	
IS THERE STILL NATIVE DIVERSITY IN CALIFORNIA GRASSLANDS? <i>by Megan E. Lulow and Truman P. Young</i>	6
Surveys of valley and south coastal grasslands support claims for placing a greater emphasis on native wildflowers when referring to the composition of native grasslands.	
UNDERSTANDING CALIFORNIA GRASSLAND ECOLOGY <i>by Paula M. Schiffman</i>	12
Species composition of California grasslands is, to a great extent, influenced by two natural factors: variable rainfall and soil disturbance produced by native animals.	
BETWEEN THE BLADES: THE EVOLUTION OF PLANT DIVERSITY IN CALIFORNIA'S PRAIRIES AND GRASSLANDS <i>by Ellen Dean</i>	16
Our assemblages of native prairie wildflowers have come together over millions of years of geologic time to enchant us with their colorful displays.	
GEOLOGY, CLIMATE, AND CALIFORNIA PRAIRIE DISTRIBUTION <i>by Glen Holstein</i>	22
Rediscovering California prairie's lost landscapes and reexamining why they're there.	
VERTEBRATES OF CALIFORNIA GRASSLANDS <i>by Gene R. Trapp</i>	31
To what degree do California's native vertebrates depend on grasslands for their survival? Is it complete dependence for a given species, or less than that?	
INVERTEBRATES OF CALIFORNIA'S PRAIRIES <i>by Glen Holstein</i>	36
California's vast prairie landscapes have been virtually ignored and so has their rich invertebrate fauna. That greatly impedes conservation of both.	
NATIVE BEES AND FLOWERS IN CALIFORNIA PRAIRIES AND GRASSLANDS <i>by Robbin Thorp</i>	40
Remnants of once extensive California grasslands and embedded vernal pool ecosystems are home for many species of important pollinators, our native bees.	
RESTORING CALIFORNIA'S INLAND GRASSLANDS: DON'T FORGET THE FORBS! <i>by Paul A. Aigner, Kristin B. Hulvey, Catherine E. Koehler, and Leslie E. Scott</i>	41
Forbs probably once dominated many of the state's inland grasslands. Including forb species in restoration projects can enhance pollination and resistance to invasion by non-native species.	
THE CNPS GRASSLAND INITIATIVE: DOCUMENTING GRASSLAND TYPES ACROSS CALIFORNIA <i>by Jennifer Buck-Diaz and Julie Evens</i>	45
CNPS's Grassland Initiative is actively collecting and assessing data to more fully understand the diversity and variation of herbaceous vegetation across California.	
CONSERVING AND MANAGING PRAIRIE, GRASSLAND, AND VERNAL POOL LANDSCAPES THROUGH COLLABORATION <i>by Pelayo Alvarez</i>	49
A partnership of ranchers, environmentalists, government agencies, and researchers is working together to protect California's grasslands.	
NEW CNPS FELLOWS	55, 56
PETER JOSEPH CALLIZO: 1937–2011	58
BOOK REVIEWS	60
LETTERS TO THE EDITOR	62

THE COVER: Spectacular masses of spring wildflowers cover the slopes of the Temblor Range, Carrizo Plain. This photograph comes from *Wildflower Wonders: The 50 Best Wildflower Sites in the World* (Princeton University Press, 2011) and is reproduced here courtesy of the author and photographer, Bob Gibbons.



Lupine (*Lupinus* sp.) and owl's clover (*Castilleja exserta*) near Arvin, CA. Photograph from *California's Wild Gardens* (University of California Press, 2005), courtesy of photographer Craig Lippus, clippus@sbcglobal.net.

PRAIRIES AND GRASSLANDS: WHAT'S IN A NAME?

by Glen Holstein

When John Muir descended from Pacheco Pass into the Central Valley in 1868 and found it a sea of flowers, he wrote, "Here it is not as in our great western prairie, flowers sprinkled in the grass, but grass in the flowers" (Worster 2008) and "All the ground was covered, not with grass and green leaves, but radiant corollas . . ." (Muir 1992). The valley impressed Muir

not just with its wildflower abundance but also its grass scarcity.

In modern vegetation terminology, Muir described a valley dominated by forbs, not grasses. Why then are these landscapes called grasslands? It is not because of Frederic Clements, inventor of the idea they were covered with bunchgrass. He called them Pacific Prairie (Weaver & Clements 1938), but in those days they were more fre-

quently called California Prairie (Shelford 1963) to distinguish them from eastern Washington's Palouse Prairie.

HOW CALIFORNIA PRAIRIE BECAME "GRASSLAND"

Grassland was not a term routinely used to describe California's prairies until Munz and Keck's six-

page plant community classification in their 1,681-page flora (Munz and Keck 1959) divided them into a smaller Coastal Prairie located in Clements' Coast Forest Climax and a larger inland Valley Grassland in his Grassland Climax (Weaver and Clements 1938). Ironically, Coastal Prairie is as rich in native grass as Valley Grassland is poor since it has numerous species in genera like *Agrostis*, *Calamagrostis*, *Danthonia*, *Deschampsia*, *Elymus*, *Festuca*, and *Poa*.

Munz and Keck justified their terminology by repeating a theory started by Clements that original native bunchgrass vegetation in California valleys was destroyed by grazing and supplanted by non-native annual grasses. The native bunchgrass part of the theory is critical because plant communities aren't ordinarily named for their weeds. For example, bluestem-sacahuista prairie in Texas (Kuchler 1964) isn't called Chinese tallowtree forest just because *Triadica sebifera* successfully invades it. In any case, Munz and Keck's flora was among the very few California botany books at that time and consequently was the standard for our taxonomy and, by extension, our vegetation. Most California prairies have been called Valley Grassland or just "grassland" ever since.

IS BUNCHGRASS THEORY TRUE?

Since the "grassland" name is based on bunchgrass theory, it's important to know if it is true. Religion is faith-based but science proceeds by determining if theories are falsifiable. Muir's observations may seem to do that, but some would explain them away. Maybe Muir just happened to arrive in California in a brief time window between death of the bunchgrasses and arrival of non-native annual grasses. However, we know that's not true because every

early visitor to California back to the earliest Spanish records saw just what Muir did. We now know this because UC Riverside's Richard Minnich compiled these extensive records in his 2008 book, *California's Fading Wildflowers*.

Thanks to Jason Hamilton (1997) and Richard Minnich we now know that Clements' bunchgrass theory was widely and quickly accepted, not because of sound evidence, but because of his god-like status as an academic superstar in the first half of the last century. His other theories like non-Darwinian evolution and the relatively unchanging climates needed for succession to climatic climax have long been debunked (Hagen 1992). Only his California bunchgrass theory retains stubborn adherents even though we now know it lacks evidence.

Clements saw that parts of California were flat and treeless like his Nebraska home and therefore, according to his theory, were in the

same Grassland Climatic Climax. That meant they had to have the same climate and dominant plants. No room was left for either California's Mediterranean climate or Muir's annual forbs since his theory dictated that dominants were never annuals and were the same throughout a climatic climax. That meant since *Stipa* species dominated prairies in Nebraska, they had to dominate them in California as well. Purple needlegrass (*Stipa pulchra*) was found to fit the bill, although Clements initially confused it with a Great Plains species (Hamilton 1997).

We now know that today's distribution of purple needlegrass in California is the same seen by its earliest visitors; it is rare in valleys and common in hilly blue oak (*Quercus douglasii*) savannas no matter how much they're grazed. Annuals can also be dominants like Muir described and as CNPS vegetation surveys consistently find. Once again our society is recording phenomena

Common hillside daisy (*Monolopia lanceolata*) and common fiddleneck (*Amsinckia intermedia*) in the Temblor Range, San Luis Obispo County. Photograph by Nick Jensen.



Muir described (1992) of many mostly annual spring forbs, followed by a few in summer and then many again in fall.

DO NAMES MATTER?

Once Munz and Keck's Valley Grassland name was adopted, Muir's wildflowers became increasingly invisible since as forbs, not grasses, they were in a plant community where they didn't belong just when they were increasingly crowded out by non-native plants. First these were grasses like wild oats (*Avena*

spp.), soft chess (*Bromus hordeaceus*), ripgut grass (*B. diandrus*), medusa-head (*Elymus caput-medusae*), and rye grass (*Festuca perennis*). But increasingly they became exotic forbs like yellow star-thistle (*Centaurea solstitialis*), winter vetch (*Vicia villosa*), and perennial pepperweed (*Lepidium latifolium*). Since on supposedly good authority all this was "grassland" and its only grasses were non-native, it is no wonder it soon got the name "non-native annual grassland." Is that a problem?

By this century's first decade our Sacramento Valley CNPS chapter

found it definitely was. First we learned that much of the floral and faunal diversity Muir described is still present among non-natives when looked for. Second we found that labeling our chapter's most extensive natural landscapes non-native annual grassland made them the only ones ignored in required general plan conservation elements, and thus land development-free fire zones at the sprawl bubble's peak. To respond, we contacted local governments and pointed out the anomalous illegality of excluding so much biologically rich land from

Purple owl's clover (*Castilleja exserta*) in Carrizo Plain, San Luis Obispo County. Photograph by Nick Jensen.



general plans and not properly naming it California Prairie. Consequently it is no longer excluded from the plan conservation elements in our chapter area.

Sprawl is now mostly stopped by problems of its own making but not entirely. In Sacramento County's Cordova Hills, thousands of acres of California prairie are currently at risk because of a project ignoring its general plan conservation considerations but unlikely to succeed as a consequence. Many governmental planners are quite receptive to reviving the old California Prairie name for California's open landscapes since they're used to new names. So are many academics, even though one recently called a hillside painted a rainbow of colors by the same kind of flowers Muir saw "ruined landscape" because it lacked bunchgrass. Most know good science is constantly in flux. The greatest resistance is from passive science consumers with the fundamentalist attitude, "My college textbook said it, I believe it, that settles it."

DOES CALIFORNIA PRAIRIE MATTER?

It does if you care about California native plants, since it's the number one habitat where they've gone extinct. It drops to third for California Rare Plant Rank 1B species and to fourth for all lists (Skinner and Pavlik 1994). This is because prairie plants tend to have wide ranges—subject to changes causing extinction—while those in other habitats are more often on lists reflecting limited but more secure ranges.

There is great concern that CO₂ release by fossil fuel burning causes dangerous climate change, so reducing it in the atmosphere is a high priority. Since plants change it to organic carbon while growing, they're important for slowing climate change. Trees are often planted to do this, but prairies do it better.



Johnny-tuck (*Triphysaria eriantha*) on older alluvium at Jepson Prairie in Solano County. Photograph by Glen Holstein.

Temperate forests on average store 8 kilograms carbon/meter square as plant material while prairies store 3, but temperate prairies store 19 as soil organic matter while forests store only 12. Consequently average prairies store 22 and temperate forests only 20. Forests also store much carbon above ground where wildfires release it, whereas prairies store most protected underground (Schlesinger 1991).

Our prairies are also world-class scenic resources we appreciate too little. A Briton ranks our Carrizo Plain and Tehachapi Range as two of the best places to see wildflowers in the world on a list weighted to places closer to his home (Gibbons 2011). Maybe we should start giving them equal respect.

REFERENCES

- Gibbons, B. 2011. *Wildflower Wonders: The 50 Best Wildflower Sites in the World*. Princeton University, Princeton, NJ.
- Hagen, J. 1992. *An Entangled Bank*. Rutgers University, New Brunswick, NJ.
- Hamilton, J. 1997. *Changing Percep-*

- tions of Pre-European Grasslands in California*. *Madrono* 44(4): 311-333.
- Kuchler, A.W. 1964. *Potential Natural Vegetation of the Conterminous United States*. American Geographical Society, New York, NY.
- Minnich, R. 2008. *California's Fading Wildflowers*. UC Press, Berkeley, CA.
- Muir, J. 1992. *John Muir: The Eight Wilderness Discovery Books*. Diadem Books, London, UK and The Mountaineers, Seattle, WA.
- Munz, P., and D. Keck. 1959. *A California Flora*. UC Press, Berkeley, CA.
- Schlesinger, W. 1991. *Biogeochemistry*. 2d ed. Academic Press, San Diego, CA.
- Shelford, V. 1963. *The Ecology of North America*. University of Illinois, Urbana, IL.
- Skinner, M., and B. Pavlik. 1994. *California Native Plant Society's Inventory of Rare and Endangered Vascular Plants of California*. 5th ed. CNPS, Sacramento, CA.
- Weaver, J., and F. Clements. 1938. *Plant Ecology*. McGraw-Hill, New York, NY.
- Worster, D. 2008. *A Passion for Nature: The Life of John Muir*. Oxford University, New York, NY.

Glen Holstein, 714 Lake Terrace Circle, Davis, CA 95616; holstein@cal.net

IS THERE STILL NATIVE DIVERSITY IN CALIFORNIA GRASSLANDS?

by Megan E. Lulow and Truman P. Young

Our understanding of the native flora of California's Central Valley is undergoing a sea change. Although this community has traditionally been described as a grassland once dominated by native perennial bunchgrasses, there have been many over the decades who have suggested that the emphasis on grasses was misplaced, and that native wildflowers (non-grass herbs) were a significant component as well (Burcham 1957; Heady 1988; Schiffman 2007; Stromberg et al. 2007; John Muir 1894; Hamilton 1997).

Recently these voices have risen again, spearheaded by Glen Holstein of the CNPS and Richard Minnich in his book, *California's Fading Wildflowers*. Our own survey work has revealed a wonderfully rich flora of wildflowers in remnant grasslands throughout the state, and the pages of *Fremontia* are often filled with fields of magnificent wildflowers. In addition to their aesthetic appeal, wildflowers contribute to ecosystem function, including nitrogen fixation, pollinator resources, habitat structure, and forage quality.



A post-fire wildflower display representing species frequently found across areas with native remnants in grassland and grassland scrub. Photograph by Jutta Burger.

A LOST LEGACY

The Central Valley and adjacent hills of California have been so heavily invaded by non-native species, particularly annual grasses (e.g., bromes and wild oats) and herbs (e.g., mustards and starthistle), that few clues remain of the original vegetation. Hiking through most former rangelands in the Central Valley or within the California Coast Range, one finds only a scattering of native plant species, or perhaps rare pockets where natives truly dominate (Noss et al. 1995). The majority of areas, particularly those recently released from grazing, have accumulated high levels of thatch and decadent growth of non-native species.

There is very little record of the composition of California grassland flora prior to the invasions of non-native species, cattle ranching, and large-scale cultivation (but see Muir sidebar, page 9). The invasion by exotic plants has been so extensive that formal classifications of California flora recognize the grassland dominated by non-native annuals as its own distinctive subtype, or alliance (Sawyer et al. 2009). In fact, there are few plant communities on the planet for which we have so little confidence about their original composition.

We have observed, as have others (e.g., Ayzik Solomeshch, Glen Holstein, Peter Hopkinson, pers. comm.; see also Tables 14.3 and 14.4 in Bartolome et al. 2007) that in both "remnant" sites and sites converted to dominance by exotic annual grasses, many native wildflower species persist. It is clear that calling these communities "grasslands" may be misleading (although we will use the term here, for form's sake).

We have been involved in surveying grasslands in two regions of California, both of which Keeler-Wolf et al. (2007) refer to as the "Valley and south coastal" type in their classification of the state's major grasslands. Large-scale grassland restorations were being planned and implemented throughout the two regions we surveyed: the foothills of the Santa Ana Mountains within the Irvine Ranch Natural Landmark in Orange County, and the Coast Range foothills on the western edge of the Sacramento Valley in Yolo County. For both regions we sought to document the occurrence and general abundance of upland native "grassland" species, and to generate a reference list to facilitate the enhancement of species diversity in grassland restoration projects. Both regions consisted of sites within a larger, often degraded landscape of grassland, as well as smaller grasslands that were part of an oak woodland or scrub mosaic.

IRVINE RANCH NATURAL LANDMARK

A map of native grasslands and the extent of their degradation was developed for management planning within the Lomas Ridge and Limestone Canyon regions of the Irvine Ranch Natural Landmark. National Natural Landmarks are designated by the US Secretary of Interior for natural areas in both public and private ownership. They are recognized as outstanding examples of the natural heritage of the country, alongside national parks, recreation areas, and monuments.

After a fire in October 2007, our team of scientists visited all but the



A mosaic of grassland (background, left), scrub (foreground), and ecotone (center), plant communities common to the Irvine Ranch Natural Landmark survey region. Photograph by Jutta Burger.

least accessible grasslands in these hills. Grasslands were defined as having less than 20% cover of woody species, including both coast live oak (*Quercus agrifolia*) and coastal sage scrub species. At each of 475 sites across the hills, we developed a list of all native species, and estimated the percent cover of each life form (grass, wildflower, shrub, and tree). Based on floristic composition, these sites were divided into six community types, or alliances (Figure 1).

Across all surveyed grasslands in the Irvine Ranch Natural Landmark, there were a total of 140 native species: 99 wildflowers, 12 grasses, 1 rush, 26 shrubs, and 2 trees. Most species were observed at low frequencies, with only two species occurring at more than half of all sites,

and only 15 occurring at more than one-fifth of all sites. The number of native wildflower species ranged from 5–61 across sites, and always far exceeded the number of native grass species (Figure 1), and also often exceeded the native grasses in cover.

Some of the most frequent species included: fascicled tarweed (*Deinandra fasciculata*), blue dicks (*Dichelostemma capitatum*), miniature lupine (*Lupinus bicolor*), coastal goldenbush (*Isocoma menziesii*), and common goldenstars (*Bloomeria crocea*). Across all surveyed grasslands, the overall abundance and species richness of native wildflowers was greater than that of woody species or geophytes (wildflowers growing from underground bulbs and

corms). However, the woody and geophyte species were more common and consistently found across multiple grasslands.

There were substantially more native species in ecotone grasslands—a transition area between two plant community types, such as native grassland and woodland, or native grassland and scrub. However, at Irvine Ranch Natural Landmark, ecotones contained half the cover of the most common native grass, purple needlegrass (*Stipa pulchra*), than the more open grassland. While these ecotone areas are species rich, they likely serve a different function to the ecosystem because the relative abundance (or cover) of species is so different from that in the core area of each plant community type.

WESTERN SACRAMENTO VALLEY FOOTHILLS

We had also carried out a survey of grassland remnants in the western Sacramento Valley foothills, limited to grasslands known to have either a native wildflower or native grass component to the flora, even if comprising only 10–15% of the total plant cover at some sites (Lulow and Young 2009). Seven areas were chosen, with a total of 58 sites surveyed during the spring and summer of 2002–2004 (Figure 2). Grasslands were defined as having less than 20% cover of woody species,

dominated by blue oak (*Quercus douglasii*) in this region. At these Northern California sites, only presence or absence of native species was recorded. Four of the seven sites had cattle or sheep grazing occurring at low levels of intensity. In general, ecotones, rocky ridge tops, and north facing slopes were better places to find remnant patches than flatter, open grassland. Nonetheless, all sites had at least 50% of their cover represented by exotic annual plant species.

Again, wildflowers dominated the native species lists. Across the seven sites, at least 79 native spe-

cies were found in the remnant grassland flora (10 grasses, 67 wildflowers, 1 shrub, and 1 tree). The number of native wildflower species in each area ranged from 20 to 36 (Figure 2). Many of these species were widespread; 25 species were observed in more than half the sites surveyed. Geophytes accounted for 20% of wildflower species that occurred in at least one-half of all sites surveyed. Some of the more frequent wildflowers included California yarrow (*Achillea millefolium*), miniature lupine (*Lupinus bicolor*), brodiaea (*Brodiaea* spp.), valley tassels (*Castilleja*

Degraded grassland dominated by non-native annual grasses at Limestone Meadow in the Irvine Ranch Natural Landmark. Photograph by David Olson.



TABLE 1. COMMON SPECIES SHARED BETWEEN SURVEY REGIONS.

Common Name	Species
Fascicled tarweed, hayfield tarweed	<i>Deinandra fasciculata</i> or <i>Hemizonia congesta luzulifolia</i>
Miniature lupine	<i>Lupinus bicolor</i>
Blue dicks	<i>Dichelostemma capitatum</i>
Arroyo lupine	<i>Lupinus succulentus</i>
Mariposa lily: splendid, Catalina, or yellow	<i>Calochortus splendens</i> , <i>C. catalinae</i> , or <i>C. luteus</i>
Gum plant	<i>Grindelia camporum</i>
Short-podded lotus, strigose lotus	<i>Acmispon</i> (formerly <i>Lotus</i>) <i>brachycarpus</i> or <i>A. strigosus</i>
California plantain	<i>Plantago erecta</i>

Note: Tarweeds, mariposa lilies, and annual lotuses did not share the exact same species between regions, but had similar taxa.
Source: Lulow, et al., 2009. Post-Fire Grassland Survey on the Irvine Ranch Natural Landmark, unpublished report. Irvine Ranch Conservancy.

attenuata), tree clover (*Trifolium ciliolatum*), and hayfield tarweed (*Hemizonia congesta*).

NORTHERN VS. SOUTHERN SURVEYS

While the survey within the Irvine Ranch Natural Landmark found that most species occur at low frequencies across a variety of sites, the two survey areas shared 8 of their 25 most common native wildflowers (see Table 1). While geophytic species represent a small fraction of the total richness, in both

surveys they were among the more frequent species across sites. This group of species are often not included in grassland restoration species lists and can be cryptic in remnant native communities, appearing aboveground primarily only after fires or wet years. These results suggest this group may be an overlooked, yet significant component of native grassland composition across the state.

There were conspicuous differences between the two areas. In particular, native clover species were found more frequently in the western foothills of the Sacramento Val-

ley, whereas more shrubs were found in the grasslands on the Irvine Ranch Natural Landmark. Greater total species richness was recorded on the Irvine Ranch Natural Landmark, but this may be because a far greater number of sites were surveyed there.

GRASSLAND? FORBLAND? PRAIRIE!

In summary, throughout the surveyed remnant sites, the number of native wildflower species was far greater than the number of native grass species, particularly in grass-

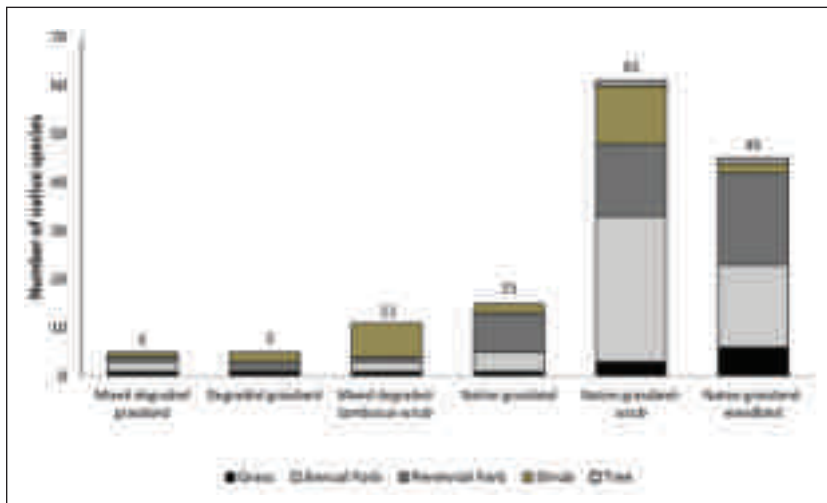
AN EARLY ACCOUNT OF THE CENTRAL VALLEY PRAIRIE

There are several accounts of the flower-rich flora of the Central Valley in the era before large-scale agriculture, but perhaps none as eloquent as this, from John Muir:

The Great Central Plain of California, during the months of March, April, and May, was one smooth, continuous bed of honey-bloom, so marvelously rich that, in walking from one end of it to the other, a distance of more than 400 miles, your foot would press about a hundred flowers at every step. Mints, gillias, nemophilas, castilleias, and innumerable compositæ were so crowded together that, had ninety-nine per cent of them been taken away, the plain would still have seemed to any but Californians extravagantly flowery. The radiant, honey-ful corollas, touching and overlapping, and rising above one another, glowed in the living light like a sunset sky—one sheet of purple and gold, with the bright Sacramento pouring through the midst of it from the north, the San Joaquin from the south, and their many tributaries sweeping in at right angles from the mountains, dividing the plain into sections fringed with trees.

—from *The Mountains of California* by John Muir, 1894

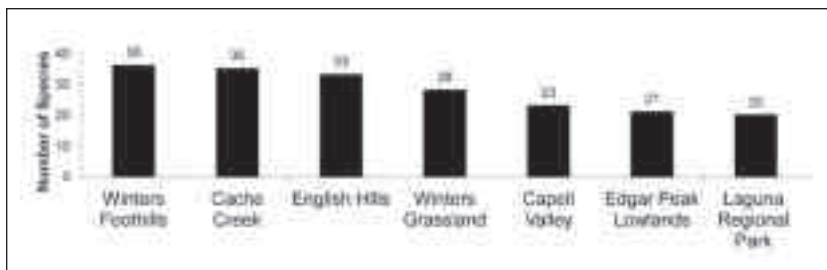
FIGURE 1. SPECIES RICHNESS OF NATIVE PLANTS AT IRVINE RANCH NATURAL LANDMARK.



Note: Based on floristic composition cluster and similarity analyses, six plant communities were identified. All sites had a minimum of 50% relative cover of non-native species.

Source: Lulow, et al., 2009. Post-Fire Grassland Survey on the Irvine Ranch Natural Landmark, unpublished report. Irvine Ranch Conservancy.

FIGURE 2. SPECIES RICHNESS OF WILDFLOWERS IN WESTERN SACRAMENTO VALLEY FOOTHILLS.



Note: Each site had a maximum of three native grass species, and had a minimum of 50% relative cover of non-native species.

Source: Lulow and Young, 2009.

lands with less non-native cover or ecotone grasslands. *Individual* native grass species often occurred at higher abundance (cover) than wildflowers, but as a class were rarely dominant.

The persistence of native wildflowers may offer a tool for better understanding the original composition of California grasslands—an important step in restoration. By comparing remnant wildflower species in more highly invaded sites to the wildflower components of grassland communities that are more intact, it may be possible to recon-

struct some of their lost components, including perennial grasses.

Disturbed areas may also have surprisingly resilient seed banks or corm banks. In grasslands disturbed for over a century and with virtually no native cover, any of the following processes—clearing built up thatch, a fire, or after responsibly applying herbicide—can stimulate native wildflower species to germinate that were not evident prior to the clearing (personal observation, M. Lulow).

When putting together a species list for restoration, identifying those

species that are able to coexist with non-native annual species can be as important as determining which species are most appropriate for a given site. This is particularly true for California grasslands, where it is virtually impossible to completely eradicate non-native annuals due to the extent of their invasion throughout the state and their prolific seed production.

Collaborative research between researchers and practitioners can greatly inform which methods and species are most effective for restoring components of California's native wildflowers to our grasslands, yet few experiments have been conducted. While there will be some species or species groups shared among regions, given the diversity of species and physical characteristics of the state, restoration approaches and species used should be honed for a given region and environment. The large number of wildflower species included in these rather coarse surveys, their functional diversity, and their aesthetic variety suggest a rich palette for ecological restoration.

These surveys also remind us of an essential question that warrants our revisiting, namely what should we call these plant communities that are (were!) a mixture of native grasses together with herbaceous non-grasses that vastly outnumber the former in species richness, and often dominate in cover. "Grasslands" seems clearly misleading. "Forblands" is dismissive of the grasses. While some feel that "prairie" evokes images of the tall-grass and short-grass regions of the Midwest, we believe that it is the most neutral and therefore most descriptive term, and we are increasingly using it to describe the original vegetation of open habitats in the Central Valley.

REFERENCES

Bartolome, J.W., et al. 2007. Valley grassland. In *Terrestrial Vegetation of California*, 3rd ed., ed. M.G. Barbour, T.



Catalina mariposa lily (*Calochortus catalinae*), a native grassland geophyte, found in fine soils. Geophytes were found frequently with remnant native species in both survey regions across grassland sites. Both photographs by Fred Roberts.

Keeler-Wolf, and A.A. Schoenherr. University of California Press, Berkeley, CA.

Burcham, L.T. 1957. California range land: An historico-ecological study of the range resource of California. Division of Forestry, Department of Natural Resources, Sacramento, CA.

Hamilton, J.G. 1997. Changing perceptions of pre-European grasslands in California. *Madroño* 44:311–333.

Heady, H.F. 1988. Valley grassland. In *Terrestrial Vegetation of California*, ed. M.G. Barbour and J. Major. California Native Plant Society, Sacramento, CA.

Keeler-Wolf, T. et al. 2007. Community classification and nomenclature. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.

Lulow, M.E., and T.P. Young. 2009. High native wildflower richness in Central Valley “grassland” sites in the western Sacramento Valley and adjacent foothills. *Grasslands* 14(3):7–11.

Minnich, R.A. 2008. California's fading

wildflowers: Lost legacy and biological invasions. University of California Press, Berkeley, CA.

Muir, J. 1894. *The Mountains of California*. The Century Company, New York, NY.

Noss, R.F., E.T. LaRoe III, and J.M. Scott. 1995. Endangered ecosystems of the United States: A preliminary assessment of loss and degradation. National Biological Service, Washington, DC.

Sawyer, J.O., T. Keeler-Wolf, and J. Evens. 2009. *A Manual of California Vegetation*, 2d ed. California Native Plant Society Press, Sacramento, CA.

Schiffman, P.A. 2007. Species composition at the time of first European settlement. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.

Stromberg, M.R., J.D. Corbin, and C.M. D'Antonio, eds. 2007. *California Grasslands: Ecology and Management*. University of California Press, Berkeley, CA.



Megan Lulow, Irvine Ranch Conservancy, 4727 Portola Parkway, Irvine, CA 92620, mlulow@irconservancy.org; Truman Young, Department of Plant Sciences, University of California, Davis, CA 95616, tpyoung@ucdavis.edu



ABOVE AND OPPOSITE TOP: Views of Carrizo Plain National Monument grasslands in different years. ABOVE: Native wildflowers including California poppies (*Eschscholzia californica*), goldfields (*Lasthenia californica*), and owl's clover (*Castilleja exserta*) are well represented. OPPOSITE TOP: Non-native annual grasses dominate, particularly hare barley (*Hordeum murinum*) and red brome (*Bromus madritensis*). All photographs by the author.

UNDERSTANDING CALIFORNIA GRASSLAND ECOLOGY

by Paula M. Schiffman

A typical California grassland includes well over 100 native plant species: grasses, forbs, geophytes, perennial herbs, and subshrubs, as well as occasional shrubs and trees. Invasive non-native species are also present, particularly annual grasses that originated in the Mediterranean region and became widespread soon after European contact and settlement, especially oats (*Avena* spp.), bromes (*Bromus* spp.), and barleys (*Hordeum* spp.). Though much less diverse, these non-natives are the species that monopolize most of the space and resources. In fact, non-natives constitute close to 100% of the grass cover in the majority of California grasslands.

How is it possible that grasslands contain about 40% of Califor-

nia's total plant species diversity (Schiffman 2007a) and, at the same time, are among the most thoroughly invaded natural ecosystems in North America? Why haven't the invaders driven the natives to extinction by outcompeting them for limited resources? To a large extent, this strange situation can be explained by two natural factors—one extrinsic and the other intrinsic—that exert overarching control on grassland ecology: rainfall and soil disturbance.

RAINFALL

Rainfall in California grasslands occurs mostly during the winter and spring and varies tremendously in quantity and timing from year to year. Some years are dry, while others are wet. In some years precipita-

tion occurs throughout the rainy season, while in other years it is finished in early winter or does not begin until spring. For grassland plants the rainfall regime is predictably unpredictable, and they are adapted to it.

Like native plants in other California ecosystems, many native grassland species deal with annual variability in rainfall by producing extensive buried seed banks. Seeds produced by generations of plants accumulate in the soil and may remain dormant, hunkered down in the seed bank for many years, waiting for the right set of environmental triggers to induce germination and establishment. Each grassland species seems to respond to a set of distinctive cues, and the amount and timing of rainfall are usually key.



A particular species' seeds may respond differently to rain occurring during the still, warm months of early fall than they would to the much colder precipitation of January and February. As a result, the species composition of any given grassland area can vary considerably from year to year. The combinations of factors responsible for facilitating the emergence of a multitude of native species from the soil seed bank are not well understood. Nevertheless, it is very clear that the adaptations that enable native grassland plant populations to sit tight in the seed bank and then to grow when climatic conditions become optimal, also inadvertently make it possible for them to avoid exposure to intense competition for limited resources that non-native invaders can inflict.

This capacity of natives to produce persistent seed banks also allows them to exploit ecological opportunities that arise after multi-year droughts, which occur periodically in California. Unlike the natives, most invasive non-native annual

grasses do not form lasting seed banks. Each spring their populations are largely derived from seeds produced the previous year. During droughts, non-native annual grasses produce many fewer seeds than usual, so a few consecutive years of low seed production can take a big toll on their populations. When sufficient rainfall does eventually recur, non-native grass seeds are much less available, and consequently these species are unable to reoccupy so much space.

This situation provides opportunities for native seeds that had been biding their time in the soil seed bank during a drought, enabling them to access considerably more resources than usual. It is in post-drought years that grasslands often have their best spring wildflower displays, sometimes with vast carpets of yellow, orange, purple, and blue. These extravaganzas of native color and diversity appear to be made possible, in large part, by the diminishment of non-native annual grass populations. Unfortunately, this is only a temporary condition.

Some non-native grass seeds invariably make it through droughts, and plants from these seeds serve as the basis for the rapid recovery of invasive populations. Within a year or two they are usually once again dominant in grasslands, making it hard to imagine that there had ever been a time when natives prevailed. Of course the native plant species are still present in these grasslands. Most are back underground, hiding in the newly replenished seed bank.

The great amount of year-to-year variability in rainfall, and the capacity for native species to persist out of sight in seed banks, greatly complicates our ability to conduct scientific studies in California grasslands. Each year the composition of the plant community at a given site can be quite different, and this natural variance can obscure the effects of interactions between native and non-native plants, relationships between plants and animals, biogeochemical dynamics of nutrient cycling, and other important ecological processes. This, in turn, complicates efforts to make science-



TOP: Slope riddled with pocket gopher mounds (*Thomomys bottae*). The grassland biomass was recently burned away, making the mounds readily visible. Disturbed soil can help to activate seed banks of native plants. BOTTOM: Close-up view of pocket gopher burrow mounds with a one-meter stick.

based management and restoration decisions in what has become a very rare type of ecosystem.

Nevertheless, seed banking is a life history strategy that has served native plant species well. For more than two centuries, hundreds of grassland natives have been challenged by heavily invaded environments and they have persisted. Without this ability to avoid competition with non-natives, the native diversity of California's grasslands would almost certainly be far less. But what will the situation be in the future, given our changing climate? It seems likely that many native species will avoid exposure to warmer temperatures and greater frequencies of cli-

matic extremes by seed banking, much as they already do. However, the long-term impact of this is unclear, as are effects of climate changes on non-native invaders. Because many native species spend a great deal of time out of sight in seed banks, it could be many decades before it is apparent whether some species are positively or negatively impacted.

SOIL DISTURBANCE

As a phenomenon, soil disturbance is much more predictable than is rainfall in California grasslands, but the effects on plants are also far-reaching. Grassland terrain is characteristically pockmarked with disturbances produced by large populations of small burrowing mammals such as pocket gophers (*Thomomys bottae*), ground squirrels (*Spermophilus beecheyi*), voles (*Microtus californicus*), and kangaroo rats (*Dipodomys* spp.). In fact, it has been hypothesized that repeated localized disturbances by small burrowing mammals created the terrain of mounds and depressions that characterizes some grassland areas with vernal pools. Grizzly bears (*Ursus arctos*) were historically abundant in this ecosystem and they also produced large excavations while in search of foods such as bulbs, grubs, and ground squirrels.

The remarkable extent of soil disturbance and the profusion of burrowing animals that produced



Thousands of circular giant kangaroo rat burrow "precincts" scattered across the grassland landscape at Carrizo Plain National Monument. In the spring, vegetation on mounds tends to be taller, greener, and different in composition compared to the surrounding grassland matrix. The line at the bottom is a dirt road.

them were described by virtually every early chronicler of California's wildlands, starting with Sir Francis Drake in 1579. In the 1770s, Spanish mission padres and soldiers such as Pedro Font and Francisco Garcés recorded similar observations, as did the naturalist John Muir, vertebrate zoologist Joseph Grinnell, botanist Alice Eastwood, and many others in the 19th and early 20th centuries (Schiffman 2007b). Today, the landscape-scale mosaics of disturbed patches produced by digging animals continue to be impressive, even in the absence of grizzly bears.

Native grassland plants have coexisted with burrowing animals in these environments for millennia. Therefore, it is not surprising that some natives have ruderal (disturbance-adapted) tendencies that enable them to exploit the churned up soil in these natural disturbances. Certain natives have distribution patterns that indicate tolerances, or even preferences, for growing on patches of recently disturbed soil. Examples include fiddlenecks (*Amsinckia* spp.), dobiepod (*Tropidocarpum gracile*), California lotus (*Acmispon wrangelianus*), as well as California mustard (*Caulanthus lasiophyllus*) and its endangered congener, the California jewelflower (*C. californicus*).

For other native species, such as alkali sacaton (*Sporobolus airoides*), burrow mounds act as safe sites, where interactions with competitors are less intense than in the surrounding grassland matrix. The vertical mixing caused by so much animal digging also adds dynamism to native seed banks. Previously buried dormant seeds become exposed when new burrow mounds are created. Burrowing can move seeds in the opposite direction as well, from the surface soil to greater depths.

Although the associations of plants growing on excavated soils frequently include native species, these disturbed patches are typically dominated by ruderal *non-native*



A giant kangaroo rat (*Dipodomys ingens*) burrow precinct covered with disturbance adapted non-native redstem filaree (*Erodium cicutarium*) and native bristly fiddleneck (*Amsinckia tessellata*, green foliage), center. The less disturbed intervening area is dominated by native California goldfields (*Lasthenia californica*, yellow flowers).

plants, particularly annual grasses, filaree (*Erodium cicutarium*), and other opportunistic species including sweet vernal grass (*Anthoxanthum odoratum*) and freeway ice-plant (*Carpobrotus edulis*). By hopping from one small disturbed soil patch to another, prolific ruderal invaders can rapidly occupy large geographic areas. The chronic nature of these disturbances then enables them to persist. It seems likely that the vast spatial extent of these animal-produced disturbances may have facilitated the initial spread and establishment of some invasive non-native plants in California grasslands. Perhaps this explains why they were able to become ecologically entrenched so quickly, before anyone noticed that the invasion was even underway.

Of course the species compositions of California grasslands—particularly ratios of native to non-native plants—are also influenced by numerous environmental factors, in addition to variable rainfall and soil disturbance. For example, the consumption of plants by animals ranging from grasshoppers and rabbits to antelope and elk, as well as domesticated livestock such as cattle

and sheep, can be significant. In addition, exposure to fire—either wildfires, which are relatively uncommon in grasslands because the fuel supply is often limited, or prescribed burns done for restoration purposes—can also have differential effects on native and non-native species. The grassland communities that reveal themselves to us each spring are a window through which we can view the responses of native and non-native plants to this complex mix of ecological processes.

REFERENCES

- Schiffman, P.M. 2007a. Species composition at the time of first settlement. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.
- . 2007b. Ecology of native animals in California grasslands. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio.

Paula M. Schiffman, Department of Biology, California State University, 18111 Nordhoff Street, Northridge, CA 91330-8303, paula.schiffman@csun.edu

BETWEEN THE BLADES: THE EVOLUTION OF PLANT DIVERSITY IN CALIFORNIA'S PRAIRIES AND GRASSLANDS

by Ellen Dean

When I walk across an ecosystem dominated by grasses, either native or nonnative, my eyes are often focused down. This isn't just to avoid ground squirrel holes or gopher mounds. I am looking for the multitude of native species growing at my feet. While most Californians see our grass-dominated landscapes as a green or brown blur, those of us who love plants

have trained our eyes to see the incredible diversity of plant form and color hiding between the blades. It is often the non-grass, native plant diversity that makes one grassland or prairie different from another.

This is especially true when examining ecosystems now dominated by non-native grasses in the interior of California. It is the native forbs still growing between the non-native blades that give us some idea of

the botanical history of a piece of land. Where did these interesting and beautiful native plants come from? Do they grow in other places besides California? How did they come together to grow in this grassland?

One of the better known scientific publications that sought to answer some of these questions is Raven and Axelrod's 1978 publication, *The Origin and Relationships of the California Flora*. This work explains in relatively plain language that the present-day flora of California is derived from various ancient paleofloras that moved over the landscape of the Americas through geologic time as the climate changed. A more recent recounting of past climates and vegetation by Constance Millar can be found in front matter of the new 2012 edition of *The Jepson Manual: Vascular Plants of California*. A third excellent description of California paleobotany and the movement of species through geologic time can be found in Steve Edwards' 2004 article in the journal *Four Seasons*.

LEFT: Bluedicks (*Dichelostemma capitatum*), with its distinctive clusters of purple flowers, grows in many types of grassland communities. Dye Creek Preserve, Tehama County. BELOW: Flowers are about one inch in diameter. Both photographs by Margaret Starbuck.



What these works tell us is that the land formation, latitude, and climate of what became California has changed substantially over geologic time. Fossil evidence indicates that many modern conifer families, including relatives of our coast redwood (the genus *Sequoia*), were recognizable and present in North America by 200 million years ago. Flowering plants were present near what would become California approximately 100 million years ago, but their diversity was relatively low until the Tertiary Period, which began 65 million years ago.

Fossils reveal that early in the Tertiary Period the climate in the region of California was warmer, with year-round rainfall. The plants that grew in this climate, such as cycads, figs, and magnolias have been extinct in California for millions of years. As the Tertiary Period progressed, the present-day land formation, soils, climate, and vegetation of California changed, and our present-day flora took shape, but the road was full of bumps and turns and ups and downs. Mountains were built due to plate tectonics and volcanism, and mountains eroded. As the land forms changed, specialized soil types such as serpentine, gypsum, alkaline plains, and vernal pool hardpans were created or exposed. Some epochs were drier, some rainier, some hotter, some colder, but overall the climate became drier and cooler.

PLANT EVOLUTION AND MIGRATION THROUGH TIME

As the climate and habitats changed, new types of plants from other areas with cooler or drier climates migrated into California, replacing those that could no longer tolerate the climate. As the Sierra Nevada rose, it became a barrier to migration from the east, creating an isolated region where the plants



Goldfields, lupines, and poppies create patterns among the volcanic rocks of Table Mountain, Butte County. Snow Mountain can be glimpsed across the Central Valley in the background. Photograph by Margaret Starbuck.

evolved into new forms unique to California. The “California Current,” an ocean circulation pattern that exists today, began to develop approximately 15 million years ago. This current was the driving force behind the development of the summer drought Mediterranean climate regime that has characterized most of California for the past four to seven million years. This climate,

along with the Sierra Nevada barrier, created “a climatic island” unique in North America. Accompanying this change in climate was a sorting and redistribution of plant species. Those that remained in regions of California with summer drought (and without surface water or fog) needed to be able to withstand six months without water.

Many of the herbs that we



Hayfield tarweed (*Hemizonia congesta*) is a late-flowering prairie species found in the hot, summer interior of California. Photograph by Margaret Starbuck.

admire in the grasslands of the interior foothills and Central Valley of California evolved an annual life history that allowed them to wait out the drought as seeds. Others became perennial herbs that died back to underground stems (bulbs, corms, or rhizomes). Most of these herbs sprout, flower, and fruit in the spring, before the drought is at its peak. A major exception to this pattern is several genera of tarweeds. These plants have developed the capacity to flower and fruit at the height of the drought before dying back until the next year.

About 2.6 million years ago, just

when they thought things couldn't get worse, California's plants were hit with the Ice Age. During the glaciations (which each lasted 40,000 to 100,000 years), sea level dropped, the climate cooled, and glaciers formed at high elevations. Glacial melt eroded hillsides, filled rivers, and formed lakes in the Central Valley. During the interglacials (each lasting about 10,000 years), the climate warmed and the sea level rose. Although most of California was unglaciated, the climate fluctuations of the glacial/interglacial cycles were challenging for plants, because they had to use their seeds or other propagules to migrate north and south or up and down in elevation. In addition, the landforms of California were continuing to change due to sea level changes, plate tectonics, volcanism, and erosion.

During the Tertiary Period and the Ice Age, plants migrated from place to place and occupied newly opened habitats. Species adapted to one soil type might find themselves preadapted to the harsh conditions of a newly available environment. Some plants became isolated on peninsulas, ridges, vernal pools, or specialized soil types. It is well known

that isolated populations sometimes speciate (see Grant 1981, for example). This partly explains why we have so many genera with species that evolved in and are unique to California.

ORIGINS OF CALIFORNIA'S PRAIRIE WILDFLOWERS

After that very long introduction, shall we return to the original questions about the wildflowers in the grass? Let us think about those herbs in our interior prairies with a well-developed Mediterranean climate. Where did all these plants come from, do they grow in other places besides California, and how did they come together in these habitats?

Daniel Axelrod hypothesized that many of our lower-elevation, interior California native plants came from more arid climates to the south and southwest. This would mean that many of the genera present in this region would also be present outside of California, especially in the arid western US or Mexico. However, some of the California species belonging to those genera would be recently evolved species that are endemic to California. Let us look at some of the most common species of the interior grassland and see if we can understand where they may have come from.

Shall we start with our state flower? Our poppies (genus *Eschscholzia*) include a number of species, such as frying pans (*Eschscholzia lobbiai*) and foothill poppy (*E. caespitosa*), as well as our California poppy (*E. californica*). Poppies are a vibrant component of many California prairies and grasslands. The closest relative of our poppies are the Mexican tulip poppies in the genus *Hunnemannia*. Mexican tulip poppies are found in the Sonoran desert of Mexico. Therefore, is it likely that our poppies in the genus *Eschscholzia* migrated into California from the south.



Poppies and birds-eye gilia (*Gilia tricolor*) grow in profusion in the prairies at Bear Creek Ranch in Colusa County. Photograph by Craig Thomsen.



ABOVE AND BELOW: California has a high diversity of clovers. A typical prairie plant list often has at least five species. White-tipped clover (*Trifolium variegatum*), shown here, grows in many regions of California, preferring moist swales or vernal pool edges within prairie habitat. Top photograph by Spencer Dukstra. Bottom photograph by Margaret Starbuck.

Similarly, bluedicks (*Dichelostemma capitatum*), a lily that emerges each spring from a corm, is thought to have evolved from an ancestor that also gave rise to several species of southern lilies (Pires and Sytsma 2002). Notable among these relatives are the beautiful, mostly Mexican genera *Milla* and *Bessera*. Therefore, this is another good example of a genus that probably originated in arid regions to the south. Bluedicks has two subspecies. One is confined to the California Floristic Province (the region of western North America from northern Baja to southern Oregon with a Mediterranean climate). The other species is more widespread in the arid western U.S.

Recent research on the evolution of another group of perennial herbs, our brodiaea lilies (the genus *Brodiaea*), indicates that they shared a common ancestor with bluedicks

(Pires and Sytsma 2002). Brodiaeas, of which there are about 18 species that are mostly endemic to the California Floristic Province, are a very typical prairie plant. *Brodiaea* was cited by Axelrod as an excellent example of a genus that evolved relatively rapidly in geologic time in response to the climatic, soil, and topographic changes that occurred in California. Once they separated from their common ancestor with bluedicks, they radiated quickly into many different species found on a number of specialized soil types.

Another very common genus found in many different interior prairie habitats is *Thysanocarpus*, which contains the annuals fringe pod, lace pod, and spoke pod. The genus has five species, four of which are found in California and one that is endemic to Baja California. Our most common California species, fringe pod (*Thysanocarpus curvipes*), is also



the most widely ranging species, distributed throughout the western U.S., British Columbia, and Mexico. The three other California species are all restricted to the California Floristic Province. This is another good example of a California prairie genus that appears to have had southern



Blow wives (*Achyrachaena mollis*) is a very common, annual prairie species, but it is rare to see it in the profusion shown here in the Cache Creek Wilderness, Lake County, where it is growing with common tarweed (*Madia gracilis*) and Ithuriel spear (*Triteleia laxa*). Photograph by Craig Thomsen.

origins. The most recent data show that the earliest diverging species branch is that of the arid Baja California endemic, *Thysanocarpus erectus* (Alexander et al. 2010).

An important and rather spectacular group of prairie wildflowers, in terms of yellow splashes of color and sheer numbers, is the goldfield genus (*Lasthenia*). Goldfields are mostly annual herbs (18 species) that occupy a wide range of prairie habitats ranging from vernal pools to dry serpentine slopes. Many of the species are endemic to the Cali-

fornia Floristic Province. One species is in Chile (thought to be bird-dispersed), and others are distributed north to Washington state. Like our brodiaeas, it has been long thought that the shift to a Mediterranean climate, coupled with our region's changes in topography, soils, and available habitat through geologic time, may have promoted relatively recent and explosive speciation in this genus.

This idea is supported by recent research on the evolution of goldfields based on DNA sequence data

(Chan et al. 2001). The origins of the genus are not completely clear at this time, but it is likely that the genus diverged from relatives that were based to the south. The closest known relatives are *Amblyopappus* (a genus with one species that grows on coastal dunes and bluffs in California, Baja California, and western South America), and *Baeriopsis* (another genus with one species that is endemic to Guadalupe Island, at the southwest corner of the California Floristic Province) (Baldwin et al. 2002).

The goldfields are in the daisy family and are part of a larger group of genera called tribe Madieae, which has its center of diversity in the California Floristic Province and contains many important interior California prairie genera, such as blow wives (*Achyrachaena mollis*) and tarweeds. Tarweed genera include tidytops (*Layia* spp.), hayfield tarweed (we have one species, *Hemizonia congesta*), and tarweeds/tarplants (*Madia* spp. and *Centromadia* spp.).

As mentioned above, some genera of tarweeds have specialized in flowering and fruiting at the height of our summer drought when few other native plants are flowering. These late flowering species include the rosin weeds (*Calycadenia* spp.) and yellow-flowered tarweed (*Holocarpha virgata*). Among the earliest tarweed lines is the genus *Raillardella* (Baldwin 2006). *Raillardellas* are now found in high-mountain environments in the California Floristic Province and Nevada. Therefore, the immediate ancestor of the tarweeds probably did not come from the south, but rather from mountain regions.

Then there are the legumes in the family Fabaceae. California is rich in legume species, and it would be hard to imagine our prairies and grasslands without our lupines (*Lupinus* spp.) and clovers (*Trifolium* spp.). The evolution of both genera is very complicated, as both

are present in the Old and New Worlds, include annuals and perennials, and occupy a wide variety of habitats. The North American lupines form a distinct group. Interestingly, two of our most common interior California prairie plants, chick lupine (*Lupinus microcarpus*) and miniature lupine (*Lupinus bicolor*), are near the bottom of the North American lupine evolutionary tree, and they are most closely related to Mojave lupine (*Lupinus odoratus*) whose distribution includes the Mojave Desert and Baja California (Eastwood et al. 2008).

The evolution of our clovers is more complicated. The California species are part of the North American diversification of the genus, and our interior prairie species have multiple origins, from the south, west, and north (Ellison et al. 2006).

To finish up our discussion of the origins of our interior California prairie plants, let us look at one of the most common and widely distributed species, California plantain (*Plantago erecta*). This wonderful little annual plant completes its life cycle each spring in a matter of weeks. It is endemic to the California Floristic Province. Like lupine and clover, the genus *Plantago* has species worldwide; some of the European species are part of the non-native flora of California (like the plantains in your lawn). Research on the evolution of plantain indicates that New World plantains evolved from Old World plantains (Ronsted et al. 2002). California plantain is part of a group of species that occur both in the eastern US and South America. Therefore, like our clovers, it is somewhat difficult to understand where this important species came from.

When we look at the origins of these beautiful plants that grow in our interior, Mediterranean climate prairies, it appears that many have probably evolved from arid-climate ancestors that moved into California from the south. However, re-

searchers are finding that some have more complicated histories, including migration from the north, from higher elevations, or perhaps on a bird's foot. Some of our interior prairie species have broad distributions that include many other western states. Others are endemic to the California Floristic Province, and some may be endemic to just a small region or confined to a particular hilltop of California. If we observe carefully and investigate, each species has a unique story to tell. The wildflower assemblages growing within the native and non-native grasses of our prairies are but snapshots in geological time.

REFERENCES

- Alexander, P.J., et al. 2010. Molecular phylogenetics and taxonomy of the genus *Thysanocarpus* (Brassicaceae). *Systematic Botany* 35:559-577.
- Baldwin, B.G., B.L. Wessa, and J. Panero. 2002. Nuclear rDNA evidence for major lineages of helenioid Heliantheae (Compositae). *Systematic Botany* 27: 161-198.
- Baldwin, B.G. 2006. Contrasting patterns and processes of evolutionary change in the tarweed-silversword lineage: Revisiting Clausen, Keck, and Hiesey's findings. *Annals of the Missouri Botanical Garden* 93: 64-93.
- Chan, R., B.G. Baldwin, and R. Ornduff. 2001. Goldfields revisited: A molecular phylogenetic perspective on the evolution of *Lasthenia* (Compositae: Heliantheae sensu lato). *International Journal of Plant Sciences* 162: 1347-1360.
- Eastwood, R.J., et al. 2008. Diversity and evolutionary history of lupins—insights from new phylogenies. In *Lupins for Health and Wealth*, ed. J.A. Palta and J.B. Berger. Proceedings of the 12th International Lupin Conference, Fremantle, Western Australia. International Lupin Association, Canterbury, New Zealand.
- Edwards, S.W. 2004. Paleobotany of California. *The Four Seasons* 12(2): 3-75.
- Ellison, N.W., et al. 2006. Molecular phylogenetics of the clover genus (*Trifolium*—Leguminosae). *Molecular Phylogenetics and Evolution* 39: 688-705.
- Grant, V. 1981. *Plant Speciation*. Columbia University Press, New York, NY.
- Millar, C.I. 2012. Geologic, climatic, and vegetation history. In *The Jepson Manual: Vascular Plants of California*, ed. B.G. Baldwin et al. University of California Press, Berkeley, CA.
- Pires, J.C., and K.J. Sytsma. 2002. A phylogenetic evaluation of a biosystematics framework: *Brodiaea* and related petaloid monocots (Themidaceae). *American Journal of Botany* 89: 1342-1359.
- Raven, P.H. and D.I. Axelrod. 1978. Origin and relationships of the California flora. *University of California Publications in Botany* 72: 1-134.
- Ronsted, N., et al. 2002. Phylogenetic relationships within *Plantago* (Plantaginaceae): Evidence from nuclear ribosomal ITS and plastid *trnL-F* sequence data. *Botanical Journal of the Linnean Society* 139: 323-338.
- Still, S. 2012. *Systematics and Taxonomic Studies of Eschscholtzieae (Papaveraceae)*. PhD dissertation, University of California, Davis. Available from Dissertation and Theses at the University of California (Publication No. AAT 3456870).



California's lupines are a large, diverse group. This annual sky lupine (*Lupinus nanus*) is growing in a sea of goldfields (*Lasthenia* spp.) on Table Mountain, Butte County. Photograph by Margaret Starbuck.

Ellen Dean, 708 Mulberry Lane, Davis, CA 95616, eadean@omsoft.com



Solano County hills in May with open prairie still green on clay sediments, but golden amid oak woodland on volcanic rocks. All photographs by the author unless otherwise noted.

GEOLOGY, CLIMATE, AND CALIFORNIA PRAIRIE DISTRIBUTION

by Glen Holstein

American vegetation ecology began a little over a hundred years ago in the Midwest, where its main founding fathers including Henry Cowles, Frederick Clements, and William Cooper started their careers. Inevitably vegetation conditions in and near the region at that time greatly influenced theories about it that they developed. Forests in the

region's wetter eastern portion extended continuously from Labrador to Florida, and grasslands in its drier west were just as continuous from Saskatchewan to Mexico. Whether forest or grassland, these landscapes were mainly altered by farms less than 100 years old.

Cowles and others developed their main ecology tenets in these kinds of vegetation. One was succes-

sion, vegetation change across time, as for example when farms are abandoned. Another was *climatic climax*, Clements' theory that succession converges toward a regional vegetation type largely determined by climate.

FACTS VS. THEORY

While climatic climax theory worked fairly well in and around the

Midwest, California caused it real problems. William Cooper saw that most of the state had a fairly uniform Mediterranean climate which climax theory said should produce one kind of vegetation. Conforming with theory, Cooper said this was chaparral, meaning shrubs once covered all the California Floristic Province's warmer and drier areas including valleys. But unfortunately for his theory, its earliest visitors never reported shrubs in valleys.

In contrast, Clements recognized California's vegetation was diverse. To fit it to his climatic climax theory, he concluded our climate was also diverse. The vast plains of the Central Valley may have reminded him of his Nebraska home state since he annexed it to his Grassland Climatic Climax (Weaver and Clements 1938) (Figure 3). To justify that, he also claimed that the Central Valley and Nebraska had the same climates, meaning Fresno's climate was more like Omaha's than Riverside's (Hamilton 1997).

Clements also claimed *Stipa* bunchgrasses once covered the Central Valley, but its earliest visitors didn't see these either except in adjacent foothills where they're still common. What the valley's earliest visitors did see was a vast sea of wildflowers, a phenomenon well documented by John Muir but also reported by even the earliest valley visitors (Minnich 2008). How then could Clements ignore these wildflowers? He had to because his theory had a rule that vegetation must be dominated by perennials (Hamilton 1997). Since the valley's wildflowers were mostly annuals, Clements' theory would not permit them to dominate vegetation no matter how many there were. Despite its rarity in the Central Valley, he found the ideal perennial his theory needed in purple needle-grass (*Stipa pulchra*), since he initially mistook it for one of his Grassland Climatic Climax's abundant Great Plains species (Hamilton 1997).

CALIFORNIA'S VEGETATION MOSAIC

Climatic climax theory had a hard time explaining California vegetation, which changed much faster across short distances than climate. In an apparently common climate forest, savanna, sage scrub, chaparral, or open prairie often coexisted in a com-

plex mosaic seen and described by California's earliest visitors. Climatic climax also lost support when it was learned how fast climate changes. Nevertheless, just 17 years ago some still interpreted the mosaic as different successional stages. Clements' claim that bunchgrass once covered the Central Valley—the later justification for calling it “grassland”—



TOP: White layia (*Layia glandulosa*) on recent alluvium of Central Valley floor in Kern County, March 2011. • BOTTOM: Ithuriel's spear (*Triteleia laxa*) on uplifted older alluvium, and riparian vegetation (in background) on recent alluvium at Tassajara Hills, Contra Costa County.

FIGURE 1. RANGELAND ECOLOGIST L.T. BURCHAM'S 1957 MAP OF CALIFORNIA'S PRISTINE VEGETATION.



Note: California Prairie is indicated in red. Graphics by Joan Kodani.

FIGURE 2. CALIFORNIA FIRE AND RESOURCE ASSESSMENT PROGRAM (FRAP) MAP OF STATE LAND COVER IN 2003.



Note: Herbaceous land cover is indicated in bright yellow. It is approximately equivalent to Burcham's California prairie. Graphics by Joan Kodani.

is even more enduring. Elna Bakker (1971), an observant non-academic, was the first to treat our mosaic as a natural phenomenon and at least partially explain its occurrence here.

Why is California different from the eastern United States? One reason is its Mediterranean climate. East of the Rockies it rains in summer when plants grow fastest, but in California the wet and growing seasons are months apart, a period when water must be stored in soils and rocks to be used when the growing season's long, warm days arrive. European vegetation ecologists like Denmark's Eugenius Warming in 1895 gave such phenomena resulting from geology's effect on vegetation much more attention than did our Midwestern ecologists, who had fewer relevant local examples. More recently Germany's Heinrich Walter (1979) has been particularly insightful in explaining how geology and climate interact to create vegetation.

Southern France has a Mediterranean climate less extreme than California's, but vegetation that similarly changes rapidly across space. It was there Josias Braun-Blanquet developed a method for describing vegetation that is now used worldwide, including by the CNPS Vegetation Program, which identifies areas with distinctive vegetation called relevés and then estimates their coverage by different species.

In summary, the US and Europe developed quite different emphases on how and why vegetation changes. Americans tended to focus on vegetation change in time through succession to a climatic climax, while Europeans focused on change across space caused by multiple environmental factors, including geology.

WHERE ARE CALIFORNIA'S PRAIRIES?

In 1957 range ecologist L.T. Burcham created a very good map of California's pristine vegetation with-

out the benefit of modern satellite imagery (Burcham 1957) (Figure 1). He mapped as "California Prairie" areas lacking dominant woody plants which occur throughout California's Mediterranean climate zone in a wide range of local climates.

California prairie occurs in Humboldt County where rainfall exceeds 70 inches and in the Cuyama and southern San Joaquin Valleys where it averages only 5. It is in Shasta Valley where the January mean temperature is 34° F and the mean minimum is 24° F, and in the Palos Verdes Peninsula where equivalent temperatures are 57 and 50. Prairie can be found on the Point Reyes Peninsula where the July mean is 54° F and the mean maximum is 58° F, and in Bakersfield where the equivalent temperatures are 84 and 99. California prairie thus occurs across the California mediterranean zone's full range of climatic diversity.

It is evident from Burcham's map that his California prairie is associated with environmental factors *other* than climate, and comparison with geological maps indicates it is closely associated with areas where clay is abundant. That's not surprising since European vegetation ecologists like Walter (1979) explain in detail why clay favors herbaceous plants such as grasses. Their root systems tend to be shallower and denser than those of woody plants so they depend more on upper soil layers. When these are rich in clay they hold more water and restrict deeper movement of water and air. For this reason, clay soil favors grasses and other herbs, while coarser soil favors woody plants.

Examples of this effect on vegetation are numerous. In Texas the 12 million-acre Blackland Prairie on clay is surrounded on all sides by post oak (*Quercus stellata*) woodland on sediments containing much less clay. It is as evident closer to home in adjacent ridges with identical climates in Solano County hills.

There prairie on Eocene marine clay is found next to oak woodland on volcanic rock. Because clay holds water near the surface, its extensive prairie stays green a full month longer than prairie patches on the volcanics.

Nevertheless California prairie's close association with clay has been essentially ignored until now, and goes unmentioned in standard texts on California vegetation. This huge gap in understanding California vegetation geography likely results from the residual influence of Clements' overemphasis on climate. While the relation of geology to vegetation is well studied at serpentine outcrops and vernal pools in California, it is otherwise ignored here more than elsewhere in the US. In Georgia (Chafin 2007), for example, rare plants are classified by natural communities defined almost exclusively by geology, but this has never been systematically done in California even though it is more climatically and geologically diverse than Georgia and has many more rare plants.

IF CLAY IS SO IMPORTANT, WHAT IS IT?

Clay is the generic name for a mineral group that has specific characteristics and is created from silicate rocks as they weather when exposed to water. It is nearly indestructible and can remain in the environment for millions of years until extreme heat or pressure eventually convert it to metamorphic or volcanic rocks. Meanwhile it can solidify into sedimentary rocks and be uplifted into high mountains. A distinctive feature is its breakup into tiny particles readily moved by wind and streams. These are called dust in air, and mud in water. Since both can be moved much farther than most non-clay minerals, they often accumulate far from where weathering created them. Clay created in

FIGURE 3. CLEMENTS (AND WEAVER 1938) "ANNEX" THE CENTRAL VALLEY TO NEBRASKA AND THE GREAT PLAINS IN THEIR GRASSLAND CLIMATIC CLIMAX.



Source: Weaver and Clements, 1938.

mountains, for example, is usually carried farther away to valley bottoms by erosion and stream transport than other minerals. Consequently California's many valleys are where clay accumulates. It is not coincidental they're also where California's prairie vegetation was most extensive

Clay's importance to plants arises when its tiny particles aggregate and pack tightly together, since they have a unique capacity to tightly hold large quantities of water and nutrients and gradually release them to plant roots. Packing is so tight however that movement of water and air

to deeper roots is restricted. Consequently, soils with lots of clay are often described as poorly drained.

PROBLEMS WITH SOIL MAPS

A word should be said about soils since they're where plants grow. Soil science deals with the interface between geology and plants and has developed its own terminology. In the United States, however, this can make clay hard to find since our soil maps classify many soils in a main sequence of orders determined more



Virgate tarplant (*Holocarpha virgata*) on Great Valley sequence strata in Napa County.

by relative age than geology. Entisols, the youngest, are followed by slightly older Inceptisols, middle aged Alfisols, and old Ultisols. In California most prairie is on this age determined soil order sequence, but some is on orders not defined by age. An example is Vertisols, an order defined by clay that cracks. It is almost always vegetated by prairie but underlies just a fraction in California because it's a relatively uncommon kind of soil.

Clay can be any age. Some is so fresh it is not considered soil, but most is weathered enough to be Entisols, Inceptisols, or Alfisols. Consequently these orders tell little about vegetation or soil materials. Entisols are just very young soils that may form on clay, sand, or rock, all of which can greatly influence vegetation. Mollisols, an order defined by dark organic matter, is characteristic of prairies in the Midwest

but here is most often associated with chaparral and oaks that darken soil below them with shed plant material. Our prairie soils with black organic matter are usually Vertisols because of cracking clay.

Geologic maps of parent material under soils are much better for predicting vegetation than soil maps. In much of the US, parent material is rock that soil-forming processes such as weathering soften into soil. However, in much of California parent material is alluvium—material eroded from uplands and carried by streams to low places where it accumulates until many feet thick. Often it begins as clay-rich mud derived from eroding upland topsoil, but even when thickly deposited in far-away valleys it retains characteristics of its original source like soft texture and fertility. Since these extend far beneath surface soils, alluvium is the basis for California agri-

cultural productivity. Because of alluvium's great thickness, soil erosion is less often a problem in California than salinity and draught.

CENTRAL VALLEY PRAIRIES

Burcham (1957) mapped most of what he calls "pristine California Prairie" in the Central Valley before agriculture had converted much of it to cropland. That matches the early valley's descriptions by visitors like John Muir, who described it as a sea of wildflowers with little grass. He identified numerous colorful forbs dominating it in spring and a second late summer domination by forbs like virgate tarplant (*Holocarpha virgata*). Many of its relatives are also prominent in this late prairie flora, but those in the tidytops genus *Layia* flower in the spring prairie. Prairie forbs Muir didn't discuss are summer bloom-

ing perennials like narrow-leaved mule's ears (*Wyethia angustifolia*) and perennial lupine (*Lupinus formosus*), which survive in prairie relicts where theory would expect purple needlegrass.

Burcham didn't map all the valley as prairie, however. A large area in Kern County was desert scrub dominated by allscale saltbush (*Atriplex polycarpa*) and spiny saltbush (*A. spinifera*). Freshwater marshes dominated by tules (*Schoenoplectus acutus*), bulrushes (*S. californicus*), and cattails (*Typha latifolia*) were widespread in the lowest parts of the Central Valley, particularly in the California Delta, in flood basins to its north, and at the edges of former Tulare Lake. Riparian forests followed major rivers into the valley and occasionally, as in northern Tulare County, broadened into wide savannas dominated by valley oak (*Quercus lobata*). Farther north in Tehama and Shasta counties a different kind of oak savanna—one dominated by blue oak (*Q. douglasii*)—extended down from surrounding foothills to almost completely cover the valley's narrow northernmost end.

Nevertheless the Central Valley's most widespread pristine vegetation was California Prairie, and from there it extended in all directions. We can see what happened to it in a recent land cover map (Figure 2) produced by remote sensing and other sources (FRAP 2003) since its herbaceous cover type is roughly equivalent to Burcham's California Prairie. This map shows a few prairie areas not mapped by Burcham and much prairie loss to urbanization and cultivation, especially in the Central Valley.

Both maps show that most, but not all, California prairie landscapes are on alluvium, which favors herbaceous vegetation because of its soft texture and often abundant clay. Historically most Central Valley prairies were on alluvium mapped as recent because it was deposited dur-

ing the 10,000 years since the Ice Age ended. Because its soft texture, high fertility, and low relief make recent alluvium the easiest parent material to use for cultivating crops and constructing buildings, most of it that was once prairie is now either farmed or urbanized.

Although it was originally less common, most Central Valley prairies are now found on older alluvium that formed from 10,000 to 2 million years ago and tends to be harder, less fertile, hillier, and located farther from the valley center than its younger relative. Consequently it is less often cultivated or urbanized and is most often used for cattle grazing, a land use that preserves many native prairie plants by minimally disturbing soil while removing many competitive non-native weeds. Prairies on older alluvium along the valley's eastern edge often have silica hardpans and a microtopography of miniature hills and valleys that preserves remnant channels of streams which once meandered across floors of valleys before Sierran uplift left them high and dry. The hardpans and microtopography created vernal pools that are by far the world's finest.

Prairie uplands surrounding vernal pools often receive much less attention, however, despite providing critical nesting sites for bees pollinating pool plants, refuge burrows for amphibians when pools dry, and habitat for a rich flora and fauna all their own. Vernal pool prairie also occurs along the valley's west edge on uplifted older alluvium, as at Jepson Prairie in Solano County, but drainage beneath its pools is restricted by salty clay pans instead of hardpans. That often causes pool water chemistry and endemic pool species to be different on the valley's two sides.

Blue oak woodland increasingly dominates on older alluvium at the valley's northern end as mean annual rainfall increases from 19 inches

at Sacramento to 39 inches at Redding. Even there, however, prairies occasionally occur on both older alluvium and on parts of the Great Valley sequence, which consists of 200- to 70-million-years-old alternating shale and sandstone marine sediments that are turned on edge, so that ridges are formed by hard sandstone and valleys between them by softer clay-rich shale. Some smaller prairies around the northern valley are famous for spectacular wildflower displays caused by forb dominance. These include Colusa County's Bear Valley on recent alluvium and Butte County's Table Mountain, where a 15-million-year-old lava flow's hard exposed surface functions like clay to keep vegetation herbaceous.

The Central Valley's recent alluvium didn't just cover the valley's extensive flat clay plains. It was also found on natural levees and major river floodplains, where groundwater was often shallow enough to be reached by tree roots and drainage was better in the usually coarser soils. These landscapes were historically dominated by valley oaks that sometimes, as at Woodland in Yolo County, grew densely enough to form forests. Where groundwater scarcity caused greater water stress, however, oaks were often spaced widely in savannas that included much prairie. These savanna prairies, the Central Valley's greatest historic grasslands, were frequently dominated by beardless wild rye (*Elymus triticoides*).

Salt accumulation in other Central Valley recent alluvium areas produced an unusual alkaline prairie often dominated by spikeplant (*Centromadia pungens*), rich in endemic *Atriplex* species, and sometimes containing the large bunch grass alkali sacaton (*Sporobolus airoides*). Alkaline prairie is most extensive in the wide, dry San Joaquin Valley but also occasionally found in the Sacramento Valley on basin rims, the interface between

alluvial fans and flood basins along major rivers.

THE VALLEY WASN'T ALL CLAY

While clay dominates the valley's parent material, it also has three large localized areas covered by sand. The northernmost in eastern Contra Costa County—before its recent thorough urbanization—was covered by coast live oak (*Quercus agrifolia*) woodland except at its northern end, where a unique scrubland was present on the Antioch Dunes just south of the Delta's western outlet. Farther south prairies once occurred on sand deposited in the San Joaquin Valley by rivers carrying it from sources in rocks ground to sand by Sierran Ice Age glaciers.

The largest of these southern sand areas is Merced County's Sandy Mush country, where sand accumulated after being carried down the Merced River from glacial erosion that created Yosemite Valley. It is identified as sand on geologic maps, but a similar Fresno County area covered by sand eroded from Kings Canyon is only indicated on soil maps. Since the Sandy Mush region was easy to farm and converted almost entirely to cropland early in the valley's history, little is known about its native plant life except that it once included the now extinct endemic Merced monardella (*Monardella leucocephala*).

Original Sandy Mush vegetation was likely prairie since there's no evidence it had dominant trees or shrubs, but it may have been prairie different from that in the rest of the valley. Studying vegetation of a recent addition to Merced National Wildlife Refuge at Sunrise Ranch—a 2,500-acre Sandy Mush site that was never plowed and has relict dunes—may reveal why such sand areas had so few woody plants despite being halfway between east Contra Costa's oak woodlands and

Kern County's *Atriplex* shrublands. The rarity in California of Sandy Mush's lack of woody plants on sand is evident to its south in western Fresno County's Ciervo Hills, where islands of tall shrubs on sand surrounded by prairie on clay are visible from miles away on Interstate 5.

Sand favors trees and shrubs because it's the opposite of clay. Air and water penetrate it freely but moisture and nutrients are scarce near its surface. Among grasses, these conditions favor bunchgrasses since their "bunch" or tussock extends roots in all directions to harvest scarce nutrients and water. Rhizomatous grasses, in contrast, do well on clay because they can densely cover its moist fertile surface (but some rhizomatous species are favored on actively blowing sand because they can quickly extend to new, more favorable locations) (Grime 2001). It is possible purple needlegrass formerly dominated the valley's sandy areas. If Clements saw that, he may have extrapolated it to the whole valley.

BREACHING THE MOUNTAIN BARRIER

Cismontane and the California Floristic Province refer to California west of the Cascade, Sierra, Transverse, and Peninsular ranges. East of them are the *transmontane* Sonoran, Mojave, and Great Basin deserts. Just about all California Prairie is west of them and *cismontane*. The mountains create a mostly impenetrable barrier in the High Sierras but are leakier to their north and south. This is evident north of Mount Shasta at the western end of the Modoc Plateau in central Siskiyou County, where typical chaparral plants like buckbrush (*Ceanothus cuneatus*) intermix with *transmontane* species like western juniper (*Juniperus occidentalis*) and significant California Prairie occurs on recent alluvium in Shasta Valley.

Far to the south in Kern County's southern Sierra Nevada, prairie also occurs in a series of alluvial valleys extending from Kern River Valley in the north to Tehachapi Valley in the south. These are often connected across intervening ridges by prairie corridors underlain by volcanic rocks that differ from the more common Sierran granite because heavier clay soils are created when they weather.

Some of California's most spectacular remaining prairies are truly *transmontane* since they occur adjacent to the Mojave Desert on uplifted clay-rich older alluvium fringing the east base of the Tehachapi Mountains and the north base of the Liebre Mountains. Prairie is absent, however, on sandy recent alluvium flooring the nearby Antelope Valley. An outstanding pristine California prairie outlier nearby is protected at Fairmont Butte in the Antelope Valley California Poppy State Reserve. These prairies are geomorphologically in the Mojave Region, but their climate is less extreme than the desert since *transmontane* Sandberg in the west Mojave prairie region has 13 inches mean annual precipitation, whereas *cismontane* Bakersfield only gets 6.

In the mountains themselves enough clay, organic matter, and water often accumulate in localized basins to suppress forest tree growth and create open *meadows*. These can look like prairies and have many plants related to those of lower elevations, but they differ in being most active, green, and colorful in June and July just when most prairie plants are brown and shedding seeds. Meadows can do this because they receive much of their water from snowmelt and thus avoid stress caused by a Mediterranean climate.

NORTH COASTAL PRAIRIE

Prairies along California's North Coast were left behind when Clements "annexed" the Central

Valley to Nebraska. That eventually caused the valley's prairies to be called "grassland" despite having little native grass, while the North Coast was ironically left as California's only "prairie" even though it had a lot. Coastal prairie north of the Golden Gate is most extensive in the rugged hills of Humboldt County, and in the low ones of northern Marin and western Sonoma counties between Santa Rosa and the coast.

Humboldt prairies are most extensive south of Eureka around Cape Mendocino and northeast of it at Bald Hills. In both areas they're on steep slopes and high ridges underlain by the Franciscan Complex, a mixture of sediments scraped off the ocean floor that plate tectonic forces were pushing into a subduction zone while the Great Valley sequence was forming farther east. Franciscan and Great Valley sediments both consist of much sandstone and shale, but the former lacks the latter's regular layering. Franciscan sediments were thoroughly mixed during their violent formation, and vegetation developing on them after they were uplifted into hills isn't so different. On a detailed Humboldt County vegetation map much of the area underlain by Franciscan is described simply as an oak woodland/grassland mosaic too complex to disaggregate, but its larger prairie areas are identifiable by mapped nests of birds like Western Meadowlark (*Sturnella neglecta*) which use them as habitat.

The mosaic isn't continuous since its Bald Hills and Cape Mendocino areas are separated by dense redwood (*Sequoia sempervirens*) forest on more recent non-Franciscan sediments of the fault-bounded Eel River Basin geological area. The basin was once a valley in Franciscan but is now uplifted so high that the Freshwater Fault at its eastern edge creates a perfect vegetation boundary. To its west are Headwaters redwood forest's rugged

hills on basin sediments, and to its east is woodland/grassland mosaic with many meadowlark nests on equally rugged Franciscan hills. Such evidence of geology controlling redwood distribution should raise doubts about its supposed fog dependence.

More evidence that Franciscan geology favors prairie is provided by their distribution in Oregon since both extend north only as far as its southwestern-most corner in Curry County and then stop. Climate is unlikely to account for this since rainfall at Gold Beach in Oregon's Franciscan-prairie zone is 78 inches but only 69 at Newport farther north in coastal conifer forest with geology like the Eel River Basin. Both towns have only a month with less than an inch of rain, but summers are two degrees warmer at Gold Beach. A climate factor likely to favor coastal prairie is the stress that salt-laden westerly winds causes trees. Forests often extend to tide-water in eastern North America since its prevailing westerlies usually blow from land, but they cross the wide, salty Gulf of Lawrence before reaching coastal prairie like Northern California's on the west coast of Cape

Breton Island. Forests extend down to saltwater, however, on its east coast.

California coastal prairie's largest area in northern Marin and southern Sonoma counties is almost entirely on five-million-year-old Wilson Grove formation marine sediments, except for an eastern extension onto non-marine older alluvium of the Santa Rosa plain. A narrow and often hilly prairie corridor on a variety of clay-rich sediments near the north shores of Suisun and San Pablo Bays and Carquinez Strait historically connected these Marin-Sonoma coastal prairies in the Central Valley.

PRAIRIES SOUTH OF THE GOLDEN GATE

South of the San Francisco Estuary prairie extends nearly continuously through the southern Coast Range from Los Medanos Hills at the south shore of Suisun Bay to the Santa Ynez Mountains at the west end of the Transverse Range. Farther south it was once extensive on the Los Angeles and Ventura coastal plains and occasionally as far as San

California goldfields (*Lasthenia californica*) on older alluvium at Jepson Prairie in Solano County.



Diego County. It is widespread on recent and older alluvium in valleys from Livermore in the north to Santa Ynez in the south, and frequently connected by prairie corridors across intervening mountains underlain by Great Valley and more recent clay-rich marine sediments. A wide prairie corridor at Altamont Pass connecting Livermore Valley prairies with those of the Central Valley across a ridge of marine sediments and older alluvium typifies many similar southern Coast Range linkages with the valley.

Wildflower displays are often spectacular on Southern Coast Range hill and mountain prairies like those north of Livermore Valley on uplifted older alluvium at Tassajara Hills dominated by Ithuriel's spear (*Triteleia laxa*) and on Temblor Range marine sediments northeast of Carrizo Plain dominated by common hillside daisy (*Monolopia lanceolata*). Similar flower displays are frequent throughout a large relatively unaltered prairie region extending from Salinas Valley in southern Monterey and northern San Luis Obispo counties southeastward across older alluvial and marine sedimentary ridges to broadly connect with both the San Joaquin Valley and Carrizo Plain, an alluvial area partially protected at Carrizo Plain National Monument that has prairies like those of the pristine Central Valley.

Diverse prairies in a triangular western Santa Barbara and San Luis Obispo county region include both typical hill and valley inland prairie and Franciscan Complex coastal prairie in northwestern San Luis Obispo County resembling that in Northern California. This region isn't all prairie, however. Chaparral, for example, dominates sandy, clay-poor older alluvium on Burton Mesa in western Santa Barbara County. Such chaparral islands surrounded by prairie or oak woodland occur throughout the southern Coast Range wherever clay is lacking. Good

examples are extensive granite outcrops covered by chaparral in the northern Gabilan Range along the Monterey-San Benito county line and the La Panza Range in central San Luis Obispo County.

Prairies were less extensive in Southern California except on recent alluvium of the now thoroughly urbanized Ventura and Los Angeles coastal plains, but some survive on clay-rich marine sediments at Oak Ridge in Ventura County and at Chino Hills, where Los Angeles, Orange, and San Bernardino counties meet. Other Southern California prairie areas are at Riverside County's Badlands on uplifted older alluvial clay, and in San Diego County at Lake Henshaw's alluvial valley and areas in its coastal hills between Camp Pendleton and Rancho Santa Fe where volcanic rocks weather to clay.

CALIFORNIA PRAIRIE: WELCOME HOME

Climate obviously matters since California has deserts in the southeast where it's hot and dry, and forests in the northwest where it's cool and wet, but California vegetation often changes abruptly even where climate doesn't. In the California Floristic Province abrupt change from woodland to chaparral, sage scrub, or prairie happens most often when *geology* changes, not climate. That suggests the province lacks a modal vegetation type determined by climate. Woodland, chaparral, and sage scrub are well known, but prairie is hardly known at all even though it is often intimately associated with woodland in savannas or complex vegetation mosaics.

Linked for too long by the name "grassland" to hypothetical bunch grass cover that scarcely and only locally existed, as well as to non-native weedy annual grasses, California's prairies deserve better than their treatment as Other in Barbour

and Billings *North American Terrestrial Vegetation's* second edition, which followed Clements' annexation of the Central Valley to Nebraska by lumping them with "other" North American grasslands rather than including them in its two chapters on "real" California vegetation. It is high time they received their rightful place in our Province's great triumvirate of woodland, chaparral, and prairie vegetation.

REFERENCES

- Bakker, E. 1971. *An Island Called California*. University of California Press, Berkeley, CA.
- Barbour, M., and W.D. Billings, eds. 2000. *North American Terrestrial Vegetation*. 2d ed. Cambridge University Press, Cambridge, UK.
- Burcham, L.T. 1957. *California Rangeland*. California Department of Natural Resources, Sacramento, CA.
- Chafin, L.G. 2007. *Field Guide to the Rare Plants of Georgia*. State Botanical Garden of Georgia, Athens, GA.
- FRAP. 2003. *Land Cover*. California Department of Forestry and Fire Protection, Sacramento, CA.
- Grime, J. P. 2001. *Plant Strategies, Vegetation Processes, and Ecosystem Properties*. 2d ed. John Wiley, Chichester, UK.
- Hamilton, J.G. 1997. Changing perceptions of pre-European grasslands in California. *Madroño* 44(4): 311-333.
- Hunter, J., et al. 2005. *Atlas of the Breeding Birds of Humboldt County, California*. Redwood Region Audubon Society, Eureka, CA.
- Jennings, C. 2010. *Geologic Map of California, Updated Version*. California Geological Survey, Sacramento, CA.
- Minnich, R. 2008. *California's Fading Wildflowers*. UC Press, Berkeley, CA.
- Walter, H. 1979. *Vegetation of the Earth and Ecological Systems of the Geo-Biosphere*. 2d ed. Springer-Verlag, New York, NY.
- Weaver, J.E., and F.E. Clements. 1938. *Plant Ecology*. McGraw-Hill, New York, NY.

Glen Holstein, 714 Lake Terrace Circle,
Davis, CA 95616; holstein@cal.net

VERTEBRATES OF CALIFORNIA GRASSLANDS

by Gene R. Trapp

To what degree do California's native vertebrates—amphibians, reptiles, birds, and mammals—depend on grasslands for their survival? If they depend entirely on grasslands to survive, then they are *obligate* users. If not, they are called *facultative* users. But to what extent do they need grasslands? Here we will consider not only the obligate species, but also the facultative species that need grasslands to such a large extent that we could call them “almost obligate.”

AMPHIBIANS

California Tiger Salamander (*Ambystoma californiense*)

Almost obligate. This species (7.6–12.7 cm long) is nocturnal, spends most of the year underground, and usually breeds in vernal pools or similar ponds that dry up in summer. Some of these pools occur in oak savanna, others on the grassy edges of mixed woodland and lower elevation coniferous forest. Many pools have been lost to agriculture and development. This species has lost 55% of its historic range and is threatened by further agricultural and vineyard growth, along with the loss of ground squirrel and pocket gopher burrows in which it summers. Introduced bullfrogs (*Lithobates catesbeianus*) are serious predators of eggs and young. The California tiger salamander is listed as a Federal and California Threatened Species.

Western Spadefoot (*Spea hammondi*)

Almost obligate. Cat-like pupils characterize this toad (3.8–6.3 cm), together with a single black sharp “spade” on each hind foot. This is used to dig backwards into soft substrate to make a burrow in which it



Western spadefoots (*Spea hammondi*) are rarely seen in California grasslands. They come out for a short period, after it rains, to breed, but then spend the rest of the year in earth-filled burrows. Photograph by Gary Nafis.

spends the dry season. Burrows of other animals are also used. Its distribution includes the Central Valley, associated foothills, and the South Coast Ranges to the coast. This toad also spends most of the year underground. It favors open areas of short grasses in sandy or gravelly soils found in valley and foothill grasslands, open chaparral, and pine-oak woodlands. It breeds in quiet streams and temporary ponds. This species is extinct in almost 80% of its traditional habitat along the south coast of California. It has also lost extensive temporary pool habitat in the Central Valley due to agriculture and development. The western spadefoot toad is a California Species of Special Concern.

There are six other species of California amphibians that can be called facultative (see sidebar, page 32).

REPTILES

Blunt-Nosed Leopard Lizard (*Gambelia sila*)

Almost obligate. This endemic lizard (7.5–12.5 cm) occurs in the

San Joaquin Valley region, including the Carrizo Plain. Its habitats are semiarid grasslands, alkali flats, and washes. It is no longer present over much of its former range due to agriculture, development, and off-road-vehicle activity. It is classified as a Federal and California Endangered Species.



The population size of the blunt-nosed leopard lizard (*Gambelia sila*) depends upon the number of mammal dens and burrows available in its arid habitat. Photograph by Gary Nafis.

There are 15 other species of California reptiles that can be called facultative (see sidebar, page 32).

BIRDS

Mountain Plover (*Charadrius montanus*)

Obligate. In spite of its name, this bird breeds in the dry short-grass region of the western Great Plains, and winters in the dry grasslands and semideserts of California's Central and Imperial Valleys, Texas, and northern Mexico. The largest concentrations are in the Imperial Valley. Its population has been declining for decades, likely due to disturbance by agriculture, and possibly pesticides. Its diet is mainly invertebrates.



The elusive mountain plover (*Charadrius montanus*) has been called the “prairie ghost” due to its habit of facing away from an intruder and squatting motionless, making it very difficult to see. Photograph by Ed Harper.

Grasshopper Sparrow (*Ammodramus savannarum*)

Obligate. This secretive, big-headed, short-tailed sparrow with an insect-like song prefers grassland with some shrubs and no trees for breeding habitat. It occurs along coastal California, plus the western edge of the Central Valley and grassy foothills of the western Sierra Nevada. It is insectivorous, and prefers grasshoppers. Overgrazing is often detrimental to its habitat. This sparrow needs open areas, as it is a visual forager. It winters in Mexico and the southeastern US, and has been in decline since the beginning of the 20th century due to habitat loss. It is a California Species of Special Concern.

Western Meadowlark (*Sturnella neglecta*)

Obligate. This species is widespread from the northern Great Plains to the Pacific Ocean. Often singing atop fence posts, showing off its brilliant yellow breast with a dramatic black chevron, it is a close relative of blackbirds. Like them, it often inserts its bill into the ground or a thick mat of grass and then

FACULTATIVE GRASSLAND AMPHIBIANS

The following amphibians found in California are facultative grassland species: they use grassland to varying extents, but not 100%.

Common Name	Scientific Name
Black-bellied slender salamander	<i>Batrachoseps nigriventris</i>
California slender salamander	<i>B. attenuatus</i>
California toad	<i>Bufo boreas halophilus</i>
Pacific treefrog or chorus frog	<i>Pseudacris regilla</i>
Northern red-legged frog	<i>Rana aurora</i>
California red-legged frog	<i>R. draytonii</i>

FACULTATIVE GRASSLAND REPTILES

The following reptiles are facultative grassland species: they use grassland to varying extents, but not 100%.

Common Name	Scientific Name
Western fence lizard	<i>Sceloporus occidentalis</i>
Side-blotched lizard	<i>Uta stansburiana</i>
Coast horned lizard	<i>Phrynosoma blainvillii</i>
Gilbert's skink	<i>Plestiodon gilberti</i>
Southern alligator lizard	<i>Elgaria multicarinata</i>
Northern alligator lizard	<i>E. coerulea</i>
Sharp-tailed snake	<i>Contia tenuis</i>
Western yellow-bellied racer	<i>Coluber constrictor</i>
Coachwhip	<i>Coluber flagellum</i>
Gopher snake	<i>Pituophis catenifer</i>
California glossy snake	<i>Arizona elegans occidentalis</i>
Common kingsnake	<i>Lampropeltis getula</i>
Long-nosed snake	<i>Rhinocheilus lecontei</i>
Common garter snake	<i>Thamnophis sirtalis</i>
Western rattlesnake	<i>Crotalis oreganus (viridis)</i>

opens the mandibles (gapes) to expose seeds or invertebrates.

Lapland Longspur (*Calcarius lapponicus*), Chestnut-Collared Longspur (*C. ornatus*), and McCown's Longspur (*Rhynchophanes mccownii*)

Obligate. Longspurs are sparrow-sized winter visitors that use prairies, pastures, open weedy and grassy fields, grain stubbles, shores, and

any open ground. They eat seeds and invertebrates. The Lapland longspur breeds in the Arctic tundra. Chestnut-collared and McCown's longspurs breed in the northern Great Plains. All are rare in California, especially McCown's.

Short-Eared Owl (*Asio flammeus*)

Almost obligate. This owl with short ear tufts was once widespread in California, but agriculture has

FACULTATIVE GRASSLAND BIRDS

The following birds are facultative grassland species: they use grassland to varying extents, but not 100%.

Common Name	Scientific Name
Turkey Vulture	<i>Cathartes aura</i>
California Condor	<i>Gymnogyps californianus</i>
White-tailed Kite	<i>Elanus leucurus</i>
Golden Eagle	<i>Aquila chrysaetos</i>
Northern Harrier	<i>Circus cyaneus</i>
Swainson's Hawk	<i>Buteo swainsoni</i>
Ferruginous Hawk	<i>Buteo regalis</i>
Rough-legged Hawk	<i>Buteo lagopus</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
American Kestrel	<i>Falco sparverius</i>
Merlin	<i>Falco columbarius</i>
Prairie Falcon	<i>Falco mexicanus</i>
Killdeer	<i>Charadrius vociferus</i>
Long-billed Curlew	<i>Numenius americanus</i>
Mourning Dove	<i>Zenaida macroura</i>
Barn Owl	<i>Tyto alba</i>
Lesser Nighthawk	<i>Chordeiles acutipennis</i>
Common Nighthawk	<i>Chordeiles minor</i>
Say's Phoebe	<i>Sayornis saya</i>
Loggerhead Shrike	<i>Lanius ludovicianus</i>
Western Kingbird	<i>Tyrannus verticalis</i>
Yellow-billed Magpie	<i>Pica nutalli</i>
American Crow	<i>Corvus brachyrhynchos</i>
Common Raven	<i>Corvus corax</i>
Barn Swallow	<i>Hirundo rustica</i>
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>
Cliff Swallow	<i>Petrochelidon pyrrhonota</i>
Rock Wren	<i>Salpinctes obsoletus</i>
Vesper Sparrow	<i>Poocetes gramineus</i>
Lark Sparrow	<i>Chondestes grammacus</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Brewer's Blackbird	<i>Euphagus cyanocephalus</i>

reduced its range dramatically, so now it breeds in scattered areas from Central California northward. Brown with light spots, it is active day and night. Its habitat is open country: prairie, coastal grasslands, agricultural fields, fresh and saltwater marshes, and shrub thickets. Voles (*Microtus*) are its primary prey, plus any other mammals or birds that it can catch. It is a California Species of Special Concern.

Burrowing Owl (*Athene cunicularia*)

Almost obligate. Active day and night, this small brownish owl is found throughout much of California except the northwestern part of the state and at higher elevations in the mountains. It is a species of open terrain and short vegetation: grasslands, steppes, and deserts. These owls are opportunistic feeders, and eat primarily larger insects and small mammals, but also any other vertebrates that they can catch. This is a California Species of Special Concern due to loss of habitat to agriculture. Burrowing owls need to use burrows made by other animals, especially California ground squirrels (*Spermophilus beecheyi*), so ground squirrel poisoning campaigns result in fewer available burrows and thus fewer owls.

Horned Lark (*Eremophila alpestris*)

Almost obligate. Found year-round throughout the state except in the northwest corner, it needs open country of short vegetation or bare ground: prairies, deserts, steppes, and alpine habitat. It is a sparrow-sized bird with a yellow face and throat, plus a black mask and bib, and two tiny black tufts on its crown. Seeds and insects are its pri-

Pairs of burrowing owls (*Athene cunicularia*) need short vegetation around their den to help them spot predators and see potential prey. There many mouths to feed here, with one adult second from the right. Photograph by Jo Ellen Ryan.



FACULTATIVE GRASSLAND MAMMALS

The following mammals are facultative grassland species: they use grasslands to varying extents, but not 100%.

Common Name	Scientific Name
Ornate shrew	<i>Sorex ornatus</i>
Broad-footed mole	<i>Scapanus latimanus</i>
California myotis	<i>Myotis californicus</i>
Western Small-footed myotis	<i>Myotis ciliolabrum</i>
Yuma myotis	<i>Myotis yumanensis</i>
Canyon bat (Western pipistrelle)	<i>Parastrellus hesperus</i>
Big brown bat	<i>Eptesicus fuscus</i>
Western yellow bat	<i>Lasiurus xanthinus</i>
Western red bat	<i>Lasiurus blossevillii</i>
Hoary bat	<i>Lasiurus cinereus</i>
Spotted bat	<i>Euderma maculatum</i>
Townsend's big-eared bat	<i>Corynorhinus townsendii</i>
Pallid bat	<i>Antrozous pallidus</i>
Brazilian free-tailed bat	<i>Tadarida brasiliensis</i>
Western bonneted (greater mastiff) bat	<i>Eumops perotis</i>
Desert cottontail	<i>Sylvilagus audubonii</i>
Black-tailed jackrabbit	<i>Lepus californicus</i>
California ground squirrel	<i>Spermophilus beecheyi</i>
Botta's pocket gopher	<i>Thomomys bottae</i>
Heermann's kangaroo rat	<i>Dipodomys heermanni</i>
California kangaroo rat	<i>Dipodomys californicus</i>
Stephen's kangaroo rat	<i>Dipodomys stephensi</i>
San Joaquin kangaroo rat	<i>Dipodomys nitratoides</i>
Western harvest mouse	<i>Reithrodontomys megalotis</i>
American deer mouse	<i>Peromyscus maniculatus</i>
California vole	<i>Microtus californicus</i>
Coyote	<i>Canis latrans</i>
Kit fox	<i>Vulpes macrotis</i>
Red fox	<i>Vulpes vulpes</i>
American badger	<i>Taxidea taxus</i>
Striped skunk	<i>Mephitis mephitis</i>
Elk	<i>Cervus elephus</i>
Pronghorn	<i>Antilocapra americana</i>

mary food. It is the only true lark native to North America.

Savannah Sparrow (*Passerculus sandwichensis*)

Almost obligate. This small sparrow occurs year-round along the

California coast, but only in summer in the northern one-third of the state and the Sierra Cascade ranges. It is a species of open country: grassy meadows, coastal marshes, dune grasses, sedge bogs, edges of salt marshes, cultivated fields, and lightly



Nelson's (San Joaquin) antelope squirrel can get all the water it needs from digestion of its foods. It does not require free water. One of its principle predators is the kit fox (*Vulpes macrotis*). An adult has stronger markings than this juvenile. Photograph by David Rosen.

grazed pastures. It has dark streaks dorsally on a brownish background, and either a yellow over-the-eye line, or a yellow spot between the eye and the beak.

There are 32 other species of California birds that can be called facultative (see sidebar, page 33).

MAMMALS

Nelson's (San Joaquin) Antelope Squirrel (*Ammospermophilus nelsoni*)

Almost obligate. This endemic ground squirrel is tan with a lateral white stripe, and can often be seen dashing between spots of shade on a hot day with its tail bent up over its back. It is 21.8–24 cm long, and is found in grassy areas, sometimes with scattered shrubs, in the western San Joaquin Valley and adjacent valleys, including the Carrizo and Elkhorn Plains. An omnivore, it eats vegetation, fungi, insects, and seeds. It is a California Threatened Species due to loss of habitat to agriculture, urbanization, and oil development.

San Joaquin Pocket Mouse (*Perognathus inornatus*)

Almost obligate. This small, orange-brown, long-faced mouse has fur-lined cheek pouches and a moderately long tail, and is a nocturnal eater of seeds and insects. It is 12.8-



The best place to see the endemic giant kangaroo rat (*Dipodomys ingens*) is on the Carrizo Plain, in the desert grasslands of southwestern San Joaquin County. It is a Federal and California Endangered Species, as is its primary predator, the kit fox (*Vulpes macrotis*). Photograph by David Rosen.

16.3 cm long, and gets the water it needs when digesting food. It is endemic to the Central Valley from Sutter Buttes to the Carrizo Plain and the Salinas Valley. It prefers dry grassland, oak savannah, and desert scrub. One subspecies is a California Subspecies of Special Concern, the Salinas pocket mouse.

Giant Kangaroo Rat (*Dipodomys ingens*)

Almost obligate. This is the largest kangaroo rat at 31.1–34.8 cm in length. It has a big head, large hind legs, a long tail, and is a seed eater, and is endemic to the open desert grasslands and scrub of the southwest San Joaquin Valley region. It is a Federal and California Endangered Species, having lost much habitat to agriculture, urbanization, and oil development. It collects seeds in its fur-lined cheek pouches and needs no free water, which it can get through digestion of dry seeds.

There are 33 remaining mammal species in California that use grasslands to varying extents (see sidebar, page 34).

REFERENCES

Bat Conservation International, www.batcon.org.
Birds of North America Online. Cornell Laboratory of Ornithology, Ithaca, NY.

CaliforniaHerps.com.

Dunn, J.L., and J. Alderfer. 2011. *National Geographic Field Guide to the Birds of North America*. National Geographic, Washington, DC.

Holing, D. 1988. *California Wildlands: A Guide to the Nature Conservancy Preserves*. Chronicle Books, San Francisco, CA.

Jameson, E.W., Jr., and H.J. Peeters. 2004. *Mammals of California*. California Natural History Guides, University of California Press, Berkeley, CA.

Mammalian Species. The American Society of Mammalogists. Allen Press, Lawrence, KS. <http://allenpress.com/publications/journals/mmsp>.

Reid, F.A. 2006. *A Field Guide to the Mammals of North America North of Mexico*. The Peterson Field Guide Series, Houghton Mifflin Company, Boston, MA.

Stebbins, R.C. 2003. *Western Reptiles and Amphibians*. 3d ed. Peterson Field Guides. Houghton Mifflin Company, Boston, MA.

Western Bat Working Group, www.wbwg.org.

Gene R. Trapp, 2313 Isle Royale Lane, Davis, CA 95616, grtrapp@comcast.net



The San Joaquin kit fox (*Vulpes macrotis mutica*) is a facultative grassland user. It occurs in the desert and desert grasslands of Southern California. Its prey is rodents, rabbits, and birds of these arid lands. Photograph by David Rosen.

INVERTEBRATES OF CALIFORNIA'S PRAIRIES

by Glen Holstein

In 1980 I ascended a steep rocky slope in dense oak-pine woodland and finally emerged in open prairie. I had reached the summit of Fresno County's Table Mountain east of Millerton Lake, one of many in California so named because of reversed topography created when lava rivers once flowing down Sierran canyons cooled to rock harder than canyon sides. The hardened lava remained as sinuous flat mesas

long after the canyons molding them eroded away. I was there to check reports of vernal pools on the mountain's top for the California Natural Diversity Database.

Vernal pools were there but what caught my eye in them weren't plants but hundreds of the biggest, most colorful beetles I'd ever seen in California. Each was nearly an inch long and brightly marked by orange and black. I expected such spectacular insects would be easy to identify in field guides but was wrong. It took UC Davis' Bohart Museum to confirm them as molestan blister beetles (*Lytta molesta*), a rare species wanted by the museum, so I made the long trip back to collect more.

A SPECIES OF THE BEE PASTURES

I asked John Pinto, a species expert, why it wasn't on rare species lists if so scarce, and he said it was probably because few cared about beetles. It is now on lists but still not federally or state listed as threatened or endangered. Recently I learned my 1980 collection is the last confirmed record of this California Central Valley prairie endemic, once widespread from Yolo to Kern counties. After the 1950s, when it was still common, it started disappearing.

It was a creature of the bee pastures John Muir described, wildflower fields with little grass extending for miles across the valley floor. It was tied as closely to those flower fields as any tropical forest specialist since it spent its adult life among them and may even have done some pollinating. Most remarkable, however, was a life cycle of five larval stages or instars it shared with its family. The first, the triungulin, was

more long-legged and active than other beetle larvae. It waited among flowers till either a pollinating solitary bee carried it to its underground nest or it crawled there on its own, where it ate pollen and went through four molts into progressively more sedentary larvae until transformed into an adult beetle by the fifth.

Muir's bee pastures and creatures dependent on them like the molestan beetle are now largely gone. Although the beetle was last seen in vernal pools, there is no evidence it was historically confined there. More likely they were just places bee pastures survived longest when invading weedy grasses crowded them off surrounding uplands.

One might expect Californians would notice the bee pasture ecosystem's loss, but they didn't. To be noticed and mourned requires a name, and since flowers aren't grass, Muir's bee pastures vanished from consciousness when they started to be called grasslands. Evidence of this is widespread in California botany. A visiting Southern California academic lecturing at UC Davis recently said that a photo of massed rainbow-colored native flowers in the Tehachapi-Liebre region—a place bee pastures survive—depicted a degraded and ruined landscape, presumably because it had no bunchgrass. A CNPS photo of massed *Lasthenia* with no grass is captioned "goldfield grassland." Whipsawed between a well-punctured bunchgrass myth and invading grass weeds, surviving bee pastures and creatures dependent on them like the molestan beetle lack value without a name or identity. That includes the splendid poppies and lupines on the new *Jepson Manual* cover, more of the vegetation unnamed and thus unseen.

This is disastrous for creatures



TOP: Red-eared blister beetle (*Lytta auriculata*), a Southern California species that resembles and is related to the molestan blister beetle (*Lytta molesta*). Photograph by Jim Hogue. • BOTTOM: A California trapdoor spider (*Bothriocyrtum californicum*) strikes at a tenebrionid beetle. Photograph by Marshall Hedin.

like the molestan beetle that depend on bee pastures because California land-use agencies on good botanical authority dismiss them as “non-native annual grassland”—the only landscape unfit for required general plan conservation elements. It is better for birds because their lobby is big enough to get attention, but those of very different habitats are still lumped as “grassland species” ranging from prairie generalists like western meadowlark (*Sturnella neglecta*) through bare ground specialists like burrowing owl (*Athene cunicularia*) that once followed herds of tule elk (*Cervus elaphus nannodes*) to those that once hunted lush valley oak (*Quercus lobata*) savanna grasslands but now use farmland like Swainson’s Hawk (*Buteo swainsoni*).

PRAIRIE INSECTS

Because bee pastures and other California prairies go unrecognized, their associated creatures like molestan beetle get virtually no attention or protection and lack comprehensive studies. Nevertheless some prairie insects and other invertebrates can be identified.

Grasshoppers of order Orthoptera, often the most abundant prairie insects, are generalist plant feeders which often range widely across North American prairies including those of California. Among its commoner prairie grasshoppers are clear-winged grasshopper (*Camnula pellucida*), big-headed grasshopper (*Eupnigodes megocephala*), devastating grasshopper (*Melanoplus devastator*), and valley grasshopper (*Oedaleonotus enigma*). Big-headed is the most exclusively Californian of these. Devastating grasshopper is named for its historic impact on vegetation in mass migrations, but habitat loss has greatly reduced these. Unlike its many relatives, its life cycle is synchronized with California’s native annual plants. Other prairie Orthoptera are endemic grass detritivores (*Clinopleura melanopleura*, *C.*



TOP LEFT: California ringlet (*Coenonympha tullia*), a prairie specialist on baby blue-eyes (*Nemophila menziesii*). • TOP RIGHT: Small checkered skipper (*Pyrgus sriptura*), an alkali prairie specialist on alkali-mallow (*Malvella leprosa*). • BOTTOM: The monarch butterfly (*Danaus plexippus*), a milkweed specialist on narrow-leaf milkweed (*Asclepias fascicularis*). All photographs by Greg Kareofelas.

minuta, and *Decticita brevicauda*), carinated shield-back katydid (*Neduba carinata*), a widespread and common species complex that includes several California endemics, California camel cricket (*Ceuthophilus californianus*), and the smaller sand cricket (*Ellipses minuta*).

Small insect orders include bristletails of primitive Archaeog-

natha. Although abundant in many habitats including prairie, their species are poorly known and lack common names. Predatory mantids in Mantodea include minor ground mantid (*Litaneutria minor*) of Californian prairies. Thrips of Thysanoptera are mostly tiny plant eaters that include Doane’s thrips (*Acanthothrips cortices*) and western flower



A prairie meloid beetle (*Lytta stygica*). Photograph by Jim Hogue.

thrips (*Frankliniella occidentalis*) that respectively eat prairie grasses and flowers, but black hunter (*Leptothrips mali*) atypically is a predator of tiny insects and mites. Neuroptera includes larger prairie predators like western mantispid (*Climaciella brunnea*) and many antlion species that wait in the conical pits they construct to devour trapped prey. Prairie predators in the small order Mecoptera include green stigma (*Bittacus chlorostigma*) and wingless scorpionfly (*Apterobittacus apterus*), remarkable among relatives in lacking wings and flight.

Cicadas famous for loud singing are among many diverse groups in Hemiptera. California prairie species include large grass cicada (*Okanagana consobrina*), small grass cicada (*O. minuta*), and red-winged grass cicada (*Tibicinoides cupreosparsus*). Other Hemiptera are plant phloem-feeders that entered a miniaturization path leading to aphids and their relatives and finally to scales, the only sessile insects. California prairie species in these groups are lupine aphid (*Macrosiphum albifrons*), Smith's grass mealy bug (*Trionymus*



A prairie grasshopper (*Melanoplus* spp.). Photograph by Jim Hogue.

smithii), fescue grass mealy bug (*T. festucae*), bunchgrass scale (*Aclerda californica*), and grass root scale (*Odonaspis graminis*). Among larger, more active California prairie Hemiptera are true bugs like the predatory western corsair (*Rasahus thoracicus*) and plant feeders like California plant bug (*Irbisia californica*), Marin grass bug (*I. mollipes*), central California grass bug (*I. setosa*), black grass bug (*I. solani*), milkweed bug (*Lygaeus tricoloratus*), California false chinch bug (*Nysius californicus*), false chinch bug (*N. raphanus*), and large milkweed bug (*Oncoeltus fasciatus*).

The beetles of Coleoptera, the



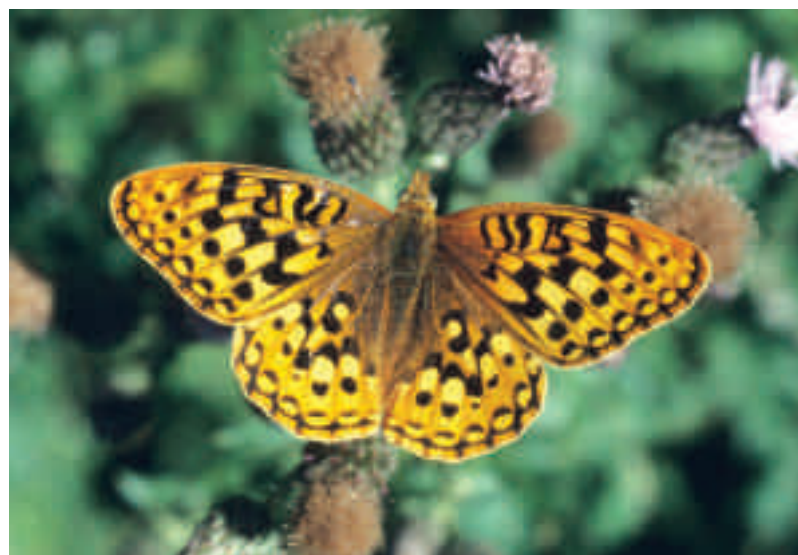
A large prairie centipede (*Scolopendra polymorpha*). Photograph by Charles Hogue.

largest insect order, include both predators and specialized plant feeders. It differs from Hemiptera in having chewing, not sucking, mouth parts and complete metamorphosis in which larvae and adults differ greatly. Other orders discussed here with complete metamorphosis are Neuroptera, Mecoptera, Diptera, Hymenoptera, and Lepidoptera. California prairie beetles include pink glowworm (*Microphotus angustus*), a western relative of eastern fireflies; molestan beetle and relatives like green blister beetle (*Lytta chloris*), small black blister beetle (*L. nigripilis*), and infernal blister beetle (*L. stygica*); pasture pill beetle (*Amphicyrta dentipes*); dimorphic flower longhorn (*Anastrangalia laetifica*); variable tiger beetle (*Cicindela terricola*); ant scarabs (*Crema-stocheilus* spp.); robust green chafer (*Dichelonyx robusta*); punctuate

blister beetle (*Epicauta puncticollis*); little bear (*Paracotalpa ursina*); and lupine seed weevils (*Tychius* spp.). The Ohlone tiger beetle (*Cicindela ohlone*) is a federally listed endangered species confined to remnant coastal prairie in Santa Cruz County.

Flies of Dip-

Coronis fritillary (*Speyeria coronis*), a violet specialist. Photograph by Jim Hogue.



tera are another large order. Ancestrally aquatic, they increasingly adapted to organic waste as well as predation and parasitism of plants and animals for larval feeding and development, but one early branch shifted to California prairie soils. These include range crane fly (*Tipula simplex*) and flightless range crane fly (*T. quaylii*). Other California prairie flies are greater bee fly (*Bombylius major*), net-veined bee fly (*Conophthorus fenestratus*), valley black gnat (*Leptoconops carteri*), and wild rye midge (*Rhabdophaga elymi*). Parasitic larvae of genera like *Aphoebantus* and *Sarcophaga* help control prairie grasshopper populations.

Even more diverse among large orders is Hymenoptera. Its primitive species are large active plant feeders, but it has evolved to miniature gall makers and seed and egg parasites, flying carnivory, sociality, and pollen feeding, the main source of flower pollination. Prairie Hymenoptera include sheath worm (*Harmolita* spp.) grass feeders; velvet ants (*Dasymutilla* spp.), which are non-social flightless wasps; kingfisher wasps (*Trielis alcione*), underground nesting prairie flower visitors; and trapdoor spider wasps (*Psorthaspis planata*), hunters of California prairie trapdoor spiders.

Ants are abundant, usually flightless social Hymenoptera in virtually all habitats including California prairie, where common ants include California red ant (*Formica subpolita*), black harvester ant (*Messor andrei*), small harvester ant (*Pheidole californica*), and California harvester ant (*Pogonomyrmex californicus*). Harvester ants carry prairie plant seeds to nests beneath conspicuous ant hills. Social Hymenoptera also include some wasps and bees. A few parasitize others, but most bees collect pollen. Not all are social, however, since solitary ground nesters are especially important for pollinating our native prairie plants.

The butterflies and moths of order Lepidoptera are almost all plant feeding specialists. Prairie butterflies include calippe and zerene fritillary (*Speyeria zerene* and *S. calippe*) that use Johnny-jump-up prairie violets (*Viola pedunculata*) and have three federally listed as endangered California subspecies. The monarch (*Danaus plexippus*) uses milkweeds (*Asclepias* spp.); and California ringlet (*Coenonympha tullia*), ox-eye satyr (*Cercyonis pegala*), and woodland satyr (*Cercyonis sthenele*) use native prairie grasses, which are also used by several skipper butterflies like common branded skipper (*Hesperia colorado*), Lindsey's skipper (*H. lindseyi*), sandhill skipper (*Polites sabuleti*), dogstar skipper (*P. sonora*), and woodland skipper (*Ochlodes sylvanoides*). Small checkered skipper (*Pyrgus scriptura*) is an alkali prairie specialist. Moths have many more prairie species, but few have common names. Exceptions are Clark's sphinx (*Proserpinus clarkiae*) and federally-listed as threatened Kern primrose sphinx (*Euproserpinus euterpe*). The genera *Adela*, *Annaphila*, and *Schinia* in particular have many moths associated with California prairie flowers.

OTHER PRAIRIE INVERTEBRATES

California's prairies have many non-insect invertebrates from vernal pool endemic crustaceans surviving only where protected from fish by surrounding prairie uplands, to relatively harmless stripe-tailed scorpions (*Paruroctonus silvestrii*), centipedes (*Scolopendra polymorpha*) longer than fence lizards (*Sceloporus occidentalis*), and large mygalomorph spiders like tarantulas (*Aphonopelma eutylenum* and *A. reversum*), trapdoor spiders (*Bothriocyrtum californicum* and *Actinoxia versicolor*), and sheet-web mygalomorphs (*Calisoga theveneti* and *C.*

longitarsis) that emerge to hunt from underground homes. These, like ground-nesting bee pollinators, only survive where prairie soils remain intact.

A FRONTIER FOR SCIENCE AND CONSERVATION

Internet searches now test the limits of knowledge but bring up almost nothing on California prairie/grassland insects/invertebrates. Insect ecosystems in Amazonian tree canopies are apparently examined more closely than those in our least known wild gardens. This may be the first article ever published on California prairie invertebrates and is written by a botanist, not a zoologist. Hopefully its undoubted imperfections will inspire others to do better.

REFERENCES

- Essig, E.O. 1958. *Insects and Mites of Western North America*. Macmillan Company, New York, NY.
- Hardwicke, K., and Heydon, S. 2009. *Molestan Blister Beetle*. Draft report for Yolo Natural Heritage Program, Woodland, CA.
- Hogue, C.L. 1993. *Insects of the Los Angeles Basin*. 2d ed. Natural History Museum of Los Angeles County, Los Angeles, CA.
- Powell, J., and C.L. Hogue. 1979. *California Insects*. University of California Press, Berkeley, CA.
- Powell, J., and P. Opler. 2009. *Moths of Western North America*. University of California Press, Berkeley, CA.
- Shanks, S. No date. *Lytta molesta*. Unpublished report for California Department of Fish and Game Natural Diversity Database.
- Shapiro, A., and T. Manolis. 2007. *Field Guide to Butterflies of the San Francisco Bay and Sacramento Valley Regions*. University of California Press, Berkeley, CA.

Glen Holstein, 714 Lake Terrace Circle, Davis, CA 95616, holstein@cal.net

NATIVE BEES AND FLOWERS IN CALIFORNIA PRAIRIES AND GRASSLANDS

by Robbin Thorp

“To make a prairie it takes a clover
and one bee,
One clover, and a bee.
And revery.
The revery alone will do,
If bees are few.”

—Emily Dickinson (1924)

One would hope to see more than one clover and one bee, and in many places one still may. We may never again see as many flowers and bees as John Muir (1894) eloquently describes in Chapter 16, “The Bee-Pastures,” in his book *The Mountains of California*:

When California was wild, it was one sweet bee-garden throughout its entire length, . . . The Great Central Plain of California, during the months of March, April, and May, was one smooth, continuous bed of honey-bloom, so marvelously rich that in walking from one end of it to the other, a distance of more than 400 miles, your foot would press about a hundred flowers at every step.

Embedded in many grasslands of the Central Valley are special ecosystems, vernal pools, renowned for their flower displays. The showy patches of flowers also provide food for many native bees whose females

specialize in collecting pollen for their offspring from particular vernal pool flowers, such as the mining bee (*Andrena blennospermatis*) that collects pollen from yellow carpet (*Blennosperma nanum*). Grasslands surrounding the pools are nesting habitats for mining bees. These bees provide an important ecological link with their pollination services between the uplands and the pool flora.

Goldfields (*Lasthenia* spp.) include early spring flowering species restricted to vernal pool ecosystems and some that occur in drier grassland areas. Most require insects to transfer their pollen. The diversity of visitors to most goldfield flowers includes specialist bees whose females collect pollen from one or a few closely related plants, generalist bees, and a variety of flies and beetles. Often several species of specialist mining bees may be found visiting the same goldfields at one location. However, not all flower visitors are effective pollinators, including some specialist bees.

Our state flower, the California poppy (*Eschscholzia californica*) provides no nectar, but only pollen as a reward to bees. Male bees rarely visit these flowers, except to find females or to spend the night within the closed corolla. Generalist bumble bees (*Bombus* spp.) and sweat bees

(*Halictus* spp.) are the main visitors, along with small pollen feeding beetles.

In late spring, gum plant (*Grindelia* spp.) attracts a diverse guild of native bees, mostly generalists, including male and female cuckoo bees. These bees have little or no hair, or their hair is scale-like and flattened on the body surface, so they are not well adapted to accumulating pollen. Females also lack any pollen transport structures, so they depend on pollen collecting host bees to provide a home and food for their young.

Let us hope and strive for protections and restorations of our prairies and grasslands so that we will have more than just one flower and one bee for our revery.

REFERENCES

- Dickinson, E. 1924. *The Complete Poems of Emily Dickinson*. Little, Brown, Boston, MA. www.bartleby.com/113/ (accessed March 28, 2012).
- Muir, J. 1894. *The Mountains of California*. The Century Company, New York, NY. http://www.yosemite.ca.us/john_muir_writings/the_mountains_of_california/ (accessed March 28, 2012).

Robbin W. Thorp, Department of Entomology, One Shields Avenue, University of California, Davis, CA 95616, rwtthorp@ucdavis.edu

LEFT TO RIGHT: Female mining bee (*Andrena blennospermatis*) that specializes in collecting pollen from yellow carpet (*Blennosperma nanum*), a California vernal pool endemic. Photograph by Dennis L. Briggs. • Worker bumble bee (*Bombus vosnesenskii*) foraging for pollen on California poppy (*Eschscholzia californica*). Generalist bees seek out a wide range of flower types. Photograph by Gary W. Zamzow. • Female sweat bee (*Halictus ligatus*) with its distinctive white bands, gathering pollen from gumplant (*Grindelia camporum*). Photograph by Kathy K. Garvey. • Male cuckoo bee (*Triepeolus* sp.) foraging for nectar on gumplant. Cuckoo bees do not gather pollen. Photograph by Kathy K. Garvey. • Soft-winged flower beetle (*Listrus* sp.), a pollen feeder, on California poppy (*Eschscholzia californica*). Photograph by Kathy K. Garvey.



RESTORING CALIFORNIA'S INLAND GRASSLANDS: DON'T FORGET THE FORBS!

by Paul A. Aigner, Kristin B. Hulvey, Catherine E. Koehler, and Leslie E. Scott

California's inland grasslands range from the foothills of the Sierra Nevada to the interior of the coast ranges, and extend almost all the way to the coast south of Santa Barbara. Also known as "valley grassland" or "valley/south coastal grassland" (Heady 1977; Keeler-Wolf et al. 2007), this herbaceous vegetation type is defined by its current dominance by non-native annual grasses and forbs. (By "forbs" we refer to all herbaceous taxa *not* in the Poaceae, the plant family that generally includes most species we think of as "grasses" and that includes cereal grains, but not rushes or sedges).

PREHISTORY

Examples of California's inland grasslands as they existed before European settlement reside almost exclusively in the collective imagination of native plant enthusiasts. No other vegetation type in California was so completely transformed before it could be studied by modern botanists, who have struggled to develop an archetype of this almost mythical plant community. While the earliest scientific speculation about the composition of grasslands before European arrival emphasized the dominance of native perennial bunchgrasses, scientific consensus has recently shifted to the view that annual and perennial forbs were dominant, with perennial grasses interspersed or occurring in patchy dense stands (Schiffman 2007).

Evidence for this view comes from the historical record, meager as it is, and from relict na-

tive-dominated grasslands, which are mostly restricted to unusual soil types across the state (Minnich 2008; Schiffman 2007). If there is one point of certainty, it is that prehistoric grasslands bore little resemblance to the golden hills of annual grasses native to Europe and Asia that dominate California's inland foothills and valleys today.

RESTORATION GOALS AND LIMITS

Restoration of grasslands to some semblance of their prehistoric state (preceding the arrival of Europeans) has been an expanding practice in California over the past two decades (Stromberg et al. 2007). The uncertainty surrounding the composition and structure of prehistoric grasslands guarantees that this endeavor will always be part art and part science, but even if a detailed descrip-

tion of these grasslands did exist and restoration ecologists had the necessary resources, meticulously reconstructing prehistoric grasslands on anything larger than a demonstration scale probably would have a high risk of failure.

For the reconstructed ecosystem to be self-sustaining (i.e., persistent without continual management intervention), land managers would need to reverse several centuries of environmental change including climate warming, increased atmospheric nitrogen deposition, the introduction of non-native species from around the world, the decline of prescribed fire as a management tool used by indigenous people, and the decline of animals such as grizzly bears, pronghorn, and elk that may have influenced grasslands through soil disturbance or grazing.

In practice, land managers typically define much more limited outcomes that will hopefully persist under current and anticipated conditions. The outcomes specified for a given project are based on best management practices as they are understood at the time, but also on the collective values and imaginations of the stakeholders involved. Commonly specified outcomes for restoration projects almost always include increasing the abundance of native species. However, they might also address grassland aesthetic appeal, provision of habitat for rare or endangered animal species, suppression of noxious weeds and enhancement of native plant diversity, community resistance to future invasion by non-native species, and provision of particular ecosystem services such

Prior to the influx of Eurasian annual grasses, California's inland grasslands were likely dominated by native forbs as illustrated by this display of royal larkspur (*Delphinium variegatum*), California goldfields (*Lasthenia californica*), bird's eye gilia (*Gilia tricolor*), slender cottonweed (*Micropus californicus*), and Indian clover (*Trifolium albopurpureum*) in a pristine serpentine grassland. Photograph by Catherine E. Koehler.



as water uptake, soil retention, pollination service, and carbon storage.

WHY INCLUDE FORBS?

Grassland restoration projects that involve active planting of native species have usually emphasized the establishment of perennial bunchgrasses over annual and perennial forbs (Stromberg et al. 2007). This bias is probably due to a number of reasons. One is the historically prevailing view that bunchgrasses were dominant in prehistoric grasslands. Another is the fact that a small complement of bunchgrass species is common throughout the state, which makes selection of species for a project manageable and commercial production of seed feasible. By contrast, there exist a greater number of grassland forbs, and many have restricted ranges, which complicates their use in restoration work. Also, bunchgrass populations are persistent once established, in contrast to annual forbs whose populations often fluctuate dramatically from year to year.

Still, many reasons exist to include forbs in grassland restoration projects, not the least of which is that forbs were likely a dominant component of many prehistoric grasslands. But even if accurate reconstruction of a prehistoric grassland assemblage is not a priority, including native forbs in grassland restoration projects can enhance many of the desired outcomes common to projects.

At the Donald and Sylvia McLaughlin Reserve, in the inner North Coast Range at the junction of Lake, Napa, and Yolo Counties, we have worked on numerous grassland restoration projects in diverse settings. We have found that increasing the cover and diversity of native forbs—either by actively planting them or by removing the invasive species with which they compete—has advanced our restoration goals. As one example, hayfield tarplant (*Hemizonia congesta*) was added to a native bunchgrass seed mix specifically to armor a restored grassland against reinvasion by yellow star thistle (*Centaurea solstitialis*, hereafter abbreviated “YST”). As a sec-

ond example, control of the invasive annual barbed goatgrass (*Aegilops triuncialis*, hereafter abbreviated “BGG”) resulted in a natural resurgence of native forbs and a corresponding increase in the activity of native bees.

STARTING CONDITION DETERMINES GOALS AND APPROACHES

The McLaughlin Reserve is a mosaic of soil types derived from serpentine (which we define broadly to include all ultramafic rocks high in iron and magnesium), volcanic, and sedimentary parent material. Serpentine soils are not tolerated by a broad range of non-native species (e.g., YST) that have invaded grasslands across the state. As a consequence, they support some of the best relict native-dominated grasslands in the region. Despite this, serpentine grasslands have not been immune to environmental change. Over the past three decades, BGG and Italian ryegrass (*Festuca perennis*) have spread rapidly into serpentine grasslands, and this process seems to be accelerated by nitrogen deposition from air pollution (Weiss 1999).

Prior to intensive management efforts that began at the reserve in 2008, these two serpentine tolerant invaders had formed dense stands in many of the reserve’s serpentine grasslands, although fortunately these grasslands still retained a high complement of native grasses and forbs. A typical serpentine grassland at the reserve includes more than 50 native forb species and 4 native grass species, all occurring within about half an acre. By contrast, grasslands on non-serpentine soils contain few to no native species, and are dominated by non-native annual grasses and forbs, particularly Italian ryegrass, wild oats (*Avena* spp.), bromes (*Bromus* spp.), medusa head (*Elymus caput-medusae*), YST, black mustard

ADVANTAGE OF USING FORBS IN RESTORATION

A grassland restoration project on Homestake Mining Company’s tailings impoundment at the McLaughlin Reserve. This project is typical of many grassland restoration projects in California in that so far it includes only grasses—in this case blue wildrye (*Elymus glaucus*), slender wheatgrass (*Elymus trachycaulus*), beardless wild rye (*Elymus triticoides*), and meadow



barley (*Hordeum brachyantherum*). Invasion by yellow star thistle (*Centaurea solstitialis*) and short podded mustard (*Hirschfeldia incana*) has been managed with broad-leaf herbicide applications, but adding native forbs such as hayfield tarplant (*Hemizonia congesta*) could provide resistance to weed invasion without herbicides. Photograph by Paul A. Aigner.

(*Brassica nigra*), vetch (*Vicia* spp.), and filaree (*Erodium* spp.).

We formulate goals for restoration in serpentine versus non-serpentine grasslands based on the difference in their condition. Given only limited damage in serpentine grasslands, preserving and restoring the apparently prehistoric condition is not only achievable, but exigent. By contrast, setting goals for non-serpentine grasslands is inevitably a more complex task. Because non-serpentine grasslands usually lack any significant native seed bank, restoring them almost always requires the reseeding of native species. In cases where residual native species cover is present, we can work to preserve this, managing invasive species and seeding additional natives.

More often than not, we find virtually no residual native plant community and must adopt a “blank slate” approach. This involves obliterating the existing community to the greatest extent possible (including the seed bank) and installing a native-dominated community from scratch. Much of our grassland restoration has occurred in partnership with Homestake Mining Company of California, which mined more than 3.5 million ounces of gold from the site between 1985 and 2002 and removed more than 1,000 acres of native vegetation in the process. Areas reclaimed after mining necessarily require the blank slate approach.

FORBS REDUCE INVASION

Our restoration work with Homestake initially took a traditional approach that emphasized the establishment of native bunchgrasses. Following the earthmoving that is employed to return soil to a disturbed site or to cover mine spoils, we applied a seed mix of up to seven native grass species. Invasion by YST has been the greatest impediment to successful grass establishment, and annual applications of a broad leaf herbicide have been necessary to

USING FORBS TO COMPETE WITH INVASIVE PLANTS

Hayfield tarplant (*Hemizonia congesta*) has a similar ecological niche to the invasive yellow star thistle. Both germinate early and spend the winter and spring developing a deep taproot so they can access deep soil moisture necessary for flowering and setting fruit in the summer. When included in grassland restoration projects, hayfield tarplant competes with yellow star thistle and reduces its ability to establish. Photograph by Catherine E. Koehler.



keep YST at bay. While herbicides are effective at controlling YST, an ecosystem that depends on regular herbicide application does not meet our definition of *self-sustaining*.

A promising technique for providing natural invasion resistance to restored grasslands is to select native species for planting that compete strongly for the same resources as likely invaders (Young et al. 2009). Native tarplants are among the grassland species most similar to YST in the timing of growth and seed set. These late-season annual forbs germinate with the first fall rains and spend the winter and spring developing a tap root. Doing so allows them to take advantage of deep soil moisture in the summer and to flower and set seed long after the majority of annuals have completed their life cycle.

Starting in 2008, we tested whether including the hayfield tarplant in a seed mix with native perennial grasses increased the resistance of the resulting community to YST invasion compared to seeding grasses alone. Over three years, tarplant abundance remained high in plots where it was seeded, and YST abundance was 18% to 63% lower compared to plots with native grass alone. Adding hayfield tarplant to the restoration seed mix also reduced the abundance of other native, late season forbs such as yellow

tarplant (*Holocarpha virgata*) and dove weed (*Croton setigerus*) that naturally colonized the experimental plots. This suggests that YST, tarplants, and other late season forbs form a guild of strongly interacting species. It also suggests that we might more effectively exclude YST if we plant a diversity of native late season forbs, each of which competes for resources with YST in slightly different ways.

FORBS INCREASE POLLINATORS

Competition for essential plant resources such as nutrients, water, and light seems to play less of a role in serpentine grasslands compared to their non-serpentine counterparts. Preliminary results from our research suggest that the non-native invasive BGG is a poor competitor, but is extremely tolerant of harsh conditions such as those found on serpentine. In grasslands with productive non-serpentine soils, BGG probably requires a disturbance that reduces competition in order to invade, but in low-productivity serpentine soils BGG can readily invade an undisturbed native-dominated grassland. We are therefore unlikely to prevent BGG from invading serpentine grasslands simply by seeding functionally similar native species.

FORBS RECOVER IN SERPENTINE GRASSLANDS WITHOUT SEEDING

At the McLaughlin Reserve, an island of barbed goatgrass (*Aegilops triuncialis*) marked by stakes is left for research in a serpentine meadow that has been restored through prescribed burning and applications of grass-specific herbicide. Barbed goatgrass seems to be one invasive weed that is not likely to be eliminated by reseeding with functionally similar native species. After removal of the invasive barbed goatgrass, serpentine grasslands return to dominance by native forbs, including many that are widespread in California—in this case mountain dandelion (*Agoseris heterophylla*) and California goldfields (*Lasthenia californica*). Photograph by Paul A. Aigner.



Nevertheless we have been successful at selectively eradicating BGG and Italian ryegrass from serpentine grasslands by using a combination of prescribed fire, grass-specific herbicides, and mowing (Aigner and Woerly 2011). These treatments seem to result in the recovery of the full complement of native forbs and grasses with no need for active seeding. The resurgence of native forbs represents a tremendous food resource for pollinators, and in the spring of 2011 we compared pollinator activity between serpentine grassland plots where BGG had been eradicated and control plots that

were infested with BGG. Native bee abundance was more than four times higher in plots where BGG had been eradicated.

CONCLUSION

These examples of grassland restoration at the McLaughlin Reserve demonstrate that forbs play multiple vital roles in grassland ecosystems. Faced with an increasing pace of global environmental change, restoration ecologists are realizing that it is increasingly difficult to reconstruct historical species assemblages, and that species for restoration should be selected to meet restoration goals under current and future conditions. Selectively including native forbs can enhance the functionality of restored grasslands and make these grasslands more resistant to invasion and resilient to environmental change. Just as importantly, including forbs can add a small reminder of the mythic beauty of California's vast prehistoric inland grasslands.

REFERENCES

Aigner, P.A., and R.J. Woerly. 2011. Herbicides and mowing to control

barb goatgrass (*Aegilops triuncialis*) and restore native plants in serpentine grasslands. *Invasive Plant Science and Management* 4: 448-457.

Heady, H.F. 1977. Valley grassland. In *Terrestrial Vegetation of California*, ed. M.G. Barbour and J. Major. California Native Plant Society, Sacramento, CA.

Keeler-Wolf, T., et al. 2007. Community classification and nomenclature. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.

Minnich, R.A. 2008. *California's Fading Wildflowers: Lost Legacy and Biological Invasions*. University of California Press, Berkeley, CA.

Schiffman, P.M. 2007. Pleistocene and pre-European grassland ecosystems: species composition at the time of first European settlement. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.

Stromberg, M.R., et al. 2007. California grassland restoration. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.

Weiss, S.B. 1999. Cars, cows, and checkerspot butterflies: nitrogen deposition and management of nutrient-poor grasslands for a threatened species. *Conservation Biology* 13: 1476-1486.

Young, S.L., et al. 2009. Functionally similar species confer greater resistance to invasion: implications for grassland restoration. *Restoration Ecology* 17: 884-892.



Native pollinators, such as this sweat bee (*Lasioglossum titusi*) collecting pollen from mountain dandelion, are four times more abundant in restored serpentine grasslands compared to those infested with barbed goatgrass. Photograph by Paul A. Aigner.

Paul A. Aigner, 26775 Morgan Valley Rd., Lower Lake, CA 95457, paaigner@ucdavis.edu; Kristin B. Hulvey, School of Plant Biology, University of Western Australia, 35 Stirling Highway, Crawley WA 6009, Australia, khulvey@gmail.com; Catherine E. Koehler, 26775 Morgan Valley Rd., Lower Lake, CA 95457, koehler@ucdavis.edu; Leslie E. Scott, 26775 Morgan Valley Rd., Lower Lake, CA 95457, lescott@ucdavis.edu

THE CNPS GRASSLAND INITIATIVE: DOCUMENTING GRASSLAND TYPES ACROSS CALIFORNIA

by Jennifer Buck-Diaz and Julie Evens

What makes a great flower year? We know that it has to do with climate, particularly rainfall and temperature, and we know that timing is everything. In some years, wildflower abundance abounds in California's grasslands, with swaths of color painting the Great Valley floor, surrounding foothills, and warm deserts. Then again, there are years like 2012, when a dry winter delays or even inhibits germination of many annual plant species.

A primary goal of the California Native Plant Society's "Grassland Initiative" is to gain a more complete picture of the variation of grasslands across the state. With better knowledge of the diversity and extent of grassland types, we can work towards comprehensive conservation of both rare and common annual-dominated plant habitats in California.

The CNPS Vegetation Program uses standardized protocols to survey and classify vegetation in California. More than 30 new herbaceous alliances have been recently described in the second edition of *A Manual of California Vegetation* (Sawyer et al. 2009), including showy annual types such as white-tip clover swales (*Trifolium variegatum* Alliance) and popcorn flower fields (*Plagiobothrys nothofulvus* Alliance). However, many grassland habitats remain unsampled, undescribed, and overlooked.

NEW VEGETATION ASSESSMENTS

Recent funding through private donations, Bureau of Land Management, California Department of Fish

and Game, Natural Resources Conservation Service, and The Nature Conservancy has allowed CNPS staff to collect additional field surveys in under-sampled areas of the state. We prioritized surveys in the San Joaquin Valley, the neighboring Carrizo Plain, and the base of the Tehachapi Mountains to fill in gaps of knowledge about grassland types.

CNPS staff collected more than 400 new herbaceous surveys across 2010–2011, with an additional 100 surveys planned for 2012. We have also compiled approximately 1,000 surveys from previous projects and through collaborating researchers. Across the first two years of sampling, we observed an amazing array

of native perennial and native annual vegetation types in grasslands. Perennial types include slopes densely studded with nodding needle grass (*Stipa cernua*), hill pockets dominated by California brome (*Bromus carinatus*), and vast landscapes of curly blue grass (*Poa secunda*). Native annual types include alkali flats characterized by tar plant (*Centromadia pungens*), small ephemeral stream terraces prickling with thistle sage (*Salvia carduacea*), and brilliantly golden slopes of common monolopia (*Monolopia lanceolata*).

We are currently analyzing both new and pre-existing grassland data to develop a comprehensive classification of grassland vegetation in



A milky way of popcorn flower fields (*Plagiobothrys nothofulvus*), sky lupine (*Lupinus nanus*) and owl's clover (*Castilleja exserta*) on the Tejon Ranch. All photographs by Jennifer Buck-Diaz except where noted.



TOP: The Temblor Range of the Carrizo Plain National Monument aflame with patches of common monolopia (*Monolopia lanceolata*) and other forbs. • BOTTOM: A vast landscape of grassland habitat is protected at the base of the Tehachapi Mountains on the Windwolves Preserve, owned and managed by The Wildlands Conservancy. New surveys from this and other sites are contributing to our knowledge of annual and perennial grassland habitats. Photograph by Rebecca Crowe.

California. However, the classification of *annual* vegetation can be complex and requires analysis beyond just the dominance or abundance of one species. Some annual grassland communities in our state consist of short-lived plants that germinate and grow quickly with cool fall/winter

rains, then bloom and set seed before the summer dryness of our Mediterranean climate. A vast seed bank in the soil offers a buffer to the system from year-to-year variation in precipitation.

In these annual systems, it is essential to pay attention to *indicator*

species because they show a preference for certain environmental settings and form particular assemblages of plants. We look closely at these species because they specialize in a particular habitat; thus, they are a better ecological indicator of that environment than a habitat generalist. Indicator species may or may not be abundant in an area or even have the highest relative percent cover in the grassland. An indicator may be inconspicuous such as dwarf plantain (*Plantago erecta*) which is correlated with specific habitat types, or it may be a large, showy plant such as thistle sage (*Salvia carduacea*) which tends to be restricted to flats, terraces, and sandy washes.

A focus on indicator species strengthens the classification of annual types by honing in on the plants that are indicative of a site, and deemphasizing generalist species that cross many different habitats and don't reflect the local or regional conditions. We use statistical analysis tools such as Cluster Analysis and Indicator Species Analysis to determine rigorous groups of species (communities) and the species that are unique to these groups. As a result, we are expanding the definition of grassland types to include native forbs as important, and some-

New vegetation types recently described by CNPS staff include stands dominated by Great Valley phacelia (*Phacelia ciliata*, purple) and common monolopia (*Monolopia lanceolata*, yellow). Slope, aspect, soils, and other environmental variables contribute to the patterns of annual vegetation.





Photographs taken at the same site can augment repeat surveys and allow a visual documentation of annual variation in grasslands. The left photo column shows stands from 2010 and the right column from 2011. The top row is a flat, open plain dominated by needle goldfields (*Lasthenia gracilis*) one year, and annual grasses the next. The bottom row is a hill slope dominated by common monolopia (*Monolopia lanceolata*) in both years, though with less cover in 2011.

times dominant, plants of the community.

For example, in the vegetation type named California Goldfields–Dwarf Plantain–Six-Weeks Fescue Flower Fields (*Lasthenia californica*–*Plantago erecta*–*Vulpia microstachys* Alliance), either one or a combination of these three indicator species is characteristically present. A variety of other native and non-native forbs and grasses can co-occur with these species and may even dominate the herbaceous layer. The presence of one or all three of the diagnostic species within this alliance indicates a particular habitat that is often composed of infertile soils such as serpentine or aged clays. While we still don't have a complete picture of all the associations (variations in types) that fit within this

alliance, we are improving our understanding of this habitat from surveys and analysis over the past few years (Buck-Diaz and Evens 2011, Buck-Diaz et al. 2012).

One exciting result of our recent data collection and analysis is the definition of 16 new herbaceous alliances, including 5 new annual grassland types such as annual sunflower fields (*Helianthus annuus* Alliance) and virgate tarplant flower fields (*Holocarpha virgata* Alliance), and perennial grassland types such as wild buckwheat patches (*Eriogonum [elongatum, nudum]* Alliance). We also describe more than 50 new associations, of which greater than half are annual types. The distinctions between perennial and annual grassland are partially defined by indicator species such as curly blue grass

(*Poa secunda*), nodding needlegrass (*Stipa cernua*), or purple needlegrass (*S. pulchra*). They are also defined through classification analyses which set meaningful thresholds between the percent cover of perennial versus annual species. These thresholds are based on the analysis of survey data. For example, deer grass (*Muhlenbergia rigens*) has greater than 5% absolute cover while non-native grasses and forbs intermix with variable cover.

SEASONAL AND ANNUAL COMPARISONS

When classifying annual vegetation types, it is also important to use characteristic species that have *temporal persistence*, i.e., a measure of

how often a species is detected over time. If you were to visit the same plot every spring over many years, which species will most likely be present no matter what the pattern of rainfall or temperature? In order to have a robust and stable classification, it will be necessary to define annual vegetation types using species that are persistent over time.

We are beginning to revisit a number of plots over a three-year period (2010–2012) to capture both the seasonal and the annual variation in grassland vegetation. We are fortunate that the climate has varied significantly over this time frame, with precipitation levels ranging from wet (7–10 inches in the San Joaquin Valley) to dry (approximately 3 inches). Though not all data collection and analysis is complete, it is apparent that some species have a higher persistence over time than others.

Preliminary conclusions of seasonal sampling show that sampling in both the spring and summer captures a more complete picture of native forb diversity, species composition, and cover. Summer surveys alone tend to over-emphasize non-

native grasses and overlook the presence of ephemeral natives. Also, in extreme drought years it may not be possible to recognize some indicators of annual types due to a complete lack of germination within plots.

These results highlight the importance of timing when sampling annual stands. If only one site visit is to be completed for an area, then the survey should be well-timed in the spring to fully represent the cover, composition, and overall significance of native plants. The classification of annual vegetation types will be refined through additional sampling across and between years in an attempt to utilize persistent and characteristic species.

Despite some of the amazing photographs in this issue of *Fremontia*, there is no denying that many grasslands in California are heavily impacted by non-native plant species. A *semi-natural* stand is the term used for habitats where exotic species make up the majority (often greater than 90%) of the relative percent cover of plants and where the species richness (a count of the number of species) is quite low. Many

non-native grassland species are generalists, meaning they thrive across multiple habitats and variable conditions, thus semi-natural stands are described differently than most native vegetation alliances.

Our current objective is to establish baseline knowledge about natural grasslands and semi-natural stands in California. Future actions under the CNPS Grassland Initiative will involve investigating the impacts of non-native plants and rangeland practices, such as grazing with sheep or cattle, that may be used to manage invasive plants. We hope to collaborate with partners to conserve and restore a representation of California grasslands, and we will work towards educating landowners and the public about the values of these under-appreciated habitats.

REFERENCES

- Buck-Diaz, J., and J.M. Evens. 2011. Carrizo Plain National Monument Vegetation Classification and Mapping Project. Draft report prepared for the Bureau of Land Management. California Native Plant Society, Sacramento, CA.
- Buck-Diaz, J., S. Batiuk, and J.M. Evens. 2012. Vegetation alliances and associations of the Great Valley Ecoregion, California. California Native Plant Society, Sacramento. Final report to the Geographical Information Center, Chico State University.
- Dufrene, M., and P. Legendere. 1997. Species assemblages and indicator species: The need for a flexible asymmetrical approach. *Ecological Monographs* 67(3): 345–366. Great Valley Ecoregion, California. Report prepared for the Geographical Information Center at California State University, Chico. California Native Plant Society, Sacramento, CA.
- Sawyer, J.O., T. Keeler-Wolf, and J.M. Evens. 2009. *A Manual of California Vegetation*. California Native Plant Society, Sacramento, CA.



Tidy-tips (*Layia munzii*) dominate the lower Carrizo Plain while common monolopia (*Monolopia lanceolata*) adorns the slopes of the Temblor Range.

Jennifer Buck-Diaz, 2707 K Street, Suite 1, Sacramento, CA 95816, jbuck@cnps.org; Julie M. Evens, 2707 K Street, Suite 1, Sacramento, CA 95816, jevans@cnps.org



Cattle grazing is used to control invasive species and reduce fire fuel loads at Mission Peak Regional Preserve in Fremont managed by the East Bay Regional Parks District. Photograph courtesy of Sheila Barry, University of California Cooperative Extension.

CONSERVING AND MANAGING PRAIRIE, GRASSLAND, AND VERNAL POOL LANDSCAPES THROUGH COLLABORATION

by Pelayo Alvarez

About 250 years ago the Spaniards arrived in California in an event that forever changed landscapes in the state. They brought with them things from the old world that were important for their survival, including livestock and a long list of plant species that thrived in California's Mediterranean climate. Some of those non-native species provide the basis for what is now a vibrant agricultural multibillion dollar industry.

Other plant species, such as yellow star thistle, were accidentally introduced and became invasive, wreaking havoc in both natural and agricultural systems, reducing production, fragmenting habitats, and altering competitive interactions among plant species and other im-

portant ecosystem processes. The scale and rapidity of the vegetation conversion was unprecedented and brought about additional management challenges to the already complex system that comprises California grasslands. Today only one percent of remaining grasslands are native. Despite that catastrophic vegetation conversion, California grasslands remain one of the most biodiverse systems in the world.

ECOLOGICAL VALUE OF GRASSLANDS

There are over 11 million acres of grasslands within and encircling the Central Valley and the interior Coast Range, many of which are

privately owned and managed as rangelands for livestock production. Grasslands in California provide multiple ecosystem services—the benefits that human societies obtain from nature—including wildlife habitat, watershed protection, open space, and climate change mitigation.

California grasslands support a wide variety of wildlife species including freshwater fish, birds, invertebrates, and mammals (Hunting 2003). There are 75 species associated with California grasslands, including 10 vertebrates, 14 invertebrates, and 51 plants that are listed as threatened or endangered under the Endangered Species Act (Jantz et al. 2007).

California valley grasslands arguably provide the most important



In serpentine soils, grazed sites (right) provided better habitat for the endangered Bay Checkerspot butterfly than ungrazed ones (left). Photograph courtesy of Dr. Stuart Weiss, Creekside Center for Earth Observation.

wintering habitat for raptors in North America (Pandolfino 2006). California Bird Species of Special Concern (Shuford and Gardali 2008) which use these habitats extensively include Mountain Plover, Burrowing Owl, Loggerhead Shrike, Grasshopper Sparrow, and Tricolored Blackbird.

Grasslands also provide impor-

ception among land managers and the conservation community regarding grazing and other ranching activities was very negative. Land managers in California quickly removed grazing from land that was historically grazed in an attempt to restore it to a natural state. After a few years and in the absence of disturbance,

tant habitat for pollinators that are essential for pollinating California's agricultural crops. The value of pollinator services from wild pollinators to California agriculture has been estimated at between \$937 million and \$2.4 billion per year (Chaplin-Kramer et al. 2011).

Despite their ecological value, California grasslands do not enjoy the same protection that other areas do. In the 1980s and 1990s the per-

the non-native annual grasses and other invasive plant species created an impenetrable thatch that further suppressed native plants. However, a few forward thinking land managers began rethinking the previously held views on the role of grazing when they saw that, on a number of private ranches, the wildflowers were still thriving in upland areas and vernal pools.

A NEW PERSPECTIVE ON GRAZING

The concept that grazing could be beneficial in the management of California grasslands was not news to the California Native Plant Society. An article in the January 1992 issue of *Fremontia* describes how grazing could be used to favor native bunch grasses (Edwards 1992). But it was not until years later that research done in California started to provide scientific evidence that

Cattle grazing vernal pools at North Table Mountain Ecological Preserve, managed by the California Department of Fish and Game. Photograph by Tracy Schohr.



properly managed grazing could be an important tool for increasing the conservation value of grasslands and associated habitats in California.

Research conducted by Jaymee Marty, an ecologist with the Nature Conservancy, and collaborators suggested that cattle grazing could be an essential management tool in maintaining biodiversity in vernal pool ecosystems (Marty 2005). Cattle consume the more palatable non-native annual grasses that invade vernal pools, allowing native plants and the species that depend on them to thrive. In addition, by reducing evapotranspiration from the non-native annual grasses, cattle grazing increases the inundation period of the pools by as much as 50 days. This allows vernal pool endemic invertebrate species to complete their life cycle (Pyke and Marty 2005).

Similar beneficial effects of grazing have been found on serpentine sites south of San Francisco Bay (Weiss 1999). These sites support many rare plant and wildlife species, including the endangered Bay checkerspot butterfly. Studies conducted by Dr. Stuart Weiss, chief scientist at the Creekside Center for Earth Observation, showed beneficial effects of grazing on butterfly habitat in south San Jose where non-native annual grasses were outcompeting the dwarf plattain, a plant that the checkerspot butterfly caterpillar feeds on. In this ecosystem, cattle selectively graze the non-native grasses over the native forbs, favoring the dwarf plattain and allowing the butterfly to thrive (Weiss 1999).

More recent research published

in the December issue of the *Journal of Wildlife Management* (Germano et al. 2011) summarizes ten years of data on the effects of grazing and invasive grasses on desert vertebrates in California. The study concluded that grazing can be used to control exotic non-native grasses and be beneficial to vertebrate species that rely on open habitats, such as the blunt-nosed leopard lizards, giant kangaroo rats, short-nosed kangaroo rats, and San Joaquin antelope squirrels, among others.

Today grazing is recognized as a cost-effective and natural tool for managing vegetation and enhancing wildlife habitat and other ecosystem services. It is also a tool that is being used by several land management agencies in California that rely on local ranchers to be able to meet their conservation goals.

Other activities associated with

ranching are also beneficial from a conservation standpoint. Ranch stock ponds play an increasingly important role in providing habitat for amphibians. In the Bay Area, stock ponds on ranchlands provide up to 50% of the remaining habitat for the threatened California tiger salamander (United States Fish and Wildlife Service 2006).

Other ecosystem services from rangelands are increasingly being recognized, including open space, watershed protection, and climate change mitigation and cultural services. Among the cultural values we should recognize are recreation, open space, and the knowledge ranchers have accumulated over generations on how to manage these lands.

Although views on the ecological importance of

grasslands and the role of ranching are gradually changing, ranchers still face numerous challenges to stay in business. Profit margins are extremely low, making conversion to other uses (vineyards, orchards) a tempting proposition to ranchers that are land rich and cash poor. Younger generations may not be interested in ranching, and land prices make it difficult for them to start their own operations. Little by little the infrastructure that once supported ranching has slowly been dismantled, making ranching in some areas a marginal activity.

A recent rangeland vulnerability assessment by the Nature Conservancy found that every year 20,000 acres of rangeland in California are converted to intensive agriculture and urbanization (Nature Conservancy, unpublished data). The loss and fragmentation of these habitats



Dark blue shows rangelands of highest conservation value and level of threat of conversion. Source: California Rangeland Conservation Coalition, 2007.

CALIFORNIA RANGELAND TRUST

California Rangeland Trust formed following a round table discussion among innovative ranchers who understood the need for a land trust dedicated to preserving not only the land, but also the stewardship and the iconic California ranching heritage that the ranchers provide. Since its founding in 1998, the Rangeland Trust has grown substantially, and to-date has protected in perpetuity over 250,000 acres of rangeland.

Rangeland Trust works to preserve grasslands through voluntary conservation easements. A conservation easement can be purchased or donated, and is an agreement between the landowner and the land trust that the land will remain as is, undeveloped forever. Funding is applied from state and federal programs, and more often these days comes from private foundations and individuals who believe that the Rangeland Trust is protecting both the heritage and the future of ranching in California. Currently, the Rangeland Trust has 120 families on its waiting list that hold nearly 500,000 combined acres of grassland.

In California, there are 34.1 million acres of grassland that provide sanctuary and habitat for the state's diverse wildlife and plant species. Of those, 22 million acres are privately owned, and all are cared for and stewarded by California ranchers.

Through the use of rotational grazing and land management practices by ranchers, rangelands provide habitat and homes for 95% of the state's endangered and threatened species. Grazing and grasslands are also key factors in the spectacular wildflowers that bloom in the spring. Many of the native flowers would be overtaken by invasive species without the use of grazing as a natural management tool.

Urban development and sprawl are major challenges for California's open spaces, and they will continue to put pressure on grasslands and the resources they provide, including clean air, clean wa-

ter, and species habitat. Between 1984 and 2006 over 400,000 acres of California grasslands—the equivalent of more than 303,000 football fields—were lost to development. With the California population still on the rise, development pressures will continue to be relentless.

Conservation easements held by land trusts are an extremely viable alternative to combat the pressures of development. Through conservation easements, ranchers can receive tax benefits and funding to ensure the future of their ranches. Many ranchers use conservation easements to ensure that the ranch stays in the family and remains economically viable. Estate taxes often leave heirs with significant debt and few options to pay the inheritance tax. At times the family is forced to subdivide and sell the ranch for development. However, a conservation easement provides a way to pay inheritance taxes and takes development options out of the equation, lowering both land taxes and the estate taxes.

The hard work and long hours put forth by land trusts in California are key in preserving the state's open spaces and resources. Conservation easements provide rangelands a preferred advantage over development options. However, with the economic downturn and state budget cuts, funds to preserve rangelands are shrinking. As funds become scarcer, land trusts like Rangeland Trust will be relying more heavily on donations from those who believe in their mission.

For the foreseeable future, ranchers and the Rangeland Trust will be facing some tough challenges. However, numerous opportunities still exist to preserve grasslands and the resources they provide for future generations of Californians. The fact that the Rangeland Trust has a half-million acres waiting to be protected through conservation easements is a hopeful sign.

—Sahara Saude

reduces their ability to provide ecosystem services and erodes the socioeconomic framework of rural communities.

The accumulation of scientific evidence on the use of grazing as a management tool and concerns over grassland conversion has created an unprecedented alliance. The US Fish and Wildlife Service took the

lead in bringing together ranchers, environmentalists, and regulatory and non-regulatory agencies, after repeatedly hearing from the environmental community about the loss of grassland habitats and species, and from the ranching community about the impact that regulations were having on their ability to stay in business.

BIRTH OF THE RANGELAND COALITION

A barbeque in Sunol, CA provided the backdrop for the first meeting of a group of 12 organizations who had the courage and vision to set aside their differences and focus on potential solutions to protect California rangelands. Among them

were representatives from the California Native Plant Society. “We did not know if we were going to a barbecue or to be barbecued,” said Carol Witham, “but it was clear that there was some common ground to work with.”

The new coalition was called the California Rangeland Conservation Coalition,¹ and founding organizations crafted a document, the Rangeland Resolution, that outlines the principles by which Coalition signatories work together. A focus map was created (see page 51) that prioritized area in the Central Valley and inner Coast Ranges where important species and habitats needed to be protected. It included 500 rare plant species in grasslands, blue oak woodlands, and vernal pool habitats.

Today the Coalition has grown to more than 100 organizations, including government agencies, researchers, environmental organizations, and others who work together to protect and enhance the economic and ecological values of grasslands in the Central Valley of California. Overall the Coalition tries to promote collaboration and improve communications among all the people and organizations who have an interest in these areas.

Science was essential in breaking the barriers between the various Coalition partners, and that made possible the creation of this broad umbrella organization. Science remains central to its ongoing work, which promotes multidisciplinary scientific collaborations and facilitates interactions between the research community, ranchers, and land managers.

Outreach efforts are focused on raising awareness of the importance

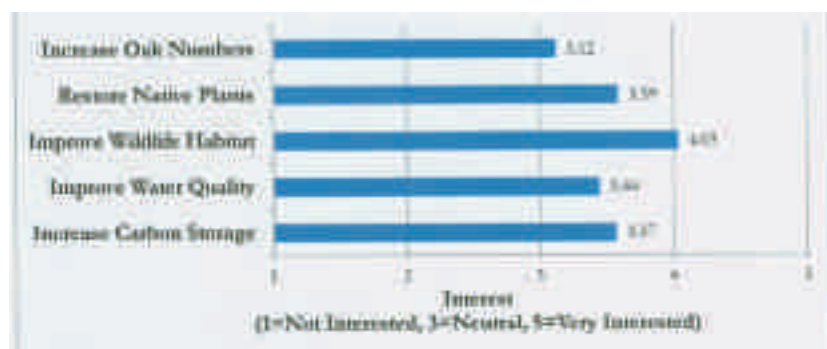
of California grasslands and the need to work with private landowners for their protection. The Coalition organizes a yearly conference, maintains a website (<http://www.carangeland.org>), and hosts several field trips, workshops, and presentations on a variety of topics such as grassland ecology and management, existing conservation programs available to ranchers, and emerging markets for ecosystem services such as car-

dinate permits for conservation projects on private lands, and improve communications with the ranching community.

RECOGNIZING SHARED VALUES

Defenders of Wildlife, a national environmental organization with a strong California presence, early on

FIGURE 2. RANCHER INTEREST IN SELECTED ECOSYSTEM SERVICE RELATED ACTIVITIES.



Ranchers in the Central Valley were asked to rate their interest in providing ecosystem services (Cheatum et al. 2011). Respondents expressed an interest in “improving wildlife habitat” and “restoring native plants.”

bon sequestration and water quality markets.

In the policy arena, the Coalition supports public policies that maintain essential infrastructure and technical capacities of government agencies, and at the same time improve the business and regulatory environment for ranchers. For instance, it supports policy tools that are important to ranchers such as the Williamson Act—which provides tax incentives to agricultural producers in California—and the estate tax.

It also seeks common ground among its signatories to increase funding for grassland conservation in California. In addition, the Coalition works to promote collaboration among several government agencies in order to increase awareness of the ecological importance of privately owned grasslands, coor-

became one of the most active members of the Coalition. “We realized that we needed to work with ranchers in order to be successful at protecting the native species and habitats that are important to our mission,” explained Kim Delfino, director of the California Office of Defenders of Wildlife. “It’s not always easy for an environmental group to partner with ranchers. Sometimes we have mistrust and preconceived ideas, but after talking with these folks, I’ve come to realize that we share a love of the landscape.”

Today Defenders of Wildlife, in collaboration with other Coalition signatories, conducts research on identifying and quantifying the public benefits of protecting California grasslands. A recent survey of ranchers in the Central Valley showed that ranchers are indeed interested in protecting ecosystem ser-

¹ The California Rangeland Conservation Coalition is an alliance of environmental organizations, government agencies, and the ranching community whose mission is to bring together ranchers, environmentalists, and government entities to conserve and enhance the ecological values and economic viability of California’s working rangelands.



In the absence of disturbance such as grazing, invasive plant species dominate vernal pools, thus reducing biodiversity. Photograph courtesy of Dr. Jaymee Marty, The Nature Conservancy.

vices such as wildlife habitat and water quality, and increasing native species (see Figure 2), provided that there are incentives available. Relying on the ranchers' desire to become more involved in conservation, Defenders is now working on the development of payments for ecosystem services programs that will give ranchers the opportunity to stay on the land while providing all the environmental benefits that California grasslands produce.

Other environmental organizations have also come to recognize the importance of California grasslands and are now working with the ranching community. By providing incentives that keep ranchers on the land, we will be better able to protect grasslands and their species.

California grasslands and coastal prairies produce many benefits to

Californians. The protection of California's prairies and grasslands requires complex solutions and is integrally linked to the ability of ranchers to continue being good stewards of the land. Fostering collaborations that cross boundaries and engage private landowners, this broad coalition is working towards the protection of these beautiful landscapes. Constantly threatened by the worst in human nature, California grasslands might very well be saved by the best of it.

REFERENCES

- Chaplin-Kramer, R., K. Tuxen-Bettman, and C. Kremen. 2011. Value of wildland habitat for supplying pollination services to Californian agriculture. *Rangelands* 33(3): 33-41.
- Cheatum, M., et al. 2011. A California rancher survey on ecosystem services. *Conservation Economics*

- White Paper. Conservation Economics and Finance Program. Defenders of Wildlife, Washington, DC.
- Edwards S.W. 1992. Observations on the prehistory and ecology of grazing in California. *Fremontia* 20: 3-11.
- Germano, D.J., G.B. Rathbun, and L.R. Saslaw. 2011. Effects of grazing and invasive grasses on desert vertebrates in California. *Journal of Wildlife Management* 75: 1-13.
- Hunting, K. 2003. Central Valley grassland habitat. In *Atlas of the Biodiversity of California*. California Department Fish and Game, Sacramento, CA.
- Jantz, P.A., et al. 2007. Regulatory protection and conservation. In *California Grasslands: Ecology and Management*, ed. M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio. University of California Press, Berkeley, CA.
- Marty, J.T. 2005. Effects of cattle grazing on diversity in ephemeral wetlands. *Conservation Biology* 19: 1626-1632.
- Pandolfino, E. 2006. Christmas bird counts reveal wintering bird status and trends in California's Central Valley. *Central Valley Bird Club Bulletin* 9(4): 21-36.
- Pyke, C.R., and J. Marty. 2005. Cattle grazing mediates climate change impacts on ephemeral wetlands. *Conservation Biology* 19(5): 1619-1625.
- Shuford, W.D. and T. Gardali. 2008. *California Bird Species of Special Concern*. Studies of Western Birds No. 1. Western Field Ornithologists and California Department of Fish and Game, Camarillo, CA and Sacramento, CA.
- US Fish and Wildlife Service. 2006. Designation of critical habitat for the California red-legged frog, and special rule exemption associated with final listing for existing routine ranching activities, final rule. http://ecos.fws.gov/docs/federal_register/fr5071.pdf.
- Weiss, S. 1999. Cars, cows, and checkerspot butterflies: Nitrogen deposition and management of nutrient-poor grasslands for a threatened species. *Conservation Biology* 13: 1476-1486.
- Pelayo Alvarez, 1303 J Street, Suite 270, Sacramento, CA 95814, pelayo@carangeland.org

NEW CNPS FELLOW: DIRK WALTERS

by David Chipping

In the fall of 1969, Dirk Walters arrived at the California Polytechnic State University campus in San Luis Obispo, having just graduated from Indiana University with a doctorate in systematic botany. He was replacing the ailing Dr. Robert Hoover, professor of botany. Dr. Hoover, who helped found the San Luis Obispo Chapter of CNPS in 1966, of course insisted that this Indiana flatlander join CNPS at once and learn the local flora.

Dirk became enchanted by California's vegetation and soon was a very active member of the local CNPS chapter. He first became chapter president in 1972, and since then has served on the chapter board in numerous capacities including president, vice-president, recording secretary, and currently as chapter historian. He also served on the state CNPS Board of Directors between 1999 and 2001.

From 1969 until his retirement in 2004, Dirk was a professor of botany in the biology department at Cal Poly. He continued to teach on a limited basis until 2009. Among his academic publications is the textbook *Vascular Plant Taxonomy*, which he coauthored with Dr. David Keil. In blending his teaching position at Cal Poly with the interests of CNPS, Dirk arranged for the Cal Poly biology department to host our chapter meetings on campus for many years. He also encouraged students at Cal Poly to become interested in native plants and join chapter field trips.

Dirk's first love was teaching, and he enjoyed taking students and CNPS members on field trips into the back country. Always stopping to give detailed descriptions and anecdotes about each plant and its ecological relationships, his infinite patience and good humor made any

Walters field trip a "must." He still leads field trips for the chapter, including the annual Shell Creek excursion. For many years he would end the spring with an overnight "President's Trip" beyond the chapter's borders. As chapter board member Mardi Niles notes:

In planning field trips, Dirk could always be counted on to lead a trip that was professional, interesting, and a lot of fun too. His trips were well planned. He always scouted out the territory to be visited the week preceding the trip, and he knew what to look for and the best possible place to find it.

Keeping up with Dirk could be the greatest challenge at the chapter's annual field trip meeting at Shell Creek. Dirk didn't want to miss anything of botanical value, even in the rain. Dirk could find that special species in a huge field of flowers. Then, before you knew it, he would be off to find another one. If you happened to spot one of the unique species before he did, he would always be so appreciative and marvel at the find. There would be a gleam in his eye and a smile on his face. He really loved being out there and sharing his expertise.

Dirk has performed botanic surveys on behalf of CNPS's conservation program and in that role has influenced planning at Hearst Ranch and other locations, including management of the West Cuesta Botanic Area in Los Padres National Forest. Dirk was a member of the working group and a photographic contributor to the joint CNPS-City of San Luis Obispo 2009 publication, *Wildflowers of San Luis Obispo, California*. He is currently active in photo-



Dirk Walters talking about the local vegetation to a group of mostly zoologists at High Mountain Condor Lookout. Photograph by Steve Schubert. The book he is holding is Robert F. Hoover's *The Vascular Plants of San Luis Obispo County* (UC Press, 1970).

graphic documentation of Carrizo Plain flora for another potential chapter publication project. He has also worked to digitize old 35mm slide collections, particularly those of the late Dr. Malcolm McLeod, a CNPS Fellow. Visitors to Carrizo Plain National Monument will see his digital restoration of plant identification books.

Beginning in the early 1980s, Dirk and his wife Bonnie monitored the endangered and now federally listed annual plant, Nipomo lupine (*Lupinus nipomensis*). This involved conducting a survey and weeding non-native plants from its habitat. In 1989 their findings appeared in the journal *Crossoma*. For over 30 years, Dirk and Bonnie have also contributed a native plant profile for each chapter newsletter, with Dirk writing the copy and Bonnie providing the illustrations. The plant descriptions and plant lore make these easy reading for all ages, while imparting a healthy dose of science. Other CNPS chapters and organiza-



Dirk Walters and Lauren Brown on Coreopsis Hill, Nipomo Dunes, San Luis Obispo County, 2010. The yellow-flowered shrub in the background is coreopsis (*Leptosyne gigantea*, formerly *Coreopsis gigantea*) in its most northern occurrence. Photograph by David Chipping.

tions have used his material in their newsletters.

The plant profiles started when Dirk produced a lab manual for his Cal Poly students to replace the impenetrable texts of the day. Dirk and David Keil maintained and updated the manual for many years. Dirk was also a major editor and contributor to a 1977 chapter-generated conference. Proceedings were published as CNPS Special Publication No. 3, *Native Plants: A Viable Option*.

There is almost no activity

within the San Luis Obispo chapter that has not benefitted from Dirk's contributions. For example, the chapter sponsors a yearly member slide show meeting, and Dirk has always been the one to collect and arrange all the photos. He has also created a number of other slide presentations, including one designed to promote CNPS at meetings of local service organizations. Dirk almost always helps to staff the "advice table" at our chapter's annual plant sale. And at local events, such

as Earth Day, Dirk has helped to assemble, host, and disassemble the chapter's tables and displays, literally for decades!

The number and variety of his contributions—all connected somehow to native plant science and education—boggle the mind, and we are indeed grateful for all he has done and continues to do.

David Chipping, 1530 Bayview Heights Drive, Los Osos, CA 93402, dchippin@calpoly.edu

NEW CNPS FELLOW: DON MAYALL

by Santa Clara Valley Chapter Board

Don Mayall, a member of the CNPS Santa Clara Valley Chapter, has been a leader for over 20 years in the areas of conservation, rare plants, and invasives. Since joining CNPS in the mid-1980s, Don has been a tireless advocate for serpentine plants and habitats, and most notably in increasing appreciation for and helping to preserve valuable serpentine

areas in Coyote Ridge and Edgewood County Park and Preserve.

While growing up as a child in Oklahoma, Don helped with his family's victory garden, and enjoyed exploring creeks in the neighborhood. After his family moved to Southern California (just east of Los Angeles) when he was 12, Don continued to spend his free time outdoors. Don attended UC Berkeley,

earning a BA in psychology and an MA in sociology and then went to work for the state of California as a labor market analyst, but still loved to be around wildlands, spending time in the Sierra Nevada and Point Reyes. Later, while living in the Berkeley area, Don enjoyed going on camping and hiking trips, passing on his love of nature to his son and daughter. During this time he

worked in the field of demographics and statistics, eventually retiring from Ohlone College in Fremont.

With his love of gardening and wildlands, it was inevitable that Don would find CNPS, which he did in 1985 by starting to buy plants at the Santa Clara Valley Chapter's plant sale at Foothill College, and joining in on field trips and classes. Around this time Ken Himes (a future CNPS Fellow) saw Don looking at photos at a chapter wildflower show and encouraged him to immediately visit the spot where they were taken. This location—which later became San Mateo County's Edgewood Park and Natural Preserve—was slated at the time to be an 18-hole golf course and recreation area.

Don became the chapter's Santa Clara County conservation chair in 1992, and around the same time, met his future wife Carolyn Curtis, who was the chapter's San Mateo County conservation chair. Don and Carolyn worked together with many others to organize a grassroots movement to protect Edgewood Park. This movement reached out to the local community, government officials, and public agencies. They developed a 30-minute video that outlined the case for saving Edgewood and which became an effective publicity tool for



Don Mayall at CNPS Santa Clara Valley Chapter Plant Sale, April 21, 2012. Photograph by Judy Fenerty.



Recording data for vegetation survey, serpentine chaparral, Coyote Ridge, 2002. Photograph by Sau San.

the effort. The video aired on the local cable television channel, and was distributed to the public and to local agencies. The battle for Edgewood Park was eventually won in the summer of 1993 when the San Mateo County Board of Supervisors finally voted to permanently protect it from development.

Inspired by Carolyn's dedication and persistence and the success of the grassroots movement to save Edgewood, Don embarked on another campaign to save a threatened region of rare plants at Coyote Ridge in south San Jose, and protecting it from becoming part of the urban sprawl in southern Santa Clara County. Much of Don's involvement with CNPS from the 1990s to the present has been focused on the protection, appreciation, and study of Coyote Ridge, a 7,000-acre serpentine area that contains numerous rare plants and animals.

Don's professional background in social sciences and statistics in-

fluenced his drive to use scientific methods to protect Coyote Ridge. Through vegetative mapping, rare plant surveying, and working with scientists from many different disciplines (botanists, entomologists and climatologists), Don's efforts have resulted in the development of a large base of knowledge about the serpentine habitat at Coyote Ridge. In 2004 Don also wrote a comprehensive and effective document that he submitted to public agencies on the routing of high-speed rail in Santa Clara County that would have destroyed the rare plant habitat on Coyote Ridge.

Don's efforts to protect this large swath of open space emphasized the importance of responsibly opening up portions of the site for public access. His ability to educate and win over visitors to Coyote Ridge has been integral to the development of a diverse group of supporters, and the formation of the Coyote Ridge Committee. Don was also a



Don Mayall and Carolyn Curtis (wife) at Joshua Tree National Park on a CNPS field trip, 1995. Photograph by (the late) Brenda Butner.

key organizer of the vegetation survey of Coyote Ridge, completed in 2004 with chapter members and the state CNPS Vegetation Program.

Over the years Don has held an impressive variety of positions with the Santa Clara Valley Chapter, including president, vice-president, field trip chair, invasive exotics chair, plant sale chair, and Weed Management Area representative. He has also served as the chapter's rare plants chair for Santa Clara County for over ten years. At the state level, Don has served since 2004 on the CNPS Invasive Exotics Committee. His participation in this

committee included regular trips to Sacramento to participate in the California Invasive Weed Awareness Coalition. Don regularly participated in lobbying the state legislature, as well as traveling to Washington and lobbying members of Congress as part of National Invasive Weed Awareness Week.

Don's clear and elegant writing has been a valuable tool for the chapter in the protection of native plants. Don's publications include several *Fremontia* articles, including a book review in January 1998 of *Kashaya Pomo Plants*, and two conservation-related articles in the Winter 2008

issue, one on serpentine endemics and the other on Coyote Ridge. He authored, along with Bob Case, "The Role of the California Native Plant Society in Invasive Exotic Plant Management," which was included in the Proceedings of the 2009 CNPS Conservation Conference.

Don has also written dozens of articles for the Santa Clara Valley Chapter newsletter, and for local environmental organization newsletters. Prior to his retirement, Don also authored several books on career guidance, employment, and labor market analysis. Don has been a tireless member of the chapter's conservation committee, and has commented for the chapter on numerous CEQA documents. He was a key member of a chapter group that worked on the 1997 Dow Drive lawsuit to prevent an unmitigated loss of Santa Clara Valley dudleya (*Dudleya abramsii* ssp. *setchellii*) which was settled with the City of San Jose (*Fremontia* 36/1: 13).

Don has been an essential and invaluable mentor to chapter members, providing guidance, scientific knowledge, and institutional memory for the collective benefit of both the chapter and CNPS in its entirety.

*Santa Clara Valley Chapter of CNPS,
3921 East Bayshore Road, Palo Alto, CA
94303, cnps_scv@yahoo.com*

PETER JOSEPH CALLIZO: 1937–2011

by Jake Ruygt

Peter Joseph "Joe" Callizo passed away in Napa on December 14, 2011. He was a widely known and well respected botanist, naturalist, and local historian who spent much of his time studying the natural areas of Napa County, and especially all aspects of Pope Valley where he was raised. An early member of the Napa

Valley Chapter of CNPS, Joe served as chapter president from 1983–86.

Joe was an only child and grew up on an 850-acre ranch that his family acquired during the Great Depression. The family raised cattle, sheep, chickens, wine grapes, walnuts, peaches, prunes, hay, and harvested some timber from the ranch. They also tried their hand at mining

on the property. This "hands on" education taught Joe about horticulture, ranching, and many building trades.

His experience working with animals on the family ranch led him to the decision to enroll at UC Davis to study zoology. After receiving his B.A., he attended UC Berkeley where he received a master's degree, also

in zoology. For a time he worked there as the head teaching assistant in the zoology department. Eventually he moved to St. Helena to assist his aging mother. He worked in the area until acquiring a job on a vineyard in Pope Valley, where he worked to maintain the roses planted in the vineyards along with other horticultural duties. In 1987 Joe was hired as the caretaker for the Napa County Land Trust's Wantrup Wildlife Sanctuary in Pope Valley, where he lived on site for 20 years until his retirement at the age of 70.

Joe's involvement in local botany spanned a period of more than 35 years. In 1976 June Foote, Napa Valley Chapter president, contacted Dr. Gilbert Muth, a biology teacher at Pacific Union College (PUC) in Angwin to establish a record of native and naturalized plants of Napa County. Joe Callizo, Dr. Muth, and Dr. Don Hemphill, professor of biology at PUC developed a computer database to record the distribution of native and naturalized plants in Napa County. The first edition included 618 species, but this grew to about 1,700 entries by 1985. Joe collected hundreds of voucher specimens between 1975 to 1985, and compiled thousands of geographic locations of Napa County plant species, along with habitat, elevation,



Joe Callizo's work as a botanist for over 35 years is largely responsible, together with faculty at Pacific Union College, for today's comprehensive online flora of Napa County's native plants.



Joe Callizo (front right) participating in a lichen keying session in 1996 sponsored by the Lichen Society at the Wantrup Wildlife Preserve.

and vegetation community data.

In later years he worked closely with Gilbert to update the computer database into the first online flora of Napa County, and assembled a file of rare plant slides taken by numerous photographers in Napa County. He also helped to locate and cut the first trails at Skyline Wilderness Park, as well as helped to start a Native American garden at Bothe-Napa Valley State Park.

In the 1980s Joe turned his attention to the land conservation activities of the fledgling Napa County Land Trust, serving on its board of trustees from 1987–1997. He strongly supported protection of public access to the Aetna/Oat Hill Mine Road, a popular hiking corridor that was

improved and opened to the public in 2009.

As caretaker at Wantrup Wildlife Sanctuary, Joe graciously assisted numerous graduate and doctoral students with research conducted there. He was also involved with the Napa Valley Natural History Association at Bothe Napa Valley State Park, hosted geologic exploration of serpentine habitats in Napa County, and collaborated on the writing of a history of Pope Valley families. He was knowledgeable about the local mushroom flora, and for a number of years led walks and organized annual mushroom fairs. His rich experience living in, observing, and studying Pope Valley for 37 years led to a 20-page interview by cultural anthropologist Felicia Shinnamon in 2007 that was published in 2011.

Joe Callizo was a gifted CNPS hike leader due to his understanding of principles of nature, his skill in identifying species, and his sense of humor. He captivated children by his teaching style, and impressed



Joe standing near a large Sonoma ceanothus (*Ceanothus sonomensis*), a California endemic, on Hogback Mountain, March 1984.

aspiring botanists such as myself. Joe continually developed pictorial identification keys to the plants of Napa County. His hundreds of voucher collections are preserved at Pacific Union College. Joe also developed the *Annual Plant Watch* Program that for a number of years was utilized by many CNPS chapters statewide to monitor rare plant populations. Joe's many contributions to the knowledge of Napa County flora touched a great many people, and he will long be remembered.

Jake Ruygt, 3549 Willis Drive, Napa, CA 94558, jake@napanet.net

BOOK REVIEWS

Wildflowers of California: A Month-By-Month Guide by Laird Blackwell. 2012. University of California Press, Berkeley, CA. 588 pages. 659 illustrations. \$70, hardcover; \$29.95, paperback. ISBN #978-0520 272064.

Dr. Laird Blackwell, author of numerous books about flowers in various regions of California, has now written a book that will be enjoyably used by lovers of California native flowers. While most guides to flowers are arranged by color or botanical family, Blackwell's book succeeds in a new approach: flowers are arranged by the months in which they usually bloom. Broader in geographical coverage than his previous books, Blackwell's book lists locations especially rich in flowers, provides details about which species can be expected to flower in a given month, and includes places where specific flowers can be expected to bloom.

Blackwell divides the state into ten geographical regions from the northwest mountains to the southern deserts, and then describes easily accessible sites within each area and the flowers that reliably bloom there. Each section opens with a geographical description, plus tips on where and when to visit, followed by descriptions of



specific locations. For example, the Coast and Coast Ranges section includes a description of Bear Valley in Colusa county, complete with a featured flower, in this case, the adobe lily (*Fritillaria pluriflora*), driving and walking directions, the best time to visit, lists of flowers especially likely to appear in colorful masses, plus other less-common flowers that one might also see. Blackwell details 67 floral hotspots in all (pinpointed on a map

too), providing ideas for new adventures for all except the best-travelled flower fans.

The bulk of this book is a month-by-month catalog of blooming flowers, covering most of the year. Each chapter briefly describes what blooms by geographical location, and provides highlights of flowers for various regions. For instance, for April, the rare Mount Diablo globe lily (*Calochortus pulchellus*) is mentioned for Mt. Diablo in the Coast Ranges. What follows is a species-by-species account of what could be expected to flower in each month. Each species is listed by common and scientific name, botanical family, along with a brief description and a photograph. Notes, habitat, and "where and when" are provided too.

For June's swamp onion (*Allium validum*), for example, blooming sites include Sagehen Creek meadow, the Warner Mountains, King's Canyon-Sequoia, Mt. Eddy, Onion Valley, and the Trinity Alps. Each site includes a range of months when flowers could be expected. Names and families correspond to the second edition of *The Jepson Manual*. The photos for each species, all taken by Blackwell, are sharp, pleasing, and useful in identification.

In all, 600 species are described and pictured. Most are herbaceous, but there are also a number of shrubs and

a few trees. The author based his choice of species on those flowers showy enough that he would go out of his way to view them, while ensuring that all areas of the state were represented. Non-natives are pictured too, in “bouquets” located between the monthly chapters. Interesting and useful material is placed at the end of the book: lists of California endemics and CNPS-listed rare and endangered species are appended, and all locations mentioned in the text are cataloged and located on a map. References to local floras and identification guides also are included. The book closes with indices of both common and scientific names.

There is a lot to like in this book, and it should find a well-used place in the library (or knapsack) of flower lovers. In addition to presenting California’s floral diversity in a novel, appealing, comprehensive, organized, and user-friendly way, Blackwell writes sentimentally and it’s clear that he loves his subject matter. “The glorious turning of the leaves eases us into winter and its joys before the flowers stir again in only a few months” is Blackwell’s good-bye to the blooming parade in the book’s last chapter.

Not all flowers in this book will be easy to find in their listed locations. No surprise here, as California’s flora is full of endemics with specialized and limited distributions. Very rarely, some of the flowers don’t in fact occur in all of their listed locations. However, this is a very minor quibble, and finding and viewing all the plants in Blackwell’s book is certain to delight wildflower lovers.

For whom is this excellent addition to California’s natural history intended? People who eagerly seek out flowers will doubtless enjoy using this book to plan trips to less familiar locales. Likewise, those who desire to begin their spring early and extend it late will discover, as Blackwell has, that something almost always is flowering somewhere in our state. Anyone curious about flowers will enjoy just browsing the diversity of species featured in the book. Lastly, this book may prove useful to gardeners as a source of potential plants that would broaden the seasonal appeal of their native plantings.

—Chris Tarp, East Bay Chapter

Beach Wildflowers of the California Transitional Coast by Joseph Cahill, PhD. 2011. Ventura Botanical Gardens, Inc., Ventura, CA. 132 pages. \$20, soft cover. ISBN #978-0615449142.

The introduction to this book states that it is a field guide to beach plants of southern Santa Barbara and Ventura Counties. Four general plant communities found along the coast are described: Coastal Strand, Coastal Salt Marsh, Coastal Sage Scrub, and Riparian Wetland. A map of the part of the coast covered by the guide is provided, with place names.

The guide contains brief descriptions of 146 native and nonnative species. These are arranged by plant family, sort of phylogenetically, in other words they are grouped such that those closely related are placed near one another. However, while the conifer family is listed first, the guide then jumps to the monocot families instead of the dicots, as is traditional. Regardless, as a scientist, I prefer phylogenetic arrangements so the reader is reminded of the relationships of plants to one another. Most field guides are arranged alphabetically or by flower color or growth form (or some combination of these).

Each plant description includes a scientific and common name, life form, size, and the habitat in which the plant grows, and these are enhanced by both useful and beautiful photographs and/or color scans. However, the scientific names do not seem to follow any one particular reference, such as the 1993 *Jepson Manual of Higher Plants of California* or the more up-to-date *Flora of North America*, but rather come from multiple sources, some outdated. The book also contains a few misspellings of plant names and factual errors. For instance, California buckwheat (*Eriogonum fasciculatum* var. *fasciculatum*) is discussed; however, it is not native to the region (var. *foliolosum* is the common one found here).

This field guide covers 87 native and 59 nonnative species, which is a much higher percentage of nonnatives than is found in California or just Ventura County (both with only about 25% nonnatives). This is in part a result of the invasion of this coastal habitat by nonnative plants, mostly be-



cause of human activities along the coast.

The book ends with a glossary of terms, followed by an index that includes family, tribe, and scientific names, with common names in parenthesis. It measures 9" x 6", and is less than one-half-inch thick, making it easy to carry in a backpack or tote bag, and is printed on high-quality glossy paper. This paperback field guide should be quite useful for beachgoers interested in the plants they may encounter, so they may want to keep a copy in their beach bag.

—David L. Magney

A State of Change: Forgotten Landscapes of California, text and art by Laura Cunningham. 2010. Heyday Press, Berkeley, CA. 350 pages. \$50.00, hardcover. ISBN#: 978-1-59714-136-9.

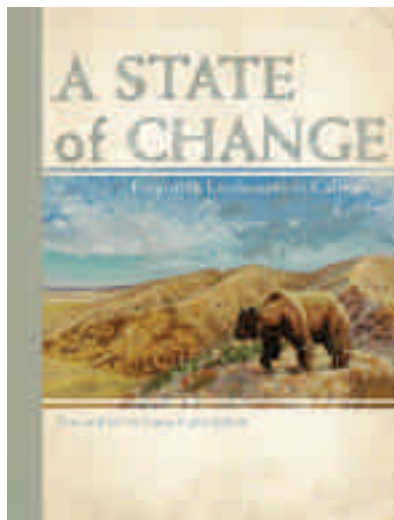
This volume is a beautiful and informative book, as well as an inspiring read. However, my first impression of it wasn’t positive, as I am not excited by the common hard cover style being currently used. There must be a cost advantage, with the art printed directly on the binding as opposed to appearing on a removable book cover. But when I started to read and examine the artwork, I was increasingly impressed by the author’s many talents. She has done her homework, her artwork is impeccable, she has worked as

a professional biologist and traveled throughout California, and she writes of her observations and experiences with considerable intelligence, thoughtfulness, and grace.

The book is extremely well illustrated, with at least 75 different color illustrations in watercolor, oil, color pencil, or pastel. There are also field sketches and other simpler illustrations throughout in pencil, watercolor, or ink.

The book's subtitle, *Forgotten Landscapes of California*, is aptly chosen. The author considers different landscapes in the state such as grasslands, marshes, rivers, and forests, and researches what they would have been like in past ages. For each she paints a picture in words, and literally with a variety of artistic media. As a botanical artist I am impressed by the quality of her line work, shown especially on pages 116–117 in a plate of drawings of different grasses found in California's grasslands. Her work on mammals, fish, and landscapes appears to be equally precise.

My favorite renderings are those where she shows a present day photograph—for example of the El Cerrito



Plaza in the East Bay region, or the San Fernando Valley in Southern California—and juxtaposes it with her painting of what it might have looked like “pre-Caucasian Invasion.” I think Laura Cunningham isn't alone in imagining these scenes. Don't many of us do just the same?

The negatives of this book are few, and mostly have to do with editorial choices. There are a few illustrations scanned from drawings on lined paper that I would have had redrawn or ed-

ited out. The design of the book is very attractive, but the text for the most part extends across the entirety of the page, making the reading slower. Her writing is so substantive yet fun to read that I don't want to be slowed down by design!

She uses common plant and animal names throughout and relies upon an appendix for scientific names. While it appears to be thorough, I would have preferred if at least some of the scientific names appeared in the text or along with the illustrations, at least parenthetically. It should also be noted that some landscapes aren't considered, in particular those of mountains and deserts.

Native Plant Society members should be aware that the author is inclusive in her treatment of biota: at least half the book pertains to fauna versus flora, but this is as it should be. Her thoughtful consideration of those landscapes that have changed most in the beautiful state of California will serve to educate those who are not yet familiar with the state, and inspire those who know this state's amazing landscapes well to take another look.

—Linda Ann Vorobik

LETTERS TO THE EDITOR

SAN BRUNO MOUNTAIN HCP: FLAWED PLAN

Patrick Kobernus' article on the San Bruno Mountain Habitat Conservation Plan (HCP) in the previous issue of *Fremontia* (38/4, 39/1: 10–17) dismayed members of the Plan's Technical Advisory Committee (TAC). An article in the October 1993 *Fremontia* (21/4: 11–14) by a TAC member (Sigg) can serve as a 19-year-in-advance rebuttal, and is more detailed than this letter. The thrust of the 1993 article was that the fate of the then two (now three) listed butterflies depends on the health of the mountain's ecosystem, which was declining.

The advice was ignored, and the ecosystem is still declining—only faster. Now that the TAC has convinced San Mateo County (Plan Operator) and the HCP Trustees that a course change is mandatory to save

the listed species, there is a small ray of hope that effective action can still be taken to preserve the mountain's ecosystem, its natural processes, and the existing species.

The HCP was supposed to restore habitat equal to that destroyed by development, but it was badly flawed from the start. Development began *before* any successful restoration could be demonstrated. The plan lacked performance standards and a solid scientific basis, and it was—and is—grossly underfunded. Further, in a conflict of interest that would span decades, Thomas Reid Associates (TRA), the consultant that prepared the environmental review of the HCP, secured one contract after another as Plan Manager because their work went unreviewed, and no other bidder could compete.

As a result, we have lost hundreds of acres to development since the HCP began, but not a single acre has been

restored. Indeed, the Kobernus article condemns itself:

Management of invasive species to protect the endangered species habitat on the mountain has been largely successful over the past 30 years. However, coastal scrub succession, in combination with expanding populations of invasive species, continue to overtake grassland habitat on the mountain.

Kobernus portrays the mere presence of the listed species as success. TRA's self-serving annual reports did the same for decades before any peer review was conducted. That peer review was scathing (Longcore 2004).

A major reason for the robust expansion of invasive species is that TRA staff lacked requisite knowledge of the young and evolving field of ecological restoration. Staff was fixated on large, obvious targets such as gorse and broom. Precious funds were spent to spray, burn, chain, or bulldoze—but

Finally, Wildflower Guides that fit in your shirt pocket!



Produced by EarthRover Software and BioHere • www.HartmanMultimedia.com

with no follow-up and poor, if any, data collection. Expensive and experimental growing plots were created and abandoned, again without data.

Amid this confused floundering, and unacknowledged by the Plan Operator, newly introduced invasives were converting native perennial grasslands to weedy forbs or shrubs. TRA's reliance on five-year plans to achieve specific results didn't allow for adapting to rapidly changing conditions. When the TAC finally took over for TRA to plan the operating budget and work scope, the planning shifted to an annual basis, allowing for immediate reaction to ever-changing conditions.

Yellow oxalis (*Oxalis pes-caprae*) is considered the number one threat, due largely to a hard-to-kill bulb and rapid dispersal that can convert intact areas into oxalis monocultures. The TAC recognized its destructive capacity and recommended devoting an entire year's discretionary budget to it, while TRA did not recognize the problem. It now infests hundreds of acres.

This letter mostly addresses biology, but the HCP's dismal results involve wider policy issues. Those are the subject of an international report (Bean, Fitzgerald, and O'Connell 1991). Put policy and biology together, and the San Bruno Mountain HCP has failed to achieve its stated mission. The Kobernus article attempts to put a positive spin on the poor execution of a flawed plan.

REFERENCES

Longcore, T., C.S. Lam, and J.P. Wilson. 2004. Analysis of butterfly sur-

vey data and methodology from San Bruno Mountain Habitat Conservation Plan (1982–2000): Status and trends. University of Southern California GIS Research Laboratory Technical Report No. 1. Los Angeles, CA.

Longcore, T. 2004. Analysis of butterfly survey data and methodology from San Bruno Mountain Habitat Conservation Plan (1982–2000): Survey Methodology. University of Southern California GIS Research Laboratory Technical Report No. 2. Los Angeles, CA.

Bean, M.J., S.G. Fitzgerald, and M.A. O'Connell. 1991. Reconciling conflicts under the Endangered Species Act: The habitat conservation planning experience. World Wildlife Fund. Harper's Graphics/St. Mary's Press, Waldorf, MD.

Members of the San Bruno Mountain HCP Technical Advisory Committee:

Jake Sigg, Conservation Chair
Yerba Buena Chapter, CNPS

Doug Allshouse, President
Friends of San Bruno Mountain

Ken McIntire, Executive Director
San Bruno Mountain Watch

OVERALL AN EFFECTIVE PLAN: THE AUTHOR REPLIES

While critics such as Jake Sigg and others have made claims that the San Bruno Mountain Habitat Conservation Plan (HCP) is a failure, those that ac-

tually visit San Bruno Mountain can see with their own eyes that this is not the case. Through the HCP, 90% of the habitat of three endangered butterfly species has been managed for over 30 years, and all three species are still locally abundant on the mountain. The conservation area also includes several rare plant species and native plant communities that have been protected and managed successfully through the HCP program.

The HCP's primary focus has been on the maintenance of the *existing* habitat and native plant communities of the mountain. This strategy has been effective overall and was implemented due to the greater importance of protecting the conserved endangered species habitat and native plant communities, and due to the higher cost of restoration work. Unfortunately, the success of this work has been overshadowed over the years by the harsh and often inaccurate criticisms by a few highly vocal people such as Sigg. Sigg has used relatively small areas (such as the restoration work on cut slopes adjacent to the developments, or the gorse infestation in the saddle) as his examples that the HCP is a failure (*Fremontia* 21/4: 11–14). However, these areas comprise less than 5% of the total area of the HCP conservation area (San Mateo County, 2008), are very expensive to manage, and have not been the primary focus of the habitat management for nearly two decades.

Over the last three years, mission blue butterflies from San Bruno Mountain have been used to reestablish an extirpated mission blue population at Twin Peaks in San Francisco (Schreiber

A Special Offer for CNPS Members



Pacific Horticulture is the only quarterly publication written by and for gardeners and plant lovers who understand the need for responsible gardening in the summer-dry climates of the West Coast states. The magazine features California natives and other non-invasive mediterranean-climate species, superb color photography, in-depth book reviews, scientific reports, and a regional garden events calendar. Visit us at www.pacifichorticulture.org.

Pacific Horticulture is now available to CNPS members at a 20% discount: \$22 per year.



Send your CNPS membership number and a check for \$22 to:
Pacific Horticulture, P.O. Box 680, Berkeley, CA 94701
or call 510/849-1627.

2012). The populations of the endangered callippe silverspot and San Bruno elfin butterflies on San Bruno Mountain are similarly robust enough to be used as source populations to seed other sites in the Bay Area where these species have also disappeared. These species would not be faring well and would possibly be on the verge of extirpation, were it not for the consistent habitat management work funded and implemented through the HCP over the past 30 years. It should be noted that this habitat management work has also protected all of the rare plant populations in the conservation area.

Yellow oxalis (*Oxalis pes-caprae*) is without doubt (as Sigg points out) a significant problem on San Bruno Mountain, and I agree that the HCP

habitat managers need to find more effective control methods. However, a more pervasive threat to the endangered species and the native grassland habitat is the process of coastal scrub succession, which is overtaking grassland at the rate of approximately five acres per year. This process is occurring in many areas of California and elsewhere where grazing and/or burning is no longer allowed or used.

I provided documentation on the impact of coastal scrub succession on butterfly habitat on the mountain in the 2008 San Bruno Mountain Habitat Management Plan, in an article in the *Journal of Insect Ecology* (2010), and in *Fremontia* in 2012 (*Fremontia* 38/4, 39/1: 10–17). Though the San Bruno Mountain Technical Advisory Com-

mittee (TAC) has been aware of the succession problem for five years, they have not focused any serious effort on addressing this issue.

San Bruno Mountain is actually in a unique situation in that there is funding and a habitat management plan in place to address brush succession and invasive species infestations consistently over the long-term (i.e., decades). Sigg and the other activist members of the TAC need to focus their efforts on addressing the biological threats to the endangered species habitat and the ecosystem as a whole, rather than continually criticizing perceived missteps in the past that have little relevance to the conservation of the endangered species and the San Bruno Mountain ecosystem today.

We all care deeply about conserving San Bruno Mountain. Many dedicated people, including biologists, planners, environmentalists, and landowners, have worked very hard for decades to protect its ecosystem. Working together we can accomplish a great deal more than when we do not.

Patrick Kobernus
Wildlife Biologist
Coast Ridge Ecology
San Francisco, CA

REFERENCES

- Longcore, T. et al. 2010. Extracting useful data from imperfect monitoring schemes: Endangered butterflies at San Bruno Mountain, San Mateo County, California (1982–2000) and implications for habitat management. *Journal of Insect Conservation* 14: 335–346. <http://www.springerlink.com/content/650207q10251p553/fulltext.pdf>.
- San Mateo County Parks Department. 2008. *San Bruno Mountain Habitat Management Plan, 2007*. Prepared in Support of the *San Bruno Mountain Habitat Conservation Plan*. Revised 2008. San Mateo County Parks and Recreation Division, Redwood City, CA.
- Schreiber, D. 2012. Endangered mission blue butterflies return to San Francisco. *The San Francisco Examiner*, April 30. <http://www.sfoxaminer.com/local/2012/04/endangered-mission-blue-butterflies-return-san-francisco>.

Telos Rare Bulbs



The most complete offering of bulbs native to the western USA available anywhere, our stock is propagated at the nursery, with seed and plants from legitimate sources only.

Telos Rare Bulbs

P.O. Box 1067, Ferndale, CA 95536

www.telosrarebulbs.com



Join Today!

CNPS member gifts allow us to promote and protect California's native plants and their habitats. Gifts are tax-deductible minus the \$12 of the total gift which goes toward publication of *Fremontia*.

- | | | | |
|--|--|--|--|
| ☐ \$1,500 Mariposa Lily | ☐ \$600 Benefactor | ☐ \$300 Patron | ☐ \$100 Plant Lover |
| ☐ \$75 Family | ☐ \$75 International or Library | ☐ \$45 Individual | ☐ \$25 Limited Income |

CORPORATE/ORGANIZATIONAL

- | | | | |
|--|---|--|--|
| ☐ \$2,500 10+ Employees | ☐ \$1,000 7-10 Employees | ☐ \$500 4-6 Employees | ☐ \$150 1-3 Employees |
|--|---|--|--|

NAME _____
 ADDRESS _____
 CITY _____ STATE _____ ZIP _____

- | | |
|--|---|
| ☐ Enclosed is a check made payable to CNPS | Membership gift: _____ |
| ☐ Charge my gift to ☐ Mastercard ☐ Visa | Added donation of: _____ |
| Card Number _____ | TOTAL ENCLOSED: _____ |
| Exp. date _____ | |
| Signature _____ | ☐ Enclosed is a matching gift form provided by my employer |
| Phone _____ | ☐ I would like information on planned giving |
| Email _____ | |

Please make your check payable to "CNPS" and send to: California Native Plant Society, 2707 K Street, Suite 1, Sacramento, CA 95816-5113. Phone: (916) 447-2677; Fax: (916) 447-2727; Web site: www.cnps.org; Email: cnps@cnps.org

CONTRIBUTORS (continued from back cover)

Megan Lulow is codirector of science and stewardship for the Irvine Ranch Conservancy, and has been with the organization since 2006.

Roger Raiche is a landscape designer, field botanist, and author with a long history of cultivating native plants. Roger was named a CNPS Fellow in 2012.

Jake Ruygt is a horticulturalist and botanist in Napa County. He has served as the conservation chair for the Napa Valley Chapter of CNPS since 1982, and worked with Joe Callizo on the online Napa Flora.

Paula M. Schiffman is a biology professor at California State University, Northridge. She conducts plant ecology research at Carrizo Plain National Monument and Santa Monica Mountains National Recreation Area.

Leslie Scott is a restoration specialist at the UC Davis Donald and Sylvia McLaughlin Reserve, working primarily in the Eticuera Creek Watershed Ecosystem in Napa County.

Robbin W. Thorp is an emeritus professor of entomology at the University of California, Davis. He has conducted research on bees for more than 55 years.

Gene R. Trapp is professor emeritus at the Department of Biological Sciences, California State University, Sacramento. His focus is field biology.

Linda Ann Vorobik is a professional botanist and botanical artist (especially *The Jepson Manual*), and a past editor of *Fremontia*. News of her workshops, shows, and lectures can be found at www.VorobikBotanicalArt.com.

Truman Young has conducted plant ecological research in various countries over the past 35 years, and has served on the faculty of the University of California, Davis since 1996.

SUBMISSION INSTRUCTIONS

CNPS members and others are invited to submit articles for publication in *Fremontia*. If interested, please first send a short summary or outline of what you'd like to cover in your article to *Fremontia* editor, Bob Hass, at bhass@cnps.org. Instructions for contributors can be found on the CNPS website, www.cnps.org, under Publications/*Fremontia*.

Fremontia Editorial Advisory Board

Susan D'Alcamo, Jim Andre, Ellen Dean, Phyllis M. Faber, Holly Forbes, Dan Gluesenkamp, Brett Hall, Todd Keeler-Wolf, David Keil, Pam Muick, Bart O'Brien, Roger Raiche, Teresa Sholars, Greg Suba, Dick Turner, Mike Vasey, Carol Witham



California Native Plant Society
2707 K Street, Suite 1
Sacramento, CA 95816-5113
Address Service Requested

Nonprofit Org.
U.S. Postage
PAID
A.M.S.

CONTRIBUTORS

Paul Aigner is resident codirector of the UC Davis Donald and Sylvia McLaughlin Reserve in Napa, Lake, and Yolo Counties, where he has studied and managed serpentine and non-serpentine grasslands for the past ten years.

Pelayo Alvarez works for Defenders of Wildlife as the conservation program director for the California Rangeland Conservation Coalition.

Jennifer Buck-Diaz is a vegetation ecologist with the California Native Plant Society where she surveys, classifies, and maps vegetation of California.

David Chipping is president of the San Luis Obispo Chapter of CNPS and past conservation director for CNPS.

Ellen Dean is curator at the UC Davis Center for Plant Diversity. She has been instructing students in plant identification and plant collecting for over 20 years.

Julie Evens is the Vegetation Program director for CNPS.

Judy Fenerty is the Santa Clara Valley Chapter delegate to the CNPS Chapter Council.

Glen Holstein is a retired botanist specializing in landscape ecology. He is also volunteer botanist and Chapter Council representative for the CNPS Sacramento Valley Chapter.

Kristin Hulvey is currently a post doctoral researcher at the University of Western Australia where she is studying woodland restoration.

Catherine Koehler is resident codirector of the UC Davis Donald and Sylvia McLaughlin Reserve and executive director of the Lake County Land Trust.

FROM THE EDITOR

The theme of this issue of *Fremontia* concerns California's prairies and grasslands, one of numerous native plant communities that are but a remnant of what they once were 25, 50, or 100 years ago. It seems as though so much of what many of us do on behalf of CNPS concerns determining the condition and extant of threatened native plant species and sensitive habitats, and attempting to protect them from further decline.

Humans are largely responsible for this decline. We exploit natural resources for basic human needs and for consumables. But too few of us pay attention to the effect our actions have on the environment. Fewer still make the connection between an eroding environment (polluted water, air, soil from toxic chemicals) and cumulative impacts to human health (cancer, birth and immune system defects) or to plants and animals (disease, acid rain, increased toxins accumulating in the food chain).

Nature cannot protect itself from what we humans do to the environment, but we can. In April 2010, in the wake of the failed December 2009 United Nation's (UN) Copenhagen climate summit, more than 32,000 scientists, environmentalists, and others from around the world assembled in Bolivia for a World People's Conference on Climate Change. The outcome of that meeting was a proclamation called "The Universal Declaration of the Rights of Mother Earth" that participants advocated be adopted by the UN.

The Declaration acknowledges the need for a new paradigm in how we humans relate to the natural world. It recognizes, as have many indigenous cultures, that all living things have a right to well-being (i.e., clean water, air, soil), and that humans are obligated to act to preserve these rights. It is a fascinating document. I encourage you to read it in its entirety, at <http://therightsofnature.org/universal-declaration/>.

—Bob Hass

(continued on inside back cover)