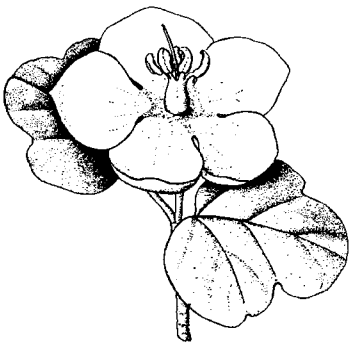
Vol. 25, No. 1 January 1997

FREMONTIA

A Journal of the California Native Plant Society



FREMONTIA

Vol. 25 No. 1 January 1997

Phyllis M. Faber, Editor • Laurence J. Hyman, Art Director • Beth Hansen, Designer

California Native Plant Society

Dedicated to the Preservation of the California Native Flora

The California Native Plant Society is an organization of laymen and professionals united by an interest in the plants of California. It is open to all. Its principal aims are to preserve the native flora and to add to the knowledge of members and the public at large. It seeks to accomplish the former goal in a number of ways: by monitoring rare and endangered plants throughout the state; by acting to save endangered areas through publicity, persuasion, and on occasion, legal action; by providing expert testimony to government bodies; and by supporting financially and otherwise the establishment of native plant preserves. Much of this work is done through CNPS Chapters throughout the state. The Society's educational work includes: publication of a quarterly journal, *Fremontia*, and a quarterly *Bulletin* which gives news and announcements of Society events and conservation issues. Chapters hold meetings, field trips, plant and poster sales. Nonmembers are welcome to attend.

The work of the Society is done mostly by volunteers. Money is provided by the dues of members and by funds raised by chapter plant and poster sales. Additional donations, bequests, and memorial gifts from friends of the Society can assist greatly in carrying forward the work of the Society. Dues and donations are tax-deductible.

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EDITORIAL

Habitat protection and restoration are the themes for this issue of *Fremontia*. European man's presence has altered the landscape in California in numerous and ongoing ways. Native plant losses and habitat degradation continue at an accelerating rate. In the opening article Dan Cooper reviews some of the vegetation resources on military bases in this state. Since several bases are reverting to non-military status, maximum efforts need to be made to assure that plants will receive consideration when bases revert to other uses. In other articles Margaret Stassforth reports on post-fire vegetation on public lands in the Santa Monica Mountains. Doug McCreary searches for ways to assure a future for oaks on grazed lands and reports on a possible tool, a treeshelter for seedlings. These three articles reflect the kinds of difficulties that exist for preserving the great diversity of our California flora.

In an article about lewisias, the authors share in their search for species definition using an isozyme analysis technique. In the world of endangered plant protection, these definitions assume increasing importance.

Please support the important work of CNPS in 1997. Each of us needs to find at least one new member for the society. We need to grow.

Phyllis M. Faber

THE COVER: Indian Spring on the Naval Air Weapons Station at China Lake in San Bernardino County. Photograph by Denise LaBerteaux.

A Brown towhee nest site at Lower Mammoth Mine in Inyo County. Photographs by Denise LaBerteaux unless otherwise noted.

HABITAT CONSERVATION ON MILITARY INSTALLATIONS

by Daniel S. Cooper and Dan L. Perlman

In early 1993 entomologist Rudi Mattoni was surveying a Navy-owned vacant lot south of Los Angeles when he noted the presence of a small blue butterfly, which he identified as a Palos Verdes blue (*Glaucopsyche lygdamus palosverdesensis*). This butterfly was believed to have become extinct almost a decade earlier, shortly after its only known habitat was converted into a baseball diamond. However, recent surveys have confirmed that it is not extinct, but is confined to a small area of coastal scrub.

The Palos Verdes blue is far from the only rare species in California that receives protection from a most unlikely source, the U. S. Department of Defense (DOD). Military land provides habitats for about 250 rare plant and animal taxa in the state, including several with virtually no occurrence outside the bases. In remote parts of the deserts and along the central coast scattered military bases support vast stretches of relatively undisturbed creosote bush scrub, oak woodland, and chaparral where military activity is often light. Near urban or agricultural regions small installations often hold the only substantial reserves of native vegetation in the vicinity.

While recent base closures may immediately benefit biotic communities on land directly affected by destructive military activities such as battle simulations and ordnance testing, in the long run many smaller holdings near urban centers will be jeopardized. Even though the high cost of cleaning up buried hazardous material (up to $250,000 per acre) may spare portions of polluted holdings from development, environmental toxins are often limited to small, easily contained areas, leaving large sections of closed bases and their habitat available for private developers. Several large bases, including Southern California's Camp Pendleton, have already taken steps

to carve up portions of their coastal property for housing developments.

In an effort to assess the implications of base closures for the conservation of biodiversity, we designed questionnaires and conducted telephone interviews with resource managers at thirty DOD installations throughout California, as well as most of the large National Park Service holdings for comparison. Offshore holdings (islands) were excluded. We requested information on the plant and animal communities present, descriptions of any ecosystem management techniques employed by each base, and the long-term prognosis for biodiversity protection. For information on the status of rare species, we relied on the Federal Register from 1991 for mammals and 1993 for plants, and consider as listed any taxa listed as Candidate 2, Candidate 1, Potentially Threatened, Potentially Endangered, Threatened, or Endangered.

Natural Communities on Bases

West of the Sierra Nevada the Department of Defense oversees 230,000 hectares of open land on twenty-three major holdings in the Central Coast, the Central Valley, and southwestern California. These represent just under one-third of the acreage managed by the National Park Service west of the deserts. Nine active or recently closed DOD bases protect five or more plant communities; three—Fort Ord near Monterey, Vandenberg Air Force Base northwest of Santa Barbara, and Camp Pendleton south of Los Angeles—support nine such habitat types within their borders. Because many military installations are located in lowland areas of Central and Southern California that historically have been altered by agriculture and urbanization, they now protect some of the most endangered plant communities in the state, such as those found in vernal pools, coastal sage scrub, and coastal salt marsh. Many of these plant communities have extremely limited ranges outside the bases on scattered national wildlife refuges, Nature Conservancy preserves, and state parks.

Camp Pendleton, a particularly well studied base between Los Angeles and San Diego, provides an example of this diversity. Of the base's seventeen natural communities, thirteen were recognized by Holland in 1986 as rare. Pendleton's 12,000 hectares of native valley needlegrass grassland is the largest remaining example of native grassland in southwestern California, now reduced to 0.5 percent of its former range throughout the state. The coastal sage scrub that occurs there represents the largest contiguous patch of this globally rare community in the country. The base also protects patches of Engelmann oak woodland, dominated by a tree species (*Quercus engelmannii*) endemic to low mesas of southwestern California, and hundreds of hectares of coastal salt marsh, which

Coastal sage scrub on a site adjacent to March Air Force Base in Riverside County. Photograph by Scott Morrison.

has already been reduced by over ninety percent along California's coast.

Miramar Naval Weapons Center in San Diego, Vandenberg Air Force Base, and other coastal installations protect unique chaparral communities maintained by regular fog cover, collectively known as maritime chaparral. At Vandenberg, this chaparral grows beneath rare southern Bishop pine forest, dominated by *Pinus muricata*, a closed-cone species restricted to small patches along the central and northern coast and Baja California. In the Central Valley the desert-like scrub of the Elk Hills (formerly a naval installation but currently administered by the Department of Energy) lies adjacent to The Nature Conservancy's Carrizo Plains Preserve and protects 30,000 hectares of valley saltbush scrub, an endemic-rich community that elsewhere has been virtually eliminated due to agriculture, flood control projects, and groundwater pumping.

East of the Sierra four mammoth bases in the Mojave Desert cover over a million hectares, and several weapons testing areas in the Sonoran Desert account for another 270,000 hectares. Death Valley National Park and Joshua Tree National Monument roughly equal the land area of DOD bases in the Mojave, and the amount of land protected by Anza-Borrego State Park in eastern San Diego County is comparable to the acreage of the various DOD holdings. According to Peter Raven, the Sonoran Desert's Chocolate Mountains represent one of the six regions of the state with a high level of relictual flora. The entire range, which lies just east of the Salton Sea, is a weapons testing zone, and relatively little is known about its biotic resources. Its thorn woodland habitat, dominated by allthorn (*Koeberlinia spinosa*), is virtually unstudied, and according to Holland does not occur in California outside this range.

As of 1993 about 250 listed plant and animal taxa were believed to be present or potentially present on DOD land, which represents roughly two-thirds of all listed or candidate species in the state. This number exceeds the number of listed species in California's national parks and monuments by about a third. Installations that are located in California's several regions of high endemism often provide the only habitat available for several plant taxa. The marine terraces of Miramar, Camp Pendleton, and Vandenberg support coastal scrub communities rich in rare endemics, and both Fort Ord and Fort Hunter-Liggett lie in the Monterey Endemic Area, a region whose unique organisms include over a dozen rare manzanitas (*Arctostaphylos* spp.), and herbs such as sand gilia (*Gilia tenuiflora* ssp. *arenaria*) and purple amole (*Chlorogalum purpureum* var. *purpureum*), which have few known occurrences outside Fort Ord and Fort Hunter-Liggett, respectively.

March Air Force Base in western Riverside County east of Los Angeles covers an area only a tiny fraction of the size of Yosemite National Park, yet its scrubby grassland harbors more listed plant taxa than either Yosemite or Sequoia National Park. Many of these species are restricted to vernal pools that form each spring in the grassland between the asphalt runways.

In the Desert Province the large installations protect pockets of taxa with naturally small ranges, often restricted to a single dune system or set of limestone cliffs,

Habitat Types and Acreages on Military Installations in California

Habitat Types	Total	# Rare	Acres
California Floristic Province	**569,650**		
Central Valley			**93,050**
Elk Hills (now DOE)	2	1	70,000
Beale AFB	4	2	19,000
Travis AFB	3	2	2,500
Castle AFB	2	1	700
NAS Lemoore	5	3	500
McClellan AFB	3	2	350
Central Western California			**330,800**
Fort Hunter-Liggett	5	1	165,000
Vandenberg AFB	10	6	100,000
Camp Roberts	5	1	43,000
Fort Ord	9	6	24,000
NAS Concord	2	1	6,500
Camp S.L. Obispo	6	2	4,800
Moffett Field	2	1	4,500
Camp Parks	2	1	2,600
NWS Alameda	1	1	2,000
Southwestern California			**145,800**
Camp Pendleton	10	9	113,000
NAS Miramar	6	4	18,000
Fallbrook Annex	6	4	8,000
March AFB	4	3	22,000
Pt. Mugu	3	2	2,200
NWS Seal Beach	1	1	1,000
El Toro	2	1	500
Norton AFB	1	1	575
Imperial Beach	2	2	325
Desert Province			**3,201,000**
Mojave Desert			**2,541,000**
NAWS China Lake	5	1	1,000,000
29 Palms	2	0	600,000
Fort Irwin	2	0	580,000
Edwards AFB	3	1	360,000
George AFB	2	0	1,000
Sonoran Desert			**660,000**
Chocolate Mtns.	2	1	600,000
USNAGR	1	0	50,000
Salton Sea	2	0	10,000
Great Basin Province			
Mococ Plateau			96,460
Sierra Army Depot	2	0	96,460

Terminology of habitat types and rarity based on Holland (1986)

including Munz's cholla (*Opuntia munzii*) at the Chocolate Mountains and Lane Mountain milk-vetch (*Astragalus jaegerianus*) at Fort Irwin, both of which are threatened by military activity at their respective installations.

Military Lands Protect Habitat

Destruction of habitat by urbanization and agriculture appears to be the most pressing threat to California's restricted terrestrial communities on military bases. Resource managers at nearly every base west of the deserts mentioned threats found commonly throughout the state, as well as off-base development, not hazardous waste, as the most likely source of plant habitat loss on their base. Drought, exacerbated by water projects designed to encourage agriculture and urbanization, continues to degrade ecosystems in the Central Valley and in the deserts. Modification of the surrounding habitat leads to increased threats from introduced and invasive plant and animal species, with wetland, riparian, and grassland habitats most affected.

Near Coso Village, Coso Mountains in the Naval Air Weapons Station at China Lake.

Cattle grazing, permitted in the management plans of several bases in western Central California and in the Central Valley, and growing populations of feral pigs (*Sus scrofa*) in the Coast Ranges bring associated environmental problems such as stream siltation and vegetation trampling. Finally, toxic chemicals released from nearby mines continue to pollute streams that flow into Camp San Luis Obispo, pesticide use in the surrounding farms may be decimating native insect populations near bases in the San Joaquin Valley, and Point Mugu's list of over a dozen toxins in Santa Clara River-fed Mugu Lagoon testifies to the presence of hazardous agricultural runoff from the nearby Oxnard Plain.

Miscellaneous military-related disturbances on base properties represent another threat to the plants found on military bases. In 1988 at a Mojave Desert base a combat unit was found camped directly on a small patch of white-margined penstemon (*Penstemon albomarginatus*), severely damaging one of this species' three known locations in the world and the only one in California.

Bases are sometimes candidates for mitigation projects that result from the loss of endangered species at off-base sites. One such project resulted in a tidally influenced saltwater lagoon on NWS Seal Beach, built by the Port of Long Beach, as mitigation for the destruction of a fishery off-base. What historically had been a fully tidal mudflat wetland, and later converted to agricultural fields to provide a foraging ground for raptors, was returned to an estuarine condition.

Several installations have been or are currently used for environmentally destructive activities such as bombing practice. The largest ordnance testing areas are confined to the installations of the Desert Province, especially those in the Sonoran Desert. At the bases in the Mojave impact areas generally take up less than ten percent of the installations' property, while Camp Pendleton and Edwards AFB reserve larger proportions of their land for testing. Historical weapons detonation often has left buried ordnance and/or has disturbed habitats at numerous installations throughout the state.

While the impact of weapons testing on biotic communities has received little study, its effects depend upon the frequency and intensity of the bombings within these areas. At Camp Pendleton, the land in more intensively bombed areas burns frequently. The wildlife caught within this impact zone (one-fourth of the base's habitat) undoubtedly suffers as a result.

Military installations have enjoyed a history of lax environmental standards regarding the use and disposal of hazardous material, a term that refers to everything from engine oil to radioactive waste, and soil and water pollution persist on many bases. Federal programs have only recently begun to address the effects of decades of aircraft painting and paint removal that have left toxins in the soil, threatening the regional water table around McClellan Air Force Base and Moffet Field. At Point Mugu and Seal Beach, residue from missile launches and buried lead bullets from firing ranges are being cleaned up by the Navy.

Public Programs to Preserve Plants

In contrast to the environmental abuse that often accompanies military training, most California installations are involved in active conservation programs, generally in conjunction with the U. S. Fish and Wildlife Service (USFWS). The status of wildlife on military installations began to receive attention during the mid-1960s, when the federal government began to encourage bases to develop and update multi-use natural resource management plans with the help of the USFWS. Recent examples come from Miramar Naval Weapons Station, where base biologists are using GIS technology to assist in mapping the base's plant communities and locate rare plants or plant communities such as vernal pools or riparian corridors. Despite such efforts, few installations had such plans or even baseline wildlife inventories prior to the 1980s, and only in the 1990s have bases begun to consider the potential for community-scale habitat management of their property.

Within the DOD the Land Condition Trend Analysis program (LCTA) has begun long-term monitoring of the habitats and organisms at every major Army/Reserves holding. While not as comprehensive as complete biological inventories, the LCTA has allowed forts Hunter-Liggett and Irwin, and camps Roberts, San Luis Obispo, and Pendleton to institute vegetation and habitat mapping and vertebrate surveys to locate rare organisms. The Legacy Program, another DOD program, had financed resource management projects on military holdings across the country, but Congress recently voted to eliminate its budget for 1997, which was $50 million in 1993.

California's Resources Agency, the entity that includes the California Department of Fish and Game, launched the Natural Communities Conservation Program (NCCP) in 1991 to avoid the species-by-species battles similar to the situation in the Pacific Northwest. The NCCP seeks the cooperation of public and private landholders to protect critical habitat for numerous organisms before it is consumed or further fragmented by development. The coastal sage scrub community of Southern California was selected as the pilot area for the plan, and Camp Pendleton and Miramar have supported the objectives of the NCCP and agreed to share data with other agencies involved in planning. Discouragingly, only about fifteen percent of the remaining coastal sage scrub was protected under the NCCP in 1995.

Mojave fishhook cactus (*Sclerocactus polancistrus*) grows in limestone areas and in creosote-bush scrub in canyons at the Naval Air Weapons Station at China Lake.

The Nature Conservancy (TNC) has become one of the most active private organizations involved in conservation on military land. In 1989 TNC signed an agreement with the Department of Defense to inventory all "significant" military installations for their biodiversity, and has assisted in numerous base management plans. Of the many projects they are supporting, TNC is coordinating the establishment of an herbarium at NWS Fallbrook Annex and has paid for baseline plant, animal, and soil surveys to locate rare species and unique habitat areas at Fort Irwin and at Beale Air Force Base.

Future of Closed Bases

The most encouraging example of post-closure conservation attention on DOD property in California comes from Fort Ord, where more than half of the property (6,500 hectares) has been transferred to the Bureau of Land Management (BLM) for habitat preservation as part of a federally funded venture to convert the property into a new public university campus. With the rapidly develop-

ing Monterey Peninsula area currently expanding around Fort Ord, local conservation groups are working toward continued preservation of its rare plants and plant habitats.

The most urgent conservation problems involve installations that have closed and currently face development. With the Pentagon favoring fewer and larger bases, it may be assumed that any California base could close, leaving its plant communities vulnerable. Unfortunately, with the current practice of mitigating habitat destruc-tion by replanting and relocating rare taxa off-site, not even the presence of endangered species ensures habitat protection.

Several bases were not included in this study because they had no resources manager or have already closed; all of these properties could fall to development without a fight. The USFWS found the habitat protected by the recently closed George Air Force Base too marginal to warrant conservation; the remaining desert tortoises were removed from the land and fines were collected as developers bulldozed the few listed plants. On the fringes of the San Francisco Bay Area, Camp Parks has ceased operations with no adequate survey of the rare species undoubtedly present on the base. A similar situation occurred at Norton Air Force Base in San Bernardino, which protects a region of alluvial scrub along the Santa Ana River from local gravel mining operations that threaten the entire range of the federally endangered Santa Ana woolly-star (*Eriastrum densifolium* subsp. *sanctorum*). Habitats on closed or closing bases near other urban areas, such as Los Angeles, may be beyond saving because of the pace at which land is developed.

Fortunately, habitats in and around the larger and more remote bases in the deserts may be relatively safe from development with the 1994 passage of the California Desert Protection Act (Senate Bill 21). This measure guarantees protection of five million hectares in both the Mojave and Sonoran deserts and establishes a 600,000-hectare Mojave National Park along with over 1.5 million new hectares of wilderness. Unique or valuable habitat on these bases and on those in other sparsely settled parts of the state, such the endemic-rich serpentine chaparral communities of Fort Hunter-Liggett, should also be spared pressure from urbanization as resource managers continue to combat the other threats affecting these holdings.

The Defense Department must continue to work successfully with government agencies and private organizations to study and preserve the habitat protected by its installations, especially that of bases facing closure and realignment. Voters and law-makers must make intelligent land use decisions that protect the natural heritage of California as well as its economic potential, especially where the balance has been historically skewed, such as in the Central Valley and in southwestern California.

In this era of consolidation and base closures, California's installations could either become covered with office parks and golf courses or they could make meaningful contributions to the preservation of California's remarkable biodiversity. The successes of species and ecosystem management programs on several California bases provide a model of active conservation fully compatible with the military mission. The transfer of Fort Ord's natural areas to the BLM should set the trend for the accommodation of rare natural communities once bases have closed. By preserving wilderness, open space, and rare plants and plant habitats in Southern California, the use of military land for conservation could help avert further destruction of California's natural heritage.

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A prescribed burn in standing chaparral was conducted at Eagle Springs in Topanga State Park in mid-June. Photographs by the author.

CHAPARRAL RESPONSE TO PRESCRIBED BURNS IN THE SANTA MONICA MOUNTAINS

by Margaret L. Stassforth

IN RECENT YEARS the value of prescribed burns has been a topic of debate among public land managers, biologists, and fire agency personnel. Managers and biologists agree that fire is necessary for the maintenance of the chaparral community and that wildfires inevitably result from the buildup of dead fuel within aging vegetation. But what constitutes chaparral's natural fire frequency—the average length of time between fires—is still a matter of contention. Researchers have estimated the average interval between chaparral fires to be from ten to forty years, while others believe that the interval is much longer.

Fire suppression has been the preferred policy on most public lands for many years. Recently some land managers, hoping to restore the natural process of fire to shrublands under their stewardship, have been conducting prescribed burns more frequently than some ecologists find acceptable. However, Keeley and his associates describe chaparral as resilient to a wide variety of fire frequencies.

Long intervals between fires rarely occur in Southern California's Santa Monica Mountains, since almost all ignitions there are human-caused and frequent, making it difficult to find stands of chaparral greater than fifty years old. According to Scott Franklin, former vegetation man-

Bush poppy (*Dendromecon rigida* ssp. *rigida*) in bloom three and a half years after a burn on the Eagle Springs Loop site.

agement officer for the Los Angeles County Fire Department, average intervals between chaparral fires in the western half of the range are fifteen to seventeen years and around twenty-five years in the eastern section.

Fire agencies, charged with protecting lives and property, are concerned with fire safety and have practiced a policy of fire suppression in the Santa Monica Mountains for most of this century. It has become apparent, however, that fire suppression has not lessened the hazard, but has led to larger fires due to a greater buildup of dead vegetation. The problem of destructive wildfires is particularly troublesome in these mountains where large tracts of open shrublands intermingle with housing development. The Los Angeles County Fire Department has been conducting a series of prescribed burns in the central portion of the range since the 1980s, particularly at the urban-wildland interface. By creating a mosaic of different-age burns, they are making an effort to reduce the hazard of wildfires during the wildfire season.

Different Fire Regimes

A map constructed by Richard Minnich compares a fifty-one-year fire history of northern Baja California, where fire suppression is not practiced, with that of Southern California. His map shows a pattern of many small, different-age burns in Baja California, and a burn pattern of far fewer but much larger fires in Southern California with an occasional very large fire. In Baja California the pattern of small burns is the result of fire's tendency to stop burning when it reaches the boundary of less flammable, younger vegetation. This phenomenon was illustrated in the Santa Monica Mountains when the 1982 Dayton fire died down at the boundary of the 1978 Kanan fire. A more recent example occurred during the 1993 Old Topanga fire. The area burned by the smaller 1985 Piuma fire was contained within the perimeter of the Old Topanga fire. The wildfire burned with much less intensity in the younger vegetation and fewer structures were lost to fire than in the surrounding, older chaparral. Significantly, in Baja California during the study period more than 2,000 fires occurred with no fire more than 6,000 acres. In contrast, during the same period southern California experienced fewer than 400 fires, with a few fires consuming more than 50,000 acres.

Because prescribed burns are frequently carried out in winter and spring, objections have arisen concerning the negative effects on chaparral species resulting from out-of-season burns. Cool-season burns in California have resulted in poor shrub regeneration for those species that reproduce only by seed germination. The seeds of these species require scarification to germinate, and low-intensity burns generate insufficient heat to crack seed coats. It is thought that chamise (*Adenostoma fasciculatum*) burls can be negatively affected by fire when burned during the spring growing season because of low starch reserves in the burls during the growth period. Additionally, winter and spring burns have resulted in poor herbaceous response, since the ground is often wet at this time and the seeds of herbs that have imbibed water are usually killed by heat. The question is: can chaparral prescribed burns be conducted out of the wildfire season, while still maintaining the integrity of this vegetation community?

Burns in the Santa Monica Mountains

To answer this question I have been monitoring chaparral regeneration after prescribed burns conducted by the Los Angeles County Fire Department in the Santa Monica Mountains for the past ten years. These studies have focused on burns in untreated chaparral and in chaparral that had been crushed by bulldozer prior to burning. Each technique carries its own set of problems. In order to burn live chaparral successfully and safely, vegetation moisture readings must fall within a certain range—above this range the shrubs won't burn, and below it the danger of a fire escape is too great. Weather conditions must also fall within ranges prescribed for safe and effective burns on each site.

In the Santa Monica Mountains optimal conditions fell, during the years of burns in standing vegetation, in late June and early July. While these burns were not cool-season burns, they still ranged from low to moderate intensity. These fire intensities were favorable for resprouting species, but carried risks for obligate-seeding species. Big-pod ceanothus (*Ceanothus megacarpus*), one of the primary dominants in these mountains, and buck brush (*C. cuneatus*), another obligate-seeding species that occurred on two small sites, were most at risk. Because of the vegetation structure formed by these species—a high shrub

Regeneration of a mixed stand of chaparral (above) on a slope above the Stone Canyon Reservoir two years after a burn. Species include resprouting chamise (*Adenostoma fasciculatum*) and laurel sumac (*Malosma laurina*) and seedlings of big-pod ceanothus (*Ceanothus megacarpus*) and bush mallow (*Malacothamnus fasciculatus*). Resprouting Eastwood manzanita (*Arctostaphylos glandulosa*) (below) two months after the burn. Shoots are up to ten inches tall.

canopy with little dead wood beneath—cool fires can kill the shrub without delivering enough heat to the ground to scarify seeds. This is particularly a problem in pure stands of *Ceanothus* species because there is no understory of lower-growing plants to carry heat to the ground.

Standing chaparral, ranging from twenty-five to twenty-eight years old, was burned between 1986 and 1989 in a series of prescribed burns. Initial seedling densities—a measure of the number of seedlings germinating in a given space—for *Ceanothus* species were lower on all sites than those reported in the literature. In a study after a wildfire in the Santa Monica Mountains big-pod ceanothus average initial seedling density was ten per square meter. On the prescribed burns in the Santa Monica Mountains average initial seedling density for the same species was about four per square meter, dropping after several years to slightly

A bulldozer crushes mixed chaparral in January before April burn. The blade is set about three feet above the ground to avoid uprooting burls and moving soil.

less than two per square meter. However, initial seedling densities on the individual transects were extremely variable on the prescribed burns. Monitoring results suggested frequency levels—a measure of the spatial distribution of each species—high enough on four sites to maintain average previous contributions to these stands by ceanothus species. The fifth site showed a substantial reduction in frequency. Low seedling germination here resulted from a lack of scarification because of the high canopy and lack of understory.

Initial seedling densities for chamise were so varied as to make averages meaningless. However, even with resprouts and seedlings contributing to this species' regeneration, there was a reduction of chamise on three of the five burn sites. Field and laboratory experiments indicated a good relationship between heat and big-pod ceanothus seed germination, but no such results for chamise. The reduction in chamise thus can be attributed to both fire-caused burl mortality, although this mortality fell within the range of that reported on wildfires, and low seedling survival.

Ten non-dominant resprouting chaparral shrub species were monitored on the various sites, with all but two resprouting one hundred percent. Those resprouting were laurel sumac (*Malosma laurina*), sugarbush (*Rhus ovata*), Eastwood manzanita (*Arctostaphylos glandulosa* ssp. *glandulosa*), toyon (*Heteromeles arbutifolia*), holly-leaf redberry (*Rhamnus ilicifolia*), chaparral currant (*Ribes malvaceum*), mountain mahogany (*Cercocarpus betuloides*), and blue elderberry (*Sambucus mexicana*). None of the three spiny redberry (*Rhamnus crocea*) shrubs occurring on the transects resprouted, but two of the three greenbark ceanothus (*Ceanothus spinosus*) shrubs resprouted. Although most of these species produced nu-

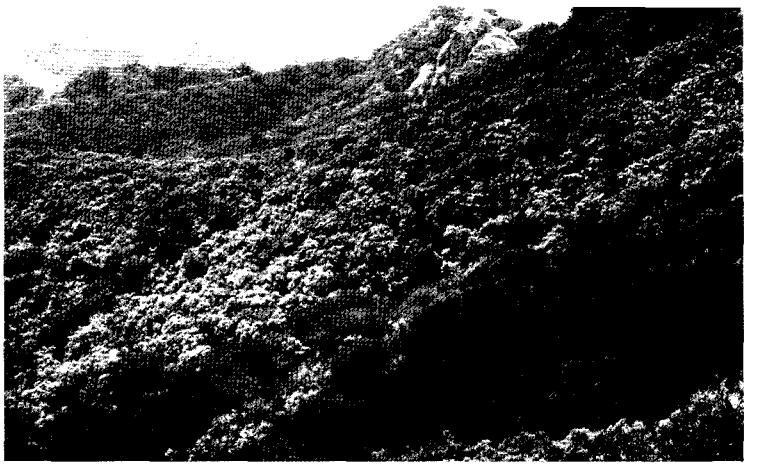
merous seedlings, few survived, with the exception of greenbark ceanothus seedlings. Regeneration of all other shrubs resulted almost entirely from resprouting. Thus, it would appear that the cooler prescribed burns favor reestablishment of the non-dominant shrubs listed above. While greenbark ceanothus had some burl mortality, survival of seedlings ensures its continued presence on the one site where it occurred.

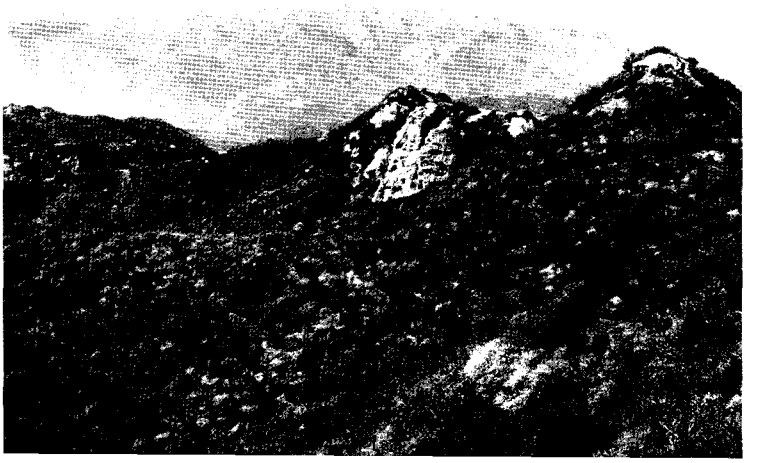
Crush-and-Burn Projects

Using the crush-and-burn technique, chaparral is crushed by bulldozer at least a month before burning, allowed to dry, and burned when weather conditions are optimal. The dry vegetation burns intensely at a time when the moisture of the surrounding vegetation is too high to cause a fire.

In 1992 a site was selected for a controlled burn near Entrada Road in Topanga State Park that had not burned since 1925. The site contained dense chaparral growth with a high diversity of shrub species resulting from its varied topography. Burning standing vegetation was not a viable alternative because houses surrounded the area on three sides. Although chamise was the most abundant species on half of the transects set out for monitoring purposes, various combinations of the resprouting greenbark ceanothus, laurel sumac, mountain mahogany, chamise, and scrub oak occurred on the other half. Twenty-five acres of mixed chaparral were crushed by bulldozer on the site in January and burned the following April.

Because this technique results in a hot fire burning close to the ground, the soil is heated enough to scarify seeds of shrubs relying solely or partially on seed germination for regeneration. However, uprooting burls was a significant problem for some species, particularly greenbark ceanothus and laurel sumac, with their large, heavy trunks. Crushing over wet ground undoubtedly contributed significantly to uprooting. Other species for the most part snapped off or, as in the case of mountain mahogany, were not uprooted at all. In addition, because resprouting occurs after crushing, there was a question as to whether these species would resprout a second time after burning. Although twenty percent of chamise and scrub oak shrubs monitored did not





Top to bottom: Chamise in bloom on a slope in Topanga State Park four years before the Eagle Springs prescribed burn. Large shrubs on the lower slope are primarily big-pod ceanothus with laurel sumac interspersed.• Immediately after the Eagle Springs prescribed burn, chamise has completely burned off but big-pod ceanothus shrubs are only partially burned.• Four years after the Eagle Spring burn, chamise and laurel sumac are growing well. There is some loss of big-pod ceanothus on the lower section of the slope. Bush poppy (*Dendromecon rigida*), a short-lived fire follower, bloomed prolifically over the whole burn site.• Six years after the Eagle Springs burn, chamise and laurel sumac continue to grow well. Old big-pod ceanothus is in bloom, but it is too soon in the fire cycle to see new seedlings from this vantage point. The gray clumps within chamise stand are dead and partially dead deerbrush (*Lotus scoparius*).

resprout, burls of the remaining species did. In spite of uprooted burls and burls that did not resprout a second time, seedlings of most shrub species germinated and survived to replace lost burls. The exception was chamise. Burl mortality and low seedling survival of chamise resulted in fewer individuals on the site than before the burn. Still, chamise remains the most abundant species on the transects, as it was before the burn.

Although sections of the site were damp when burning was carried out, seeds of herbaceous species germinated well. A fine mosaic of unburned and burned-over ground resulted from the uneven distribution of crushed vegetation, and a different group of herbaceous species appeared on burned and unburned areas. In fact, seventy-eight species were counted on the entire site, a far richer herb flora than occurred on any of the burns in standing vegetation. While herb and shrub seedlings had less-than-normal time for growth before the dry season, shrub seedling mortality was not increased over that found during the monitoring of burns in standing chaparral or reported in the literature on seedling survival after wildfires. All herbaceous species bloomed and set seed before the onset of summer's heat.

Another controlled burn was undertaken on Zuma Ridge in 1993. Conditions were different on this approximately 200-acre site, which last burned by wildfire in 1978, and results differed from those observed on the Entrada site. Crushed in April and burned in May, dominant species in the Zuma Ridge vegetation were chamise, mountain mahogany, and big-pod ceanothus, with greenbark ceanothus occurring on one transect. Because the vegetation was only fifteen years old, far less growth had accumulated here, particularly on south-facing slopes. Two northeast-facing slopes supported a heavier load of vegetation, and there was less dead fuel on all slopes. Crushing resulted in few uprooted burls because the younger stems were more flexible, and all clumps of mountain mahogany resprouted a second time after burning. However, low chamise seed germination coupled with burl mortality caused by the fire resulted in fewer chamise shrubs than were present before the fire. Moreover, the light fuel load did not burn intensely enough on most transects to scarify ceanothus seeds, with the exception of the two northeast-facing slopes. The heavier fuel load here led to a fire hot enough to scarify seeds and thus seed germination was adequate for shrub replacement.

The herbaceous flora was both diverse and abundant, in spite of areas of damp ground while burning took place. Thus, this site lost some small stands of big-pod ceanothus on south-facing slopes because not enough seedlings survived and chamise individuals have been reduced, while resprouting mountain mahogany held its ground. It is probable that the low seedling survival for chamise and big-pod ceanothus was due to the timing of this late spring burn which did not give seedlings adequate growth time before the summer dry season.

Management Implications

Assuming that fire prescriptions are followed and vegetation that cannot carry a hot fire is not burned, it would appear that prescribed burns can be conducted in the Santa Monica Mountains in such a way as to achieve hazard reduction while maintaining the natural chaparral ecosystem. Ideally, attention should also be paid to the vegetation fuel load, timing of burns, and reproductive mode of shrub species to be burned. While longer intervals between fires may be more desirable from a biological point of view, in these mountains where so much residential development intermingles with shrublands, the threat of aging highly flammable vegetation to lives and property is great during wildfires. A continuing program of contiguous prescribed burns over the years, which creates a fine mosaic of different-age fires at the urban-wildland interface, could greatly lessen this threat. Although it is impractical to expect to recreate an overall mosaic such as that found in northern Baja California, a program that creates a safer environment and maintains chaparral ecosystem integrity could be developed. The technology for doing this is available and should be used.

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Congdon's lewisia (*Lewisia congdonii*) is one of over three hundred sensitive plant species managed by the USDA Forest Service. Photograph by Lottie V. Jenvey.

SAW-TOOTHED LEWISIA: TO BE OR NOT TO BE

by Mike Foster, Elizabeth Carroll, and Valerie D. Hipkins

AMONG THE 300-plus sensitive plant species managed by the USDA Forest Service (FS) in California are three CNPS List 1B (rare and endangered in California) cliff-dwelling lewisias: saw-toothed lewisia (*Lewisia serrata* sensu stricto), Cantelow's lewisia (*L. cantelovii*), and Congdon's lewisia (*L. congdonii*). The recent reduction of saw-toothed lewisia under Cantelow's lewisia (*The Jepson Manual* 1993:902) prompted FS botanists from five Northern California national forests to team up with scientists from the National Forest Genetic Electrophoresis Laboratory (NFGEL) to analyze and compare the genetics of these rare plants.

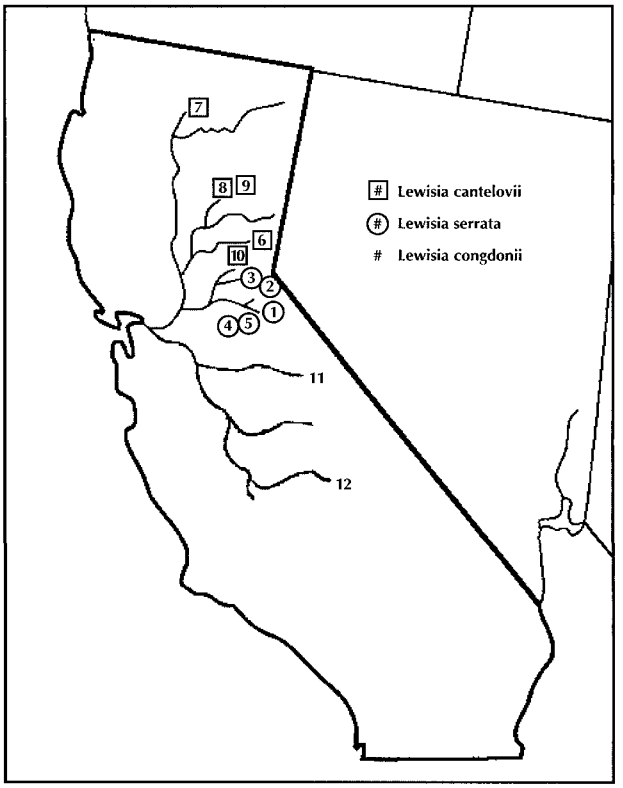
In the two decades since saw-toothed lewisia was described, the taxonomy of this plant has been subject to debate. In 1974 Heckard and Stebbins recognized that saw-toothed lewisia is closely related to Cantelow's lewisia, and with Congdon's lewisia the three taxa "form a series of geographic variants along the western Sierra Nevada." They chose to describe saw-toothed lewisia as a full species, since "their ranges do not overlap, and no morphological intergradation between them has been found." Saw-toothed lewisia was distinguished from Cantelow's lewisia by its coarsely serrate leaves, reduced number of cauline leaves, and smaller petals. Heckard and Stebbins also noted that saw-toothed lewisia possesses fewer pink veins per petal, a shorter scape and inflorescence, and smaller cauline bracts than Cantelow's lewisia.

Shortly thereafter, in 1975, Hohn also recognized that

Cantelow's lewisia is related to Congdon's lewisia but chose to consider saw-toothed lewisia as a morphological and geographically isolated subspecies of Cantelow's lewisia. Hohn based her determination primarily on the shapes and margins of the leaves, and stated that "no consistent morphological character could be found to substantiate taxonomic separation at the specific level." Hohn suggested that cauline leaf number is not a reliable indicator of phylogeny in the evergreen lewisias, and could not be used as a distinguishing character. In her key to the evergreen species of *Lewisia*, Hohn used leaf dentation (denticulate vs. serrate), leaf shape (apex retuse vs. rounded), petal length (7-8 mm vs. 6-7 mm), and distribution to separate *L. cantelovii* ssp. *cantelovii* from *L. cantelovii* subsp. *serrata*.

In 1989 Matthew retained saw-toothed lewisia as a full species "pending further studies," but recognized that an argument could be made for reduction to subspecific status under Cantelow's lewisia. Like Hohn, Matthew agreed that the cauline leaf number is not a useful distinguishing feature, but otherwise used the same characteristics for distinguishing these two taxa as Heckard and Stebbins—leaf morphology, petal length, and inflorescence architecture.

These three taxa are alike in many ways, including their relative rarity, general habitat preferences, and narrow endemism. Potential threats to these perennial herbs include horticultural collection, road maintenance, and hydroelectric development. Each taxon has a discrete geographic distribution though they all prefer bedrock cliffs or rocky slopes in rugged river canyons that are typically moist in the winter and spring and bone dry by midsummer. Congdon's lewisia is found in disjunct locations on the canyon walls of the Kings and Merced rivers. Saw-toothed lewisia is endemic to the canyons of the American River and its tributaries. Cantelow's lewisia enjoys a wider distribution from the inner gorges of the Yuba River north to the Feather River watershed, with two disjunct populations known from the middle reaches of the Sacramento River above Shasta Reservoir.



Location in northern California of *Lewisia serrata*, *L. cantelovii*, and *L. congdonii* populations sampled for genetic analysis. Sampled populations are indicated by number.

Saw-toothed lewisia (*Lewisia serrata*) is easily distinguished by its serrated leaf margins. Photograph by Mike Foster.

As pointed out in "Whither Rare Plants in *The Jepson Manual*" (*Fremontia* 22:23-27), not all of California's many taxonomic issues were resolved by the nearly concurrent release of *The Jepson Manual* and the CNPS *Inventory*, much of this due to the imperfect and dynamic nature of taxonomy. Saw-toothed lewisia provides a case in point. Not included in the key to the genus *Lewisia*, it is ambiguously placed at the bottom of the entry for *L. cantelovii*: "Pls with smaller infl, deeper lf serrations have been called L. serrata." This entry is noteworthy in that *L. serrata* has not been explicitly reduced to synonymy under *L. cantelovii* (for contrast, see *L. pygmaea* ssp. *glandulosa*).

For FS botanists on the Shasta-Trinity, Plumas, Tahoe, and Eldorado national forests, the taxonomic status of saw-toothed lewisia and Cantelow's lewisia raises more than just academic questions—it poses a conservation quandary. Forest Service botanists often conduct viability assessments regarding the impacts of proposed projects on sensitive plant species, an assessment that hinges in part on the known distribution and abundance of the species in question. The lack of consensus regarding the status of

saw-toothed lewisia challenged FS botanists to consider these plants in light of their own field experience. Based on a combination of inflorescence architecture, leaf morphology, habitat preferences, and range, we felt that an argument could be made for recognizing saw-toothed lewisia as a distinct species. To explore this determination, we collected and genetically analyzed live tissue samples from saw-toothed lewisia, Cantelow's lewisia, and Congdon's lewisia.

Genetic Analysis at NFGEL

NFGEL examined the genetic diversity of saw-toothed, Cantelow's, and Congdon's lewisia using isozyme analysis. Isozyme analysis is a technique that can identify genetic differences within groups of plants or animals. In the laboratory, plant material (such as seed or leaves) is prepared for analysis by first grinding the tissue in an extraction buffer. The ground sample contains a number of biochemical compounds, some of which are enzymes. The sample is placed in a starch gel and an electric current is applied to the gel which separates the enzymes contained in the sample.

Isozymes are enzymes that differ in their chemical properties and therefore migrate (or separate) to different positions on the gels. We visualize these isozymes by adding a substrate and dye that produces colored bands at the site of the enzymatic chemical reactions. Different banding patterns are observed when we stain for different enzymes. We are able to determine levels of variation and diversity when we visualize more than one band, or different bands, among individual samples of a taxon. Because isozymes are a product of DNA, an isozyme analysis screens individuals for variation in their DNA at the locus producing the enzyme.

Isozyme data allow direct quantification of the genetic variation within taxa, as well as measurement of the similarity between taxa. Genetic variation can be found at different taxonomic levels (i.e., among and within individuals, populations, species, etc.). In addition to quantifying the total variation in a taxon, isozymes can also show how much of that variation is found among subgroups. For example, if all individuals within the populations of a species contain the same genes near the same frequencies, most of the genetic variation for that species is said to reside within populations (each population carries about the same genetic information as any other population).

However, if individuals in one population contain genes not found in individuals in another population, most of the genetic variation for that species would reside among populations (populations would be genetically different from each other). These different levels of genetic variation represent what geneticists call "genetic structure" and provide a way of looking at how genes are patterned across the landscape. Isozymes can also provide a direct measure (at least at those genes measured) of the genetic similarity between taxa. The magnitude of the genetic similarity among populations can have important ramifications in choices of which and how many populations of a species to conserve. These direct, quantifiable measures are not possible with other data such as morphological characters.

Besides quantifying the amount and distribution of genetic variation within a taxon, isozymes can be applied to such problems as identifying individuals and hybrids, distinguishing ramets from genets, and determining parentage. Isozymes are also useful for testing species concepts, especially when dealing with taxa that are morphologically similar. Although a taxon can't be recognized as a species solely on the basis of isozyme data, the presence or absence of certain genes can provide evidence to support a species recognition.

In our study of *Lewisia*, FS botanists collected leaves from at least thirty individual plants per population and shipped them to NFGEL. Five populations each were

NFGEL

THE NATIONAL FOREST Genetic Electrophoresis Lab (NFGEL) was established in 1988 to provide a link for applying Forest Service research to national forest management problems. NFGEL's mission is to provide Forest Service personnel the opportunity to assess genetic diversity to aid in decision-making. NFGEL's analyses utilize both DNA and isozyme technologies and are kept current through our continual contact with the research community.

Following development of the Forest Service Genetic Resources Strategic plan, NFGEL's program expanded to encompass new areas of challenging research. A whole new array of questions relating to threatened, endangered, and sensitive plants has provided NFGEL with new and intriguing work.

NFGEL works closely with botanists and other natural resource specialists to ensure that analyses and methods are appropriately addressing the issues at hand. Our quality assurance program exemplifies the FS commitment to long-term genetic research in providing quality results to our on-the-ground managers.

Future projects will increase knowledge and awareness of the genetic diversity found on our national forests by providing crucial data for ecosystem management. NFGEL is located at the USDA-Forest Service Placerville Nursery in Camino, CA; call ahead and arrange for a visit. We always enjoy visitors. (916) 642-5065.

Leonardi Falls is the type locality for *Lewisia serrata*. Photograph by Mike Foster.

sampled from saw-toothed and Cantelow's lewisia, and two populations from Congdon's lewisia. Samples were prepared and electrophoretically analyzed at twenty-two isozyme loci following NFGEL standard operating procedures.

Genetic Variation and Similarity

The isozyme results corroborate what Heckard and Stebbins recognized: saw-toothed and Cantelow's lewisia are more closely related to each other than either is to Congdon's lewisia. Additionally, the three taxa are genetically distinct from each other and contain more isozyme variation than the average plant species. According to Hamrick and Godt, the average expected heterozygosity (a measure of genetic diversity) in plant species is 0.149. Expected heterozygosity in saw-toothed, Cantelow's, and Congdon's lewisia are 0.219, 0.349, and 0.286, respectively. An expected heterozygosity value of zero indicates that there is little or no genetic diversity measured within a species or population. Saw-toothed lewisia populations contain less total genetic variation relative to populations of Cantelow's and Congdon's lewisia.

The isozyme data indicates that saw-toothed and Cantelow's lewisia are not exchanging genes and are, therefore, maintaining separate gene pools. This can be shown by looking at the data for the gene PGI-2. Every individual of saw-toothed lewisia that we analyzed is homozygous for allele #1 (all individuals contain the same form of the gene). However, no individual of Cantelow's lewisia contains an allele #1, but instead contains either allele #2 or allele #3. Individuals of Cantelow's lewisia are either heterozygous (contain one allele #2 and one allele #3) or homozygous for either allele #2 or allele #3. If saw-toothed and Cantelow's lewisia were exchanging genes, we would observe some #1 alleles in Cantelow's lewisia and some #2 and/or #3 alleles in saw-toothed lewisia. In addition, at the genes we measured, there are twenty-two alleles in Cantelow's lewisia that are not found in saw-toothed lewisia, and five alleles in saw-toothed lewisia that are not found in Cantelow's lewisia.

Genetic identity values are often used to assess the similarity among populations, infraspecific taxa, and species. Generally, the average genetic identities among populations of a species are high (genetic identity is often > 0.90; i.e., populations are at least ninety percent similar to each other), while lower genetic identities are characteristic among species in a genus (0.67; i.e., species in a genus share on average sixty-seven percent similarity). According to Crawford, genetic identities of infraspecific taxa often range from approximately seventy to ninety percent.

Saw-toothed and Cantelow's lewisia share sixty-seven percent genetic similarity (genetic identity = 0.67), which coincidentally matches that of the congeneric average genetic identity for plants. Populations within Cantelow's lewisia share at least seventy-four percent similarity, and those within saw-toothed and Congdon's lewisia share at least eight-two and eighty-seven percent similarity, respectively. Saw-toothed lewisia populations 1 and 2 and 4 and 5 show almost complete genetic similarity within pairs. Therefore, within these two pairs of populations the alleles are very similar in their presence and frequency.

Populations 1 and 2 share 99.7 percent similarity and occur along the same American River northern tributary, while populations 4 and 5 are 100 percent similar and are located close together along a southern tributary of the same river. These two sets of paired populations may actually represent two large populations instead of four.

Genetic structure estimates indicate that these lewisia populations are genetically distinct, or different, from each other. When we look at all the genetic differences we measured in saw-toothed lewisia, thirty-seven percent (FST = 0.37) of these are unique to a population. The remaining sixty-three percent are genes that are found in any of the saw-toothed populations. In Cantelow's lewisia, forty-six percent (FST = 0.46) of the measured genetic differences are unique to a population (or we can say 'among populations'). This amount of among-population variation is quite large compared to other plants and shows that, generally, a single lewisia population carries genetic variation that is not found in the other populations.

Management Implications

Overall, the lewisia populations we studied are highly differentiated as demonstrated by the slightly low genetic identities (seventy-four to 100 percent) among the lewisia

Starch Gel Electrophoresis — The Process

IN THE LABORATORY, plant material (such as seed or leaves) is prepared for analysis by first grinding the tissue in an extraction buffer. The ground plant sample contains a number of biochemical compounds, some of which are enzymes. The sample is placed in a starch gel and an electric current is applied to the gel which separated the enzymes contained in the sample. Isozymes are enzymes that differ in their chemical properties and therefor migrate (or separate) to different positions on the gels. We visualize these isozymes by adding a substrate and dye which produces colored bands at the site of the enzymatic chemical reactions. Different banding patterns are observed when we stain for different enzymes. We are able to determine levels of variation and diversity when we visualize more than one band, or different bands, among individual samples of a taxon. Because isozymes are a product of DNA, an isozyme analysis screens individuals for variation in their DNA at the locus producing the enzyme.

populations, and the high genetic structure estimates (indicating that most of the variation we measured is found among the populations). Smaller, more ecologically limited populations, such as those of these lewisias, may have a decreased potential for gene flow, resulting in more differentiation and isolation among populations.

Our isozyme data supports the recognition of *Lewisia serrata* as a separate species. The calculated genetic similarity between saw-toothed and Cantelow's lewisia is consistent with the identity value for the average congeneric species. Also, the presence of alternate alleles at the PGI-2 locus, and the existence of a large number of species-specific alleles, indicates that saw-toothed lewisia and Cantelow's lewisia are reproductively isolated and are maintaining separate gene pools.

There are multiple definitions of what constitutes a species. The familiar 'biological species' is basically defined as a reproductively isolated system of breeding populations. However, other often used concepts of species include an ecological species, evolutionary species, genetic species, and biosystematic species. When employing a genetic and evolutionary species concept, our isozyme data indicates that saw-toothed lewisia is a full species and not a subspecies of Cantelow's lewisia. Genetic distances are indicative of congeneric species (genetic species concept) and illustrate the isolation among populations. The existence of alternate alleles in the data shows that the two species are reproductively isolated, and therefore, are on separate evolutionary pathways (the evolutionary species concept).

The isozyme analysis indicates that saw-toothed lewisia is distinct from Cantelow's lewisia and the genetic data, on its own, supports Heckard and Stebbins classification of *L. serrata* as a separate species. Additional field work and a comparative analysis of morphological traits is currently being performed by Sandi Richerson, Sacramento State University, in an effort to gain further insight into the taxa. However, based on available morphological, ecological, and now genetic information, FS botanists will continue to refer to this taxon as *Lewisia serrata*.

For FS botanists, the results of this study show that these two rare plants have distinct genomes and are therefore worthy of continued consideration as sensitive species. To ensure that allelic and genotypic diversity is retained within these species, all populations should be maintained, and impacts to individuals avoided or minimized.

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Clay mariposa lily (*Calochortus argulosus*), the Inner Coast Range form, usually has one base color on the inner and outer petals, while the Outer Coast Range forms are usually bicolored with a white interior and pink or lavender exterior. Photographs by the author.

THE GENUS CALOCHORTUS IN CALIFORNIA: PART II

by Hugh P. McDonald

Part I of this article appeared in the July 1996 issue of *Fremontia*, pages 25-28.

Mariposa Section

Mariposa species bloom from late April to early May. Flowers are generally large, upright, and open with three large petals forming a grail or goblet-shaped bloom. For convenience these will be grouped by primary habitat below, but it should be noted that many of the species occur in more than one habitat.

Native perennial bunchgrasses or introduced annual grasses of Eurasian origin, or some combination, cover California grasslands. What such areas looked like before the introduction of annual grasses is anybody's guess, but such exotics do not seem to prevent the growth of calochortus species. Probably the earliest of the grassland species is Santa Catalina mariposa (*Calochortus catalinae*), which can be found in bloom as early as April. This species grows near the coast in Southern California, from southern San Luis Obispo County to San Diego County. It is found on windward slopes of the Coast Ranges, often in grassy openings, and less frequently in chaparral. Its habitat is wet by Southern California standards; the plant is nourished by storms from the Pacific. The flowers are lilac or, more commonly, bicolored with lavender tones on the outer petals, white on the inside, and dark purple spots at the base of the inner petals. Another early-blooming grassland species is Davidson's mariposa (*C. davidsonianus*), which occurs a from Ventura County south to San Diego County and from the coast to high in the Peninsular Ranges. In high-altitude meadows, the plants bloom up to two months later than on the coast. The petals are generally pink, with a few hairs on the inner base.

On the inner leeward side of the Central Coast Ranges, beautiful mariposa (*Calochortus venustus*) grows on grassy slopes from the Bay Area south to Los Angeles County and in the southern Sierra Nevada. In the Sierra the plants often grow on steeper terrain, which compensates for the greater rainfall they receive. At higher altitudes *C. venustus* can be found growing among shrubs and even in shade in

pine forests. Flowers of this species come in a wide range of colors, including marvelous bicolors with red or pink on one side and white or yellow on the other. The inner and outer petals have elaborate spots, striations, and other markings, often in still other colors, so that the overall effect is one of great beauty. Some consider these to be the most beautiful flowers in California, quite outstripping the state flower in aesthetic appeal and diversity. Still another Inner Coast Range species is the San Luis Obispo mariposa (*C. simulans*), a relatively rare plant confined to a small area in eastern San Luis Obispo County. This species grows on grassy slopes, in chaparral, and even in oak woodlands. The flowers are usually bicolored, with white or, more rarely, yellow on the inner petals and lavender or pink on the outside. Like *C. splendens, C. catalinae*, and some other species, there is a small, rounded spot at the base of the inner petals.

To the north, Hoover's mariposa (*Calochortus argillosus*) grows in grasslands from northern Santa Barbara County to Contra Costa County. In the southern part of its range, this species grows on the coast, but further north, where the rainfall is greater, it is found inland. (The coastal form may be a distinct species; it is at least a distinct variety.) Flowers in the coastal form are white on the inside and lavender on the outside; there are red markings at the base of the inner petals. The northern variety, which grows around San Francisco Bay and in adjacent counties, is either bicolored, with white on the inside and lavender on the outer, or more monochromatic. The flowers also have mariposa markings on the petals, with spots, blotches, or striations in glorious profusion and variety. Each flower in a stand is slightly different: nature prefers variety in many of the *Calochortus* species, and uniformity in others. Often growing in the same location in the San Francisco Bay Area is gold nuggets (*C. luteus*), which shares grassy meadows with *C. argillosus* on the central coast and occurs up through the North Coast Ranges to Shasta County and south again in the foothills of the Sierra Nevada all the way to Kern County. This is the only species known to occur in the Sacramento Valley, although it is sparse there. The plants are more common, even abundant, just as one leaves the valley and encounters the first slopes of the foothills. The form in the North Coast Ranges and Sierra foothills is slightly different than the Central Coast Range form, as the former usually has a brown spot on the middle of the yellow petals. *Calochortus luteus* is perhaps the most common California species. Flowers also occur at higher altitudes, where hybrids between them and superb mariposa (*C. superbus*) can be found. Hybrid stands contain both yellow and white flowers, reflecting the primary color of each parent species. Superb mariposa grows in bunchgrass meadows as well as more shady shrub or pine-oak woodlands, usually at higher altitudes than *C. luteus*. The species ranges from Kern County north to Shasta County and also loops around in the inner North Coast Ranges. Abundant stands can sometimes be found in the central Sierra Nevada and in Shasta County. The flowers come in a multitude of colors, from white through yellow, pink, lavender, and purple to red, with interesting bicolors, and the full panoply of mariposa markings.

Near the northern end of the range of *Calochortus superbus* is perhaps the rarest California species of all, Callahan's mariposa (*C. syntrophus*), a newly discovered species. This plant grows in only one small area of Shasta County. The flowers are white with a yellow throat and a red spot on the middle of the petals. It blooms in June.

A May-blooming species usually found in chaparral is splendid mariposa (*Calochortus splendens*), a tall, graceful plant with exquisite pink or lavender flowers. The petals are covered with a few long, white hairs and, in some stands, there is a small, purplish, dark spot at the base of the petals. The plant grows between the shrubs and must get quite tall for its blooms to reach the sun. The shrubs provide support against the winds, protection from certain predators, and light shade. This species ranges from Colusa County in the north to Ventura County, mostly in the Inner Coast Ranges. Dunn's mariposa (*C. dunnii*) is much rarer and grows in chaparral to the south in San Diego County and Baja California. It is confined to only three known stands, all at fairly high altitudes in the Peninsular Ranges. A June bloomer, it has white flowers with brown mariposa markings at the base of the inner petals.

Deserts are often ablaze with mariposa flowers even earlier than those found along the coast. Straggling mariposa (*Calochortus flexuosus*) can be found as early as April in southeast California at the border between the low-altitude Colorado Desert and the medium-altitude Mojave. It grows with less than fifteen inches of annual rainfall and is among the most difficult to establish in cultivation outside the desert. The species ranges from California eastward to Colorado, where the flowers can bloom up to two months later. In California the plant is frequently found near washes, which are wet by desert standards. Here it can take advantage of the extra supply of water channeled through the wash during infrequent rains. The plant often twines itself up among tough desert shrubs or lies prostrate on the rocky desert floor. The flowers are white to lavender, with a yellow throat.

Alkali mariposa (*Calochortus striatus*) grows in the desert in wet meadows formed by streams and springs coming out of the mountains. The streams, fed by snowmelt, have found their way leeward to the desert, and they flow out until they disappear into sinks: rare desert wetlands. The plant is as rare as the desert wetlands themselves. Flowers are white or pink with narrow, dark stripes on the petals. The species ranges from San Bernardino County to southern Nevada, in a horseshoe-shaped range at the edge of the Antelope Valley and then northeast into Nevada. The plants can also be found in low-lying mountain meadows on the leeward side of the slopes, blooming in May.

For species growing in the mountains, bloom time is

Calochortus for Specific Climates

Mild moist climates

C. albus
C. amabilis
C. amoenus
C. pulchellus
C. monophyllus
C. tolmiei
C. umbellatus
C. uniflorus
C. argillosus
C. catalinae
C. davidsonianus
C. luteus
C. palmerae
C. splendens
C. superbus
C. venustus (Sierra strains)
C. vestae
C. clavatus (Outer Coast Range forms)
C. obispoensis
C. plummerae

Mild dry climates

C. albus (Southern California strains)
C. catalinae
C. flexuosus
C. splendens
C. simulans
C. striatus
C. concolor
C. kennedyi
C. clavatus
C. ambiguus
C. plummerae
C. venustus (Inner Coast Range strains)
C. weedii

Cold dry climates

C. elegans
C. greenei
C. flexuosus
C. leichtlinii
C. venustus
C. macrocarpus
C. bruneaunis
C. kennedyi
C. invenustus

Cold moist climates

C. albus (Sierra form)
C. amabilis
C. coeruleus
C. elegans
C. minimus
C. nudus
C. uniflorus
C. longebarbatus
C. leichtlinii
C. palmerae
C. superbus
C. vestae

delayed until the snows melt. Montane wetlands flooded by streams remain wet longer than surrounding dry areas. In the mountains of Southern California, Palmer's mariposa (*Calochortus palmeri*) has adapted to these wet mountain meadows, sometimes called cienegas, in the Tehachapis and the Transverse and Peninsular ranges. The species also grows on the banks of alpine streams or even right in them in a few instances. At lower altitudes, where the plants bloom in late May, Palmer's mariposa is rare; more frequently, it is encountered at high altitudes blooming in June and July. The flowers are white to purple with small brown spots at the base.

To the north, in the dry montane habitat in the Sierra Nevada and Cascade and Warner ranges, species from Mediterranean-type climates must do all of their growing in a short time. With little summer rain in California, the annual water supply, however voluminous, disappears in the period between late spring and the end of the rainy season, which quickly follows. Montane species adapt by growing quickly. This is the pattern for Leichtlin's mariposa (*Calochortus leichtlinii*), a common plant at high altitudes in the northern Sierra Nevada. The plant is easily seen in Yosemite National Park in June and July. The flowers are almost always white with a yellow throat and black mariposa markings, but can be grayish, or rarely pale yellow or pink. The plants are usually found in grassy openings between conifers.

Goddess mariposa (*Calochortus vestae*) grows in the North Coast Ranges. The plants can be found in low-lying grassy meadows blooming as early as May, but are more common on higher altitude ridges and peaks in June. This species prefers wet growing conditions, but summer drought. Like superb mariposa and beautiful mariposa, the striking flowers have variable combinations of colors and patterns on the petals. The species ranges from Napa County to Humboldt County.

Another type of mariposa that grows in California is a close relative of the Utah state flower, the sego lily. These occupy some of the same habitats as the mariposas covered above, and often can be found growing nearby. A species that grows in both grassland and chaparral is the "club-haired" mariposa (*Calochortus clavatus*), which has knobby, hairy nectaries surrounded by club-shaped hairs. There are two varieties in the Central Coast Ranges. Inland, on leeward slopes, is a pure yellow form, which ranges from Stanislaus County south to San Luis Obispo County in grasslands of the Inner Coast Ranges and blooms in May. On windward slopes, centered in San Luis Obispo County, is a form with yellow petals and extensive brown markings, which blooms in June. To the south is an intermediate form with lighter brown markings. This plant blooms in the Santa Monica and Tehachapi ranges in May. The latter two forms are chaparral endemics. Finally, there are disjunct populations in the central Sierra Nevada that bloom in late June and into July. This last form resembles the well marked form from San Luis Obispo County, although there are minor points of difference. The Sierran plant grows in woodlands, although the plant seems to bloom better when the woods burn in one of the periodic summer fires caused by lightning.

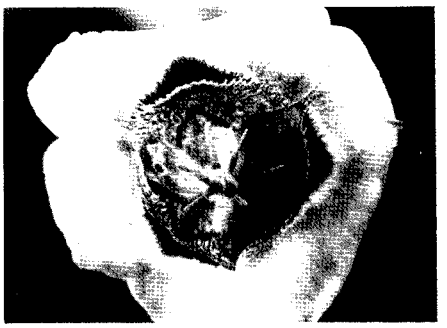
South of the range of the club-haired mariposa is another sego lily relative. This plant closely resembles *C. clavatus* and occupies similar chaparral habitat to the south. The June flowers can be found at high altitudes in the Peninsular Ranges, from San Bernardino County south to northern Baja California. The large, yellow blooms of goldenbowl mariposa (*C. concolor*) are an impressive sight appearing between the closely spaced shrubs. At still higher altitudes is shy mariposa (*C. invenustus*), which grows in montane habitat not unlike that of *C. leichtlinii*

and blooms at much the same time. However, the range of *C. invenustus* lies south and west of the Sierran species. This species can occasionally be found as far north as Alameda County, but it is much more common in the higher San Gabriel, San Bernardino, and San Jacinto mountains. There it grows in clearings among the pines or among small shrubs. The plants are small and delicate with flowers in subtle shades of white, pink, and lavender, often in combination with one another. Far from being not beautiful, which is the literal translation of its Latin epithet, the beauty of shy mariposa charms all who find it.

California's deserts have their sego relative as well, the well known desert mariposa (*Calochortus kennedyi*), which blooms about the same time as the other desert species in late May. The spectacular flower is a brilliant vermilion, which stands out even more against the subdued grayish tones of the surrounding flora in its desert habitat. The plants are most at home on juniper and sage slopes, but can be found on flats in the drier parts of the desert, growing well away from creosote bush on tiny stems, buried to the neck as it were. Like *C. flexuosus*, this species ranges considerably to the east: as far as west Texas according to some reports. In the eastern and northern Mojave, other color forms appear, including orange, apricot, and yellow.

To the north, in eastern California, the medium-altitude Mojave is gradually replaced by the high deserts of the Great Basin with their own mountain ranges and intervening sage valleys. High deserts have a temperate climate pattern, with four seasons. They are much colder in winter than low-altitude deserts, although summers are almost as hot. Two sego lily relatives have adapted to these extremes of temperature, one in dry habitat and the other in wetlands. The Great Basin mariposa (*Calochortus bruneaunis*) is a sego lily look-alike that ranges from eastern California across Nevada and Oregon to Idaho, Montana, and northwest Utah. The plants grow both on sage slopes and in juniper and pinyon forests of the Basin Ranges. This species survives cold with little snow cover, and then grows in the brief spring with scant rainfall and drying desert winds. Despite its forbidding habitat, the plant is fairly abundant in eastern California and Nevada, perhaps because few others compete for such unappetizing terrain. The flowers are brilliant white with dark sego lily markings above green or yellow at the base of the petals and a green vertical stripe on the exterior. It is not easy to grow on the coast but well worth the effort. In the wild the flowers bloom from May to July, depending on altitude.

Just as the Mojave Desert has small wetlands fed by streams and springs from the Transverse and Tehachapi ranges, and northeastern California has wetlands fed by streams from the Cascades, there are seasonal wetlands in the Owens Valley fed by streams and springs flowing from the Sierra Nevada. Owens Valley mariposa (*C. excavatus*) ranges from Inyo to Mono counties in seasonally wet meadows that are fed by streams flowing east out of the high Sierra through the desert into the Owens River. Mineral salts collect in these bottomlands, and a few specialized plants have adapted to the unusual growing conditions in these salt-laden meadows. Owens Valley mariposa is another sego lily relative that has found a niche in this limited habitat. The plants prefer the light shade of shrubs, but will grow in the open. As with its nearby dryland relation, *C. bruneaunis*, the petals are crisp white, with dark spots at the base. The flowers appear in May and June. Unfortunately, the Metropolitan Water District of Southern California bought up the water rights to much of this runoff, and water that once nourished plants in Owens Valley now irrigates the golf greens and lawns of subdivisions originally covered with drought tolerant shrubs and wildflowers. As a result, Owens Valley mariposa is on the CNPS watch list.



Even further north in the desert is sagebrush mariposa (*Calochortus macrocarpus*), with large lavender and blue flowers. It is among the many species that grow with artemisia. The plants also grow in association with juniper and other desert-montane species. Sagebrush mariposa can be found on the eastern side of the Cascades, in volcanics. It ranges north and east from Lassen, Modoc, and Siskiyou counties to British Columbia and Montana. This species is not a sego relative, but stands by itself among the mariposa lilies with its long sepals and gray-green stems. The flowers are variable in color, from purple and blue tones to rarer whites and pinks in the north. It is a common species on the Columbia Plateau, blooming from late June to as late as August at higher altitudes.

Cyclobothras Section

Finally, most botanists recognize a third section or division of the mariposa lilies, although this has recently come under critical scrutiny. The third division has fewer species in California; most of its members are found in Mexico. These are the Cyclobothras of southern and central California. The four species in this group grow in similar habitats but in different parts of the Coast Ranges. In general they grow on windward slopes, but at least a

The endemic Callahan's mariposa (*Calochortus syntrophus*) (top), was recently discovered in east Shasta County. *Calochortus superbus* (bottom) has unusually large "nectar guides" which lead the pollinator in towards the V-shaped nectary.

few stands of each species can be found on the dry leeward sides. Their habitat is chaparral, often on steep slopes, where the tall plants can be partly shaded from intense sun. They all bloom late for coastal species, generally in mid- to late June and into July. This late-blooming habit is a characteristic of the group unrelated to altitude, rainfall, or other geographic factors. To the south, in San Diego, Orange, and southwest Riverside counties, as well as in Baja California, grow Weed's mariposa (*Calochortus weedii*) and its color varieties. The flowers are usually a bright yellow, but on many plants there are brown markings. The inner petals and edges are covered with short hairs, each of which has a tiny spot at the base. The flower is goblet-shaped on a rather tall stem. In Orange County there is a form that is bicolored with a pale cream base and a purplish top. Plummer's mariposa (*C. plummerae*), which is similar in form, grows from northeastern Riverside County up through the San Bernardino Mountains and west into the San Gabriel and Santa Monica mountains. It is more variable in color than *C. weedii*, with purple, lavender, rose, pink, red, and bicolor forms and some flowers so pale that they are almost white. Unfortunately, it grows in foothill canyons on land attractive to developers, so it has recently become endangered.

Further north and west is another species, vestus mariposa (*C. vestus*). This is a fairly rare species that grows only in the area around Santa Barbara and Ojai and in a disjunct population in southwest Monterey County. The plants grow on ridgelines, slopes, and occasionally in grassy openings, usually in the partial shade of shrubs or oaks. The petals can be white, pink, or reddish, but are usually mottled red and white. The flowers have a distinctive band of thickly packed brown hairs around the petal edges, referred to as a fringe in tulips. The plant also blooms later than all the other California species, in late July and into August. This late-blooming habit is not the result of winter snows delaying spring growth, for in its coastal habitat the temperature rarely gets below freezing even on December nights. This is simply a characteristic of the species, one of several that distinguish it from species to the south and north.

Moving north along the coast, another species can be found whose relation to the three other Cyclobothras is remote. Instead of a large goblet, its flower is small, star-shaped, open, and intensely covered with petal hairs. The blossom looks something like a yellow and brown cat's ear, so hirsute are its petals. This is the San Luis Obispo mariposa (*Calochortus obispoensis*), a fairly rare species confined to the vicinity of San Luis Obispo. Like Weed's and Plummer's mariposas, the plant blooms in June, primarily on chaparral slopes.

Finally, there is one species from even further north that has yet to be classified satisfactorily. It shares some of the characteristics of the Cyclobothras and some of section Calochortus. This is the now well known Tiburon mariposa (*Calochortus tiburonensis*), discovered only twenty years ago, which grows only on Ring Mountain Preserve in Marin County. The flowers of this unusual species are tan or brownish with yellow and brown petal hairs and other markings. Despite its small numbers, it is variable, no two quite alike. Its habitat is a serpentine outcrop just east of a ridgeline with scattered grasses and rocks. This is a fairly wet area, although somewhat protected from Pacific Ocean storms by Mt. Tamalpias and other peaks to the west.

Growing Mariposas

California is home to almost two-thirds of the known species of the genus *Calochortus*. Adjacent states such as Oregon and Arizona have a few more, so most of the species are at home in our climate. California bulbs have evolved in their native habitat by adapting to its patterns of climate. For the most part this consists of a wet winter and spring and a dry summer and autumn. With rare exceptions, the bulbs are adapted to this pattern of wet and dry seasons. Thus the first and most important rule for growing calochortus and most other native bulbs is that they should not be watered in summer. If they are they will rot and not reappear the next year. The serious grower will therefore grow calochortus in an area that is kept dry in summer and early autumn. If an area of ground is not available, the bulbs should be grown in containers or pots that are dried out in summer.

If it rains more than a trace in any given week, no watering is necessary. If it does not rain the bulbs should get one inch of supplementary watering. Bulbs from dry areas, such as the Inner Coast Ranges, can easily withstand a week without watering, especially in the ground, and should not be watered unless it hasn't rained significantly in two weeks and no rain is expected. In other words, species from low-rainfall areas will survive on normal rainfall unless it is a drought year. The desert species should never be watered, even in dry years. They will be quite content with the reduced rainfall of dry years, and may even bloom better during droughts. A good rainfall year to us may be a deluge for desert species, so cease all watering at the end of the rainy season, usually mid-May; calochortus bulbs do not want to be kept slightly moist during the summer; they want to be dried out completely.

Seeds should be planted one-quarter to one-half inch under the surface of the soil or potting mix. They can be planted any time before the rainy season begins. In areas with wet climates, such as northwest California, a small amount of fungicide can be added to the top of the mix or soil to prevent damping-off of species from drier areas, but most local species don't require this treatment. Bulbs should be planted from two to four inches deep, the larger bulbs deepest. Species from the desert should be planted still deeper.

A good potting mix for general use was developed by the University of California at Davis. It consists in one-half sphagnum peat moss and one-half sharp, coarse sand by volume. This must be mixed by the grower, as it is not yet available commercially; peat is available at most nurseries. This mix has been tested and works well with all *Calochortus* species. However, other light, well drained mixes have also been used successfully; these usually contain from one-third to one-half sand, which is the drainage element, plus various combinations of organic matter or soil. A bulb fertilizer should be mixed in, e.g. Lilly Miller Bulb and Bloom or 49er Bulb Fertilizer. Bulb fertilizers are better for bulbs than other types of fertilizers, as they are especially formulated for bulbs. Use of manure is not advised. A small pot will do for the smaller species, such as cat's ears, while a larger, one-gallon pot is advised for the larger species. This size pot has enough capacity for up to ten bulbs if they are given sufficient fertilization.

If there is an area of ground available that can be kept dry in summer, most species will do better in the ground. In heavy, clay soils, peat and sand should be mixed into the soil. The soil should be amended by adding up to fifty percent UC Davis mix by volume and to a depth of about eight inches, to add drainage and texture. In sandy soils only peat needs to be added for enrichment. For in-between soils, less amendment is necessary, especially if there is good drainage. Small rocks should be left in the soil. Some calochortus will survive any type of soil, but the soil amendment is best for many different types of bulbs or out-of-area bulbs. A small amount of bulb fertilizer is beneficial in most soils. Species from dry areas may get too much water in the ground, and may do better in pots in wetter areas.

Most species prefer part shade or filtered shade, at least during the heat of the day. More specifically, most prefer that the base of the plant is shaded and the top, especially the flower, is in sun. This can be easily arranged by placing the pot behind some slightly taller item, so that the pot, but not the entire plant, is shaded. In very hot areas, potted plants can be placed on the east side of the house or structure, and the plants will receive morning sun, but not the more intense rays of the afternoon. Fairy lanterns and pussy ears prefer filtered shade, as in a lath house or under a tree or shrub with an open canopy. On the coast shade may not be necessary.

Rodents will eat most native bulbs, while deer, grasshoppers, snails, and slugs will eat the foliage. Aphids and other sucking insects can stress the plants by piercing and sucking. Keep in mind the maxim that "the enemy of your enemy is your friend." Barking dogs can sometimes scare away timid deer, while the odor of wild onions may curb their appetites. Birds check the grasshoppers; cats control rodents. Lady beetles, lacewings, and spiders prey on aphids. Snails must be baited or removed by hand.

Seeds of species from the high mountains or from eastern California may require cold stratification to germinate in mild winter climates. This involves exposing the seeds to cold and wet conditions for six to eight weeks. If the temperature in your area does not stay below 40 degrees F average for at least six to eight weeks in winter, seeds can be cold stratified by placing them in a ziplock bag with some wet peat in the bottom of a refrigerator and then transplanted after germination. Alternatively, the pot can be placed directly in the refrigerator and ice put on top until the prolonged melting of the ice results in germination. California species that require this treatment in mild-winter areas are: *Calochortus coeruleus, C. elegans, C nudus, C. minimus, C. greenei, C. longebarbatus, C. leichtlinii, C. palmerae, C. bruneaunis*, and *C. macrocarpus*.

Landscape Uses

Calochortus in containers can be used as an attractive specimen planting for any outdoor area. The container can be placed on a deck or patio or brought indoors while the plant is in bloom and then removed during dormancy. The taller species make excellent cut flowers, lasting over a week. Containers can be filled entirely with calochortus or mixed with other natives. One can even plant different species with similar growing requirements in the same container, and watch them bloom in succession. For example, one could combine *C. uniflorus*, an early-blooming member of section Calochortus, *C. venustus*, a mid-season mariposa, and *C. weedii*, a late-blooming Cyclobothra. These three would bloom in succession with three different forms and colors, lavender, white, or bicolor, and yellow. All can be grown in one container, for they all are California species with similar requirements for sun, moderate water, and dry summers. Similarly, one could combine different species from section Mariposa in one container for different combinations of form and color.

In the ground calochortus can add an accent to a bed of natives or form an attractive planting by themselves. The smaller species are excellent in rock gardens, while the larger ones are suitable for borders. Calochortus can be used as accents or specimen plants in dry gardens along with Mediterranean plants that require dry summer dormancy. A more specialized planting of this type would consist simply of Mediterranean-climate bulbs, such as those from Greece, Turkey, South Africa, Chile, and California. Calochortus species also could be included in a planting of California bulbs alone or in gardens with plants from specialized habitats, such as all desert species.

Unlike many plants, calochortus tolerate, and in some cases prefer, poor soils such as serpentine. They can be used to make a showy seasonal planting in what otherwise would be a barren area. Many grow on slopes in the wild and can be used to beautify an otherwise unremarkable hillside. Woodland species can add color to shady areas.

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TREESHELTERS: AN ALTERNATIVE FOR OAK REGENERATION

by Douglas D. McCreary

SINCE THE TURN of the century there has been concern that the natural regeneration of several species of native California oaks, including blue (*Quercus douglasii*) and valley (*Q. lobata*) oak, is inadequate for long-term species maintenance. This concern arose because in some locations people could see only a few or no small trees in understories of existing stands. There have also been inventories that indicate that in some oak stands the age distribution is skewed, and there do not appear to be sufficient young trees to replace mature trees that die or are cut down. Recent reports have shown that while small seedlings less than half an inch in diameter at their base may be present, there are locations where sapling-sized trees are rare or entirely absent.

A cow grazing among treeshelters. Photographs by the author.

The reasons for this apparent inability of small oaks to develop into larger saplings and then mature trees in certain areas are complex, and a variety of hypotheses have been proposed to explain their absence. In general, the causes of poor regeneration are site-specific, and the causal factors at one site may be different from those at another. One of the more popular explanations is that the change in general composition of herbaceous vegetation in California oak woodlands during the last 200 years from one of predominantly native perennial bunchgrasses to introduced Mediterranean annuals has created a much more difficult environment for the successful establishment of oaks. Annuals are more competitive for water in early spring and create much harsher growing conditions for oaks. Other theories suggest that the exclusion of fire in the last century has altered normal ecological processes; there has been an increase in rodent populations which damage young seedlings; and the introduction of domestic grazing animals results in poor regeneration, since both sheep and cattle browse young oak seedlings. While detrimental, the effects of browsing on oak seedlings is usually not lethal, at least initially, since oaks are generally able to resprout after their tops are clipped off. It is not clear how many years this process of clipping and sprouting can continue before the seedlings are killed. In some situations browsing may even be beneficial, since it can alter the shoot-to-root ratios, which improves internal water relations. However, over time, the detrimental impacts of livestock on soil bulk density, water infiltration, water holding capacity, and organic matter are likely to negate any beneficial effects.

In poorly managed, excessively grazed pastures almost all herbaceous vegetation, including young oaks, may be consumed, and mature trees are often hedged up to the height that the animals can reach. In these environments seedlings have little chance of becoming established, and those that survive may remain stunted for decades. However, there are examples of "good" regeneration in some grazed areas, as well as examples of "poor" regeneration in some ungrazed areas.

Since approximately eighty percent of rangelands with oaks in California are privately owned and the primary economic activity on these lands is ranching, an important

task is to promote better oak regeneration on rangelands grazed by livestock. Some have suggested removing grazing animals from oak woodlands, but there are a variety of reasons why this is not practical in most cases. First, there is no evidence that eliminating cattle or sheep causes a sudden increase in oak seedling or sapling recruitment, even over a period of ten years. Even with livestock removed, there can be other barriers to regeneration, including weed competition, deer browsing, and insect herbivory. Tecklin and McCreary demonstrated that removal of animals that consume forage may exacerbate other problems. A build up of thatch resulting from livestock exclusion created an ideal habitat for meadow mice (*Microtus californicus*). Populations of these animals increased, resulting in severe damage, growth setback, and even death of numerous oak seedlings and sapling from bark stripping. In an adjacent area where weeds were kept down there was no damage. Eliminating livestock therefore may create a new set of environmental conditions equally inhibiting to successful sapling recruitment.

Another reason why removing livestock from rangelands may not promote oak conservation is related to land use. Aside from the issues of property rights and who should decide how individuals should manage their land, there certainly are many worse uses of large blocks of land than ranching. Large ownerships associated with livestock operations generally preserve the wild character of the property, providing open space values to the public at minimal cost. While there have been and are abuses, most ranchers consider themselves good stewards of the land and want to maintain the ecological integrity of their property, at least partly to help ensure its long-term productive capacity. Eliminating grazing would, no doubt, force many current owners to sell or subdivide, resulting in a patchwork of small ranchettes and rural subdivisions. Such fragmented development can have devastating effects on the integrity of oak woodlands and on wildlife habitat values, not to mention visual impacts, problems of fire suppression, and resulting requirements for public services.

During the past several years researchers have been evaluating alternative approaches for regenerating oaks on grazed lands. Hall and co-workers found that the timing and intensity of grazing can affect damage to blue oak seedlings planted in pastures grazed by cattle. Other studies, such as those by Bernhardt and Swiecki and by Adams, have evaluated various types of small "exclosures" for protecting planted oaks from livestock, with varying degrees of success. These exclosures may be large enough to protect a clump of seedlings, or just to protect an individual plant. Exclosures must be sturdy enough to protect seedlings from 1,200-pound animals, so they often require considerable maintenance. This translates into high cost, reducing the incentive for private landowners to undertake such protection. Such expenditures have become even less likely since the livestock business has suffered from depressed cattle prices. Another approach, which has not been seriously tested but may be more cost effective, would be to use temporary electric fencing to control cattle. Fencing could be installed when livestock were present and then removed. Alternatively, electric fencing could be left in place semi-permanently, but used to protect narrow planting strips adjacent to existing fences.

Willow shoots browsed by cattle after growing up and out of the top of a four-foot treeshelter.

Can Treeshelters Work?

A variation on the exclosure approach, which we have been testing at the Sierra Foothill Research and Extension Center (SFREC) and elsewhere, is to use treeshelters to protect individual seedlings in grazed pastures. Treeshelters are rigid, translucent, double-walled plastic cylinders of varying heights and are generally cheaper than exclosures. They were developed in England and have been used there for more than a decade. They are reported to not only protect seedlings from a variety of animals, but also to

stimulate above-ground growth by acting as mini-greenhouses. We have conducted several experiments evaluating treeshelters—some in plots where livestock were excluded and some in areas accessible to cattle. In order to use treeshelters on lands grazed by cattle, however, we have found it necessary to secure them with extra-heavy metal posts, as the wooden posts normally used are easily broken off when animals rub against them.

In 1993 Tecklin and I undertook a study at the Concord Naval Weapons Station using valley oak seedlings. The planting areas were in fields grazed by cattle, as well as by a resident herd of elk. Fifty-two seedlings were protected by four-foot tall treeshelters secured with six-foot metal fence posts, and compared to fifty-two seedlings protected with eighteen-inch tall aluminum screen cages attached to wooden stakes. All seedlings were from a common seed source and had been raised for four months in one-gallon tubes. After one field season none of the treeshelters was seriously damaged or rendered ineffective, while over forty percent of the screen cages were missing or damaged. Seedlings inside the shelters also had greater survival (fifty-eight versus fifty-two percent) and grew significantly taller (twenty-nine versus twelve inches).

Young valley oak (*Quercus lobata*) seedlings (top) at edge of canopy in grazed pasture photographed in 1987. Eight years later in 1996 (bottom), the seedlings have remained small and stunted from livestock and deer browsing.

A second study was conducted at the SFREC as part of a project to restore woody vegetation along a 2,000-foot section of a perennial creek that previously had been cleared. Five month-old blue, valley, and interior live (*Quercus wislizenii*) oaks were planted, along with two species of willow and one of cottonwood. Treatments included seedlings protected with treeshelters but exposed to cattle and deer; seedlings inside fenced plots accessible to deer but not to cattle; and unprotected seedlings in unfenced plots exposed to both cattle and deer. After three growing seasons, approximately sixty percent of the oaks in treeshelters were alive, with an average height of fifty-four inches. However, less than ten percent of the oak seedlings inside the cattle exclosures (but not protected with tree shelters) were alive, while none of those unprotected and exposed to cattle survived. Average height of the oak seedlings from fenced treatment was only twenty-four inches. As at Concord, animals did tend to rub against the shelters and posts, and in several cases bent them partially over, but did little permanent damage to the shelters and had little effect on the seedlings. The animals were only in the plots for three winter months, however, and it is possible that with longer grazing intervals, damage would have been more extensive.

We have conducted several experiments in ungrazed pastures. These studies have shown that treeshelters can greatly accelerate growth rates, at least for blue oak, and potentially reduce the interval necessary for seedlings to grow above the height where they are vulnerable to browsing. In one study, unirrigated blue oaks in four-foot shelters averaged just under five feet tall after two years, compared to unsheltered seedlings, which were just a foot tall. There was little animal damage in this trial, so these differences were mostly due to accelerated shoot growth caused by environmental conditions within the shelters. In another study, small suppressed field-grown two-year-old seedlings were retrofitted with treeshelters and almost immediately began to grow rapidly, while their unprotected counterparts remained stunted. It should be noted that the accelerated shoot growth may come with a cost. Svihra reported that while the height of several container-grown woody species, including holly oak (*Quercus ilex*), was significantly greater in treeshelters after one year, root growth was reduced, suggesting that initial height acceleration may result from a differential partitioning of photosynthate from the roots to the shoots.

Blue oaks (*Quercus douglasii*) growing out of treeshelters, some six feet tall, two years after planting.

Critically important is the fate of exposed oak shoots once they grow up and out of the tops of the shelters. If livestock continue to chew off the shoots and hedge back new growth, then the shelters will offer little long-term benefit. At present we do not know how serious a problem this is. It is clear that cattle can reach to the top of four-foot shelters. In the riparian restoration study cattle have repeatedly browsed willow shoots growing out of the tops of shelters, and while there has been some browsing of oak shoots, it has been considerably less. It appears that the severity of injury to oaks will depend on what else is available to eat and how long animals are allowed to graze. In poorly managed pastures where there is little available forage, injury to exposed oak shoots could be considerable. Next fall we will have an opportunity to evaluate the effects of cattle grazing on seedlings that have grown out of the tops of shelters, since we are going to reintroduce cattle to a pasture where more than a hundred blue oaks are currently growing above four-foot tall shelters. A remedy for continued browsing may be to use taller shelters or to put extenders on four-foot shelters as the seedlings grow out of the tops. At a site where there was intensive pressure from a resident deer herd (but no livestock), we placed two-foot shelters on the tops of the four-foot ones as the plants grew taller. This prevented damage to new growth, but it may not work as well where cattle are present; larger animals may knock off the extenders, which are stuck down inside the original shelters.

Not a Panacea

Our results to date suggest that treeshelters help protect planted oak seedlings in pastures grazed by livestock, but they are not a panacea. Other strategies, such as removing livestock at critical times, using other types of protective cages, or installing electric fences, may be more appropriate. However, based on the results of our initial trials, treeshelters do appear promising since they not only initially protect seedlings from cattle, but also greatly reduce herbivory from grasshoppers and voles. They also promote much more rapid growth and make it easier to reduce weed competition.

Treeshelters do require regular upkeep and maintenance. One of the first things we discovered was that in grazing areas it is necessary to secure the treeshelters to the metal posts using wire, rather than relying on the plastic cinch straps that come from the manufacturer.

Without the wire, the shelters can easily be knocked off the supporting posts when animals rub against them. To prevent this, we wrapped wire around the shelters at two locations—approximately one foot from the ground, and one foot below the top—and used heavy-duty posts.

Treeshelters usually come with plastic mesh protectors that are placed over the tops of the tubes to prevent birds from falling down inside. While these may work well in ungrazed planting areas, we found that if cattle were present, they would remove the mesh—often chewing it up and then spitting it out—leaving the tops of the shelters exposed. To prevent birds from falling down inside, we therefore recommend threading wire through the tops of the shelters to create a more secure physical barrier.

Treeshelters also should be checked regularly. If there are any weed seeds inside the shelters at time of planting, they can germinate and the competing plants can grow rapidly, shading and suppressing the seedling inside. When this happens, it is necessary to lift up the shelters and remove the weeds. Afterwards it is important to make sure the tubes are again buried an inch or two in the ground to create a seal and prevent a chimney effect, which can dry out the seedlings.

It is still uncertain how long treeshelters should be left in place. Certainly if the object is to protect seedlings from livestock, the shelters should remain until the plants are large enough to withstand browsing. This could take a number of years. The shelters we used in our earliest trials were called Tubex; after five years they showed little sign of deterioration in an ungrazed pasture. There has been concern that since treeshelters promote faster growth, the saplings will become too tall and skinny and may topple over when the treeshelters are removed. We removed treeshelters from about a hundred blue oaks after five years and found that if the plants had grown above the tops of the shelters for at least a year, they became quite sturdy and did not lean or fall over when shelters were removed. If the shelters were removed before the seedlings had grown up and out the top, the seedlings tended to fall over.

While treeshelters aren't cheap, they have come down considerably in price in the last few years. Four years ago, a four-foot shelter with stake cost approximately four dollars. Today the cost is under two dollars, although adding a metal fence post would nearly double this. While this is still probably too expensive to expect many ranchers to undertake large-scale planting and protection, installing these devices is cheaper than either taking land out of production for five to ten years or building individual exclosures. Treeshelters therefore appear to provide a promising alternative for restoring selected areas to oaks on lands grazed by livestock.

Valley oaks monitored by the author after three growing seasons show moderate seasonal browsing.

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PHYLLIS FABER

At the June 1996 state board meeting, Phyllis Faber was made a Fellow of the Society because of her many past and ongoing contributions to the California Native Plant Society. Phyllis has also made significant contributions through her long-term monitoring studies of marshes in San Francisco Bay. In the past, she has been a biology instructor at the College of Marin and Antioch University and in training programs for groups such as the Environmental Forum of Marin and Audubon Canyon Ranch.

She served on the California Coastal Commission from 1973 to 1979 and remains on the board of the League for Coastal Protection. She was a founding member of the successful Marin Agricultural Land Trust in 1980 and was chairman of the Significant Natural Areas Program Advisory Committee of the California Department of Fish and Game for many years.

Phyllis has authored two wetland field guides which are still in print and a Fish & Wildlife Service Community Profile on Southern California Riparian Communities. She has been editor of *Fremontia* since 1984 and vice-president of CNPS Publications since 1989. She promoted and launched the Society on an expanded role in publications—new CNPS titles such as our successful *California's Changing Landscapes* and a series of valuable local floras, including the new Sonoma flora.

For many years she has been the Marin Chapter's legislative chairman and perennially serves on the state's development and membership committee. Future generations of Californians will benefit from Phyllis' long-range vision and preservation efforts of California's natural landscape and open spaces.

Wilma Follette of the Marin Chapter interviewed Phyllis on a lovely warm late afternoon in June on the Marin Headlands looking out at the city while wisps of fog came and went over the Golden Gate Bridge.

WF: *First the usual questions. Tell us about your growing up years.*

PF: I grew up in New York City near the East River until high school years. New York was difficult for me as a child because of the enormous restrictions on my freedom. It was especially hard on warm spring evenings when I yearned to be outside. But I will always have a great love for that city and many fond memories of special places, many of which still exist.

WF: *How about your education?*

PF: I was given a wonderful education for which I will be forever grateful. I had an early interest in biology, which has given me a lifetime of pleasure. I started out as a zoologist and microbiologist and didn't come to the world of plants until quite late.

WF: *Tell us about your family.*

PF: I have a great family—a husband, two sons, and a daughter who are attentive friends and all live in California, as well as a delightful extended family of close relatives that give me constant pleasure and comfort.

WF: *Travel has been a large part of your life. What has it meant for you?*

PF: From the time I was very young, I've always traveled a lot. In recent years it has been my ambition to visit all the important vegetation types around the world—and I am almost there. I think I can now recognize the most basic elements of quite a few of the world's plant communities. My travels also make world events relevant and interesting because I've been to so many of the places and have a sense of what conditions are like and what the people are like.

WF: *You have also been very involved in other environmental organizations and programs. Tell us about some you have most enjoyed taking part in.*

Visiting with pygmies along the Ituri River in Zaire in 1986. Photograph by Larry Heckard.

PF: My first California love was to help in the great effort to develop coastal zone management to protect the resources of California's extraordinary coastline. The biological resources are so rich and today its beaches are more accessible to the public than in any other state except Oregon. The passage of Proposition 20, the coastal initiative, was just in the nick of time as there was so much unspoiled. Sadly, the dangers today under the current administration are greater than at any time since the late 1960s.

Out of my work on the Coastal Commission grew a joint effort with Ellen Straus from West Marin to form a land trust to preserve agricultural lands in our county by extinguishing development rights through conservation easements. The Marin Agricultural Land Trust, the first agricultural land trust in the nation, now has acquired the development rights for over twenty-five percent of all the agriculture lands in the county.

The Planning and Conservation League is another organization on which I'm proud to serve as a board member. PCL is critically important to California. There is no other group that fights bad environmental legislation and supports good as effectively as PCL. Everyone in California who shares a concern for the environment should be a member.

WF: *Growing up in an eleventh-floor apartment in New York, how did you arrive at a relationship with plants?*

PF: When I was very young, I was sent to a camp in Maine where we were taken for walks in a wonderful pine woods—it was magic for me. I can still remember how beautiful the wildflowers were and how intrigued I was that they had names. I could lie in my camp bed, hear the pines soughing and smell their fragrance. I didn't know life could get so good. Imagine coming from an apartment in NYC to all those wild treats and freedom.

WF: *How did you get interested in native plants and end up editing* Fremontia*?*

PF: You and Gini Havel got me hooked on native plants, a whole new world. I have been going out with you and the Marin Chapter now for twenty years as well as taking courses at Berkeley from people like Herbert Baker and Bob Ornduff. I have learned so much that my daily world is indeed very rich.

I put together a wetland field guide in 1982 in hopes that developers and lawyers would more easily identify wetlands and retreat if they knew they had a wetland before they invested so much money that they couldn't retreat. I think it was Bob Ornduff who had seen that book and suggested me as a lay person who might be interested. I have not made many changes in *Fremontia* over the twelve years I've been editor as I have always liked what Marge Hayakawa created. *Fremontia* serves several audiences, and I try to keep each of them in mind and balance the offerings. The major goal of the journal is to increase an understanding of and interest in California's native plants.

WF: *You have greatly expanded the scope of the publications of CNPS with* Changing Landscapes *and other books. Where do you see publications going for CNPS?*

PF: I think CNPS should be the center for botanical literature in California. We should have local floras throughout the state; we should keep important books in print; and we should greatly expand the public's interest in and understanding of California's unique flora through beautiful and accessible publications. CNPS books should be on every bookshelf in California.

WF: *What do you see—hope for—in the future for the Society in general?*

PF: I'd like to see closer ties with universities, schools, and with other non-profit organizations. I'd like to raise the botanical literacy of the state so that we are successful in preserving its native flora through such avenues as public agencies and the California legislature. I'd like to see the Society grow and the membership at least double to provide greater funding for its important work. Each and every member could make that happen. We need a larger and more diverse base to undertake all the things needed for plant protection in California as the state grows and changes politically.

Wilma Follette

BOOKS RECEIVED

A Sierra Nevada Flora by Norman F. Weeden. 1996. 259 pages. A new and revised edition of the handy and practical guide for the Sierran flora found above 3,500 feet from Lassen south to Walker Pass. Updated to conform to *Jepson Manual* names, this guide has representative drawings and keys making identification easy for all. Available from Wilderness Press, 2440 Bancroft Way, Berkeley, CA 94704. $15.95 softcover.

California Gardens by Winifred Starr Dobyns. 1996. 231 pages, 207 full-page black and white photographs. Originally published in 1931, this book beautifully chronicles, through photographic portraits, a landscape history of gardens and garden designers in the first two decades of this century. Several gardens illustrated have become landscape legends in California such as the Huntington, the Bourn and Gavit estates, Filoli, and Lotusland. Available from Allen A. Knoll, 200 West Victoria, San a Barbara, CA 93101. $55.00 hardcover.

BOOK REVIEWS

The Flora of Guadalupe Island, Mexico by Reid Moran. 1996. 190 pages. Available from California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118. $40 hardcover.

Islands have often attracted because of their exotic quality and relative inaccessibility. Mountains hold a similar appeal. A mountainous isle thus is nirvana. Baja California, Mexico, has innumerable islands and islets; Ira L. Wiggins's *Flora of Baja California* (1980) tabulates forty-seven. The volcanic oceanic Guadalupe Island is the most distant from the mainland (162 miles), the second tallest (4,249 feet maximum elevation), and, after Angel de la Guarda and Cedros islands, the third largest (96.5 square miles).

Reid Moran's excellent book includes a two-page bilingual abstract, a fascinating fifty-two-page introduction to the island and its flora with thirty-five figures, and a detailed 118-page catalog of the flora with forty-four photographs. Examination of the superb photos, the extensive introduction, and the elaborate accounts of some species (e.g., four pages of text and five photos for the endemic *Cupressus guadalupensis* subsp. *guadalupensis*) repeatedly evokes the reaction "I want to go there."

Fortunately, as Moran relates in a nine-page history of botanical collecting, he and twenty other collectors or collecting teams have researched Guadalupe Island, starting with Edward Palmer (1831-1911) in 1875, who was inspired by an 1874 report on the devastating effects of goats on the flora. No one knows when goats were introduced, presumably as a source of meat for sailors. John Muir's "woolly locusts" have irrevocably altered the island by fostering soil erosion, drying up springs by killing trees (fog drip from which added significantly to the meager rainfall), and causing the extinction or extreme endangerment of native species. House cats and mice are other problems.

In addition to seven ferns and three gymnosperms, Moran lists 206 species of angiosperms that come and go: forty-five, or 20.8 percent, mainly European weeds, seem adventive, with another fifteen, or 6.9 percent, possibly alien. More than thirty species, or 13.9 percent, are probably extinct on the island. Of the 156 native taxa, thirty-four, or 21.8 percent, are endemic, but at least five of these are extinct. *Baeriopsis* (Compositae) and *Hesperelaea* (Oleaceae) are endemic monotypic genera. As Moran points out, Guadalupe Island is a southern outlier of the California Floristic Province, with relationships mainly with the islands of Southern California: 114 native taxa grow in Alta California; only eight grow strictly in Baja California; 101 occur on the islands of California, with nineteen being insular endemics.

Typographically, the volume is nicely set, and the bibliography is exceptionally comprehensive (though *The Jepson Manual* and *Flora of North America North of Mexico*, both of which have some relevance to the northern Mexico flora) are not listed. The latter work treats *Pinus radiata* var. *binata* as a synonym of *P. muricata*, although Moran's taxonomic placement seems better to me. Moran obviously could not have cited the recently published *Sonoran Desert Plants* (fall 1995), which maps seven taxa for Guadalupe Island, including a collection of *Agave shawii* (subsp. *goldmaniana*), a species not mentioned in Moran's flora. I am intrigued by this discrepancy because this Southern Californian and Baja endemic is hardly inconspicuous. A table listing the 216 taxa in the flora also would have been helpful, and the section on plant collectors should have noted the birth and death years of the principals. However, these minor omissions detract little from this splendid flora. Moran's book is a most significant contribution to the bibliographies of endemism, oceanic islands, conservation, and Baja California.

Rudolf Schmid
University of California, Berkeley

The Forgotten Pollinators, by Stephen L. Buchamann and Gary Paul Nabhan. 1996. 292 pages. This is the perfect book to take to a sunny, grassy meadow filled with flowers on a lazy summer day. Once we are settled in a comfortable spot and are reading, it is nearly impossible to put this book down—unless we take the authors' advice to heart and begin noticing the busy pollinators all around us. When we do this we are in a small way doing what Stephen Buchmann, entomologist and bee expert at the University of Arizona, and Gary Nabhan, author and director of science at the Arizona-Sonora Desert Museum in Tucson, have been doing for many years. Their adventures and studies have taken them to the forests, fields, hills, and deserts of the world, where they have observed plant pollinators at work. Edward O. Wilson, in his foreword, reminds us of the dominance on land of flowering plants and insects. A majority of these flowering plants must have insects to help them reproduce, and the insects that have coevolved with them must have flowering plants for food and their own reproduction. Many of the relationships between plants and their special pollinators are so finely tuned that one can be extinguished upon the disappearance of the other.

The intricate, fragile network of dependencies ultimately affects all of us through the precarious maintenance of our forage and food crops and our wild floras. Until recently, the interactions between plants and pollinators were ignored in most discussions of biodiversity and agricultural stability. Five years ago the authors took part in a one-day symposium they call the Conservation of Mutualisms. The delegates came together to discuss the broken relationships between rare desert succulent plants and their pollinators. The beginning of the Forgotten Pollinators Campaign, of which this book is a part, began at that symposium with the enthusiastic endorsement of the participants.

As part of their campaign to publicize the worldwide disappearance of plant pollinators, Buchmann and Nabhan recently visited the San Francisco Bay Area. In interviews they described the pollination crisis: 103 kinds of birds, eighty-two mammals, and countless butterflies, moths, and bees are threatened with extinction. Bad weather, mite invasions, pesticides, and habitat loss are some of the causes.

Today, the authors remind us, we should thank a pollinator for "one out of every three mouthfuls of the food we eat and beverages we drink." In a later interview, and with the help of Alice Waters of Chez Panisse, they created a breakfast of "tea pollinated by flies and bees, figs pollinated by wasps, kiwis by bumblebees, mangoes by fruit bats, and chocolate by flies and midges." After reading this book, we will all stop and remember our plant pollinators with every bite we take.

Elly Bade

The Natural History of Pollination, by Michael Proctor, Peter Yeo, and Andrew Lack. 1996. 479 pages. Written for biologists and interested amateurs, *The Natural History of Pollination* describes in detail, with excellent photographs, drawings, graphs, and charts, all the ways plant pollination takes place through wind, birds, mammals, bees, flies, beetles, moths, and butterflies. This new book, a completely rewritten version of *The Pollination of Flowers* (1973), is bound to become a basic reference for a new generation of teachers, students, naturalists, and wildlife gardeners wanting to learn more about plants and their pollinators (especially as a follow-up to first reading *The Forgotten Pollinators*.

Members of the University of California Botanical Garden community will be interested to know that the bibliographies in both books cite the writings of Herbert and Irene Baker of U.C. Berkeley. Dr. Baker, former director of the botanical garden, and his wife were modern pioneers in the study of pollination biology, and they and many of their students have used the resources of the garden in their research.

Halfway around the world in England, where they live and work, the authors of *The Natural History of Pollination* decry the loss of wild pollinators worldwide. Their message is the same as that of Stephen Buchmann and Gary Nabhan in Arizona: without pollinators we are all at risk.

Elly Bade

NOTES AND COMMENTS

Dear Editor:

In his article "Singleleaf Pinyon Pines in California" (*Fremontia*, July 1996) Stephen K. Langer cites a 1974 article of mine in making his case for accepting D.K. Bailey's 1987 proposal that *Pinus monophylla* be split to yield a new species, *P. californiarum*. As Langer states, Bailey's proposal has not been widely accepted. I would like to correct an error, probably made by a printer's devil, regarding my position on pinyon pine taxonomy, and to suggest why Bailey's proposal has had little acceptance.

The statement "Lanner considered that all singleleaf pinyons belonged to one species, *Pinus edulis*" should, of course, read "*Pinus monophylla*." In fact, I still believe, for reasons I stated in the 1974 paper, that there is no *P. edulis* in California, only two-needled variants of *P. monophylla*. This position is consistent with recent findings of genetic analysis of isozymes in the New York Mountains pinyon stand.

Pinus californiarum has had difficulty being accepted because Bailey's case for it is not persuasive. The case is purportedly made mainly on the basis of statistics on morphological characters, but the data are not analyzed by standard methods. Few readers, for example, would know how to interpret Bailey's subjectively derived term "quasi-maximum," which preempts the use of the more familiar mean or average. Or the substitution, in Bailey's Table 1, of lower and upper deciles ("inter-decile ranges") for ranges of values. This is highly misleading because the use of these statistics is not made evident anywhere in the table, thus ambushing the reader accustomed to means and ranges. It also prevents comparison with other published data. Thus in Bailey's Table 1, *P. californiarum* subsp. *californiarum* is said to have "9-16" resin ducts per leaf. How do these numbers, which are lower and upper deciles, relate to my earlier published findings of a range of three to sixteen among trees in a Baja California plot; or the common occurrence of five resin ducts at Anza-Borrego? Other examples can be cited in this table of supposedly diagnostic characters.

Disturbingly, that same 9-16 resin ducts appears in Langer's *Fremontia* paper also, and as in Bailey's Table 1, there is no mention of whether this is a range or some other thing. Langer's table, in fact, contains numerous other entries identical to those of Bailey's Table 1, suggesting perhaps that his two years of field work followed closely in Bailey's footsteps. Some of the other problems the reader of Bailey's paper must deal with are the numerous indeterminate trees and the meaning of the term "subtaxa."

Of course, it is more a matter of art than of science whether a large, varying system of plant populations should be subdivided, even on the basis of analyzable metric characters, into subspecies or species. But if scientific credibility is claimed, the work has to be verifiable and repeatable. A comprehensive, verifiable, and repeatable biosystematic study of the singleleaf pinyons is yet to be made. Until it is, the most prudent course is to accept one singleleaf pinyon species, divided into the varieties or subspecies that seem logical.

Ronald M. Lanner, Logan, Utah

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WE'RE BRAND NEW: Go Native Nursery offers California native plants; open weekends from 11:00 a.m. to 6:00 p.m., at Cypress Flower Farm, 333 Cypress Avenue, Moss Beach, California. Ph/Fax (415) 728-3067. (gonative@coastside.net).

THEODORE PAYNE Foundation offers a wide selection of California native plants, seeds and informative books. Wildflower seeds, blends and books are available by mail order; plants sold only at our nursery (Wed-Sun, 8:30-4:30). To receive catalogs, please send $3.00 to Theodore Payne Foundation, 10459 Tuxford St., La Tuna Canyon, CA 91352. For more information call (818) 768-1802. Wildflower blooming reports are offered through our Wildflower Hotline (818) 768-3533.

YERBA BUENA NURSERY and Botanical Gardens. Growers of 600+ varieties of California Native Plants, Ferns & Exotic Ferns. New for Spring 1996—Garden Shop, Tea Terrace. Open daily, 9-5. 19500 Skyline Blvd., Woodside, CA 94062. (415) 851-1668. Catalog $2.00.

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Services

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California Native Plant Society

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Dues include subscriptions to *Fremontia* and the *Bulletin.*

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ADDRESSES

Memberships; Address Changes; Officers; General Society Inquiries: CNPS, 1722 J Street, Suite 17, Sacramento, CA 95814. Tel: (916) 447-CNPS(2677) (FAX) (916) 447-2727

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MATERIALS FOR PUBLICATION

Members and others are invited to submit material for publication in *Fremontia.* Two copies of manuscripts, double-spaced, (plus an IBM-compatible disc in Word-Perfect or ASCII file) should be submitted to *Fremontia* with name, address, phone number, and an identification line for Notes on Contributors. Botanical nomenclature should conform to *The Jepson Manual* (1993), with common name followed by botanical name. Black-and-white photographs, preferably 8x10 or accompanied by negatives, or original 35mm color slides.

NOTES ON CONTRIBUTORS

Elizabeth Carroll is lab director at the National Forest Genetic Electorophoresis Laboratory of the USDA Forest Service in Camino, California.

Dan Cooper was a research associate at the Kern River Research Center in Weldon monitoring riparian birds. He is now in Latin America leading nature tours.

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Margaret L. Stassforth received a masters degree in geography from the University of California, Los Angeles, and continues to monitor post-burn vegetation in the Santa Monica Mountains.

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