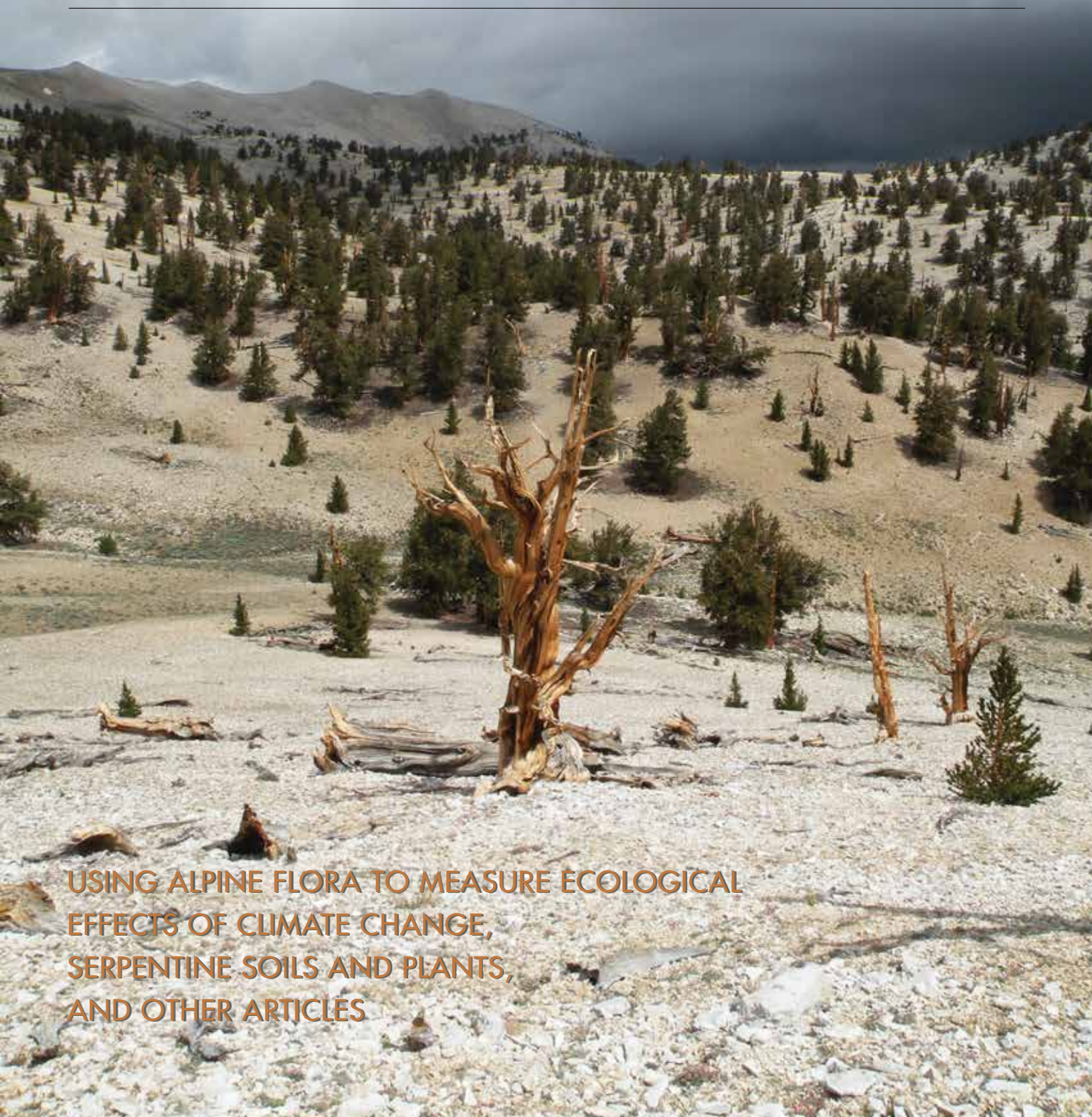


FREMONTIA

JOURNAL OF THE CALIFORNIA NATIVE PLANT SOCIETY



USING ALPINE FLORA TO MEASURE ECOLOGICAL
EFFECTS OF CLIMATE CHANGE,
SERPENTINE SOILS AND PLANTS,
AND OTHER ARTICLES

FREMONTIA

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*Dedicated to the Preservation of
the California Native Flora*

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

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

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THE COVER: California bristlecone pine woodlands at their upper limit give way to the alpine zone above, a cold, treeless biome being studied carefully for evidence of climate change. Photograph by Stu Weiss.

The early morning is cool and clear, as long shadows of the last and highest-elevation trees stretch across the open slopes ahead. Our team hikes steadily on toward the summit, carrying measuring tapes, compass, level, strings, pin flags and markers, quadrat frames, data binders, cameras, small blackboard, and plant press. After pausing on top to distribute the equipment, everyone sets about a task—some lay out the survey system, some assemble the plant list.

A beautiful world of alpine plants lies at our feet; spectacular views meet our gaze in every direction. It is not yet mid-morning, but we check the sky for the first signs of cloud formation...nothing yet. As soon as the survey areas are defined with colored strings, the work of identifying each plant species and assessing its coverage begins. Meanwhile two people begin the extensive photo documentation protocol.



USING ALPINE FLORA TO MEASURE ECOLOGICAL EFFECTS OF CLIMATE CHANGE

by Jim Bishop

Our California team, which is working to establish monitoring sites in the higher mountains of the state, is part of an international effort to detect and measure changes in the alpine flora that would be expected to occur as the climate changes. As an ecosystem at a climate extreme—one that is very temperature dependent—the alpine

zone is a sensitive indicator of such change.

NEED FOR A UNIVERSAL ALPINE-MONITORING PROTOCOL

During the past century, scientists have observed changes in alpine flora and in tree line elevation. In Scandinavia, for example, tree

lines have risen by over 500 feet. Where conditions become less harsh, a greater number of species can survive. Species richness of many alpine peaks has increased, and on one summit in the European Alps increased from one to ten species over 100 years. That would be expected if the cold alpine elevations are warming. But until the last ten years, there had not been a stan-

dard, universal, and replicable process for assessing such changes.

In response to the need for better scientific data and more valid comparisons, the Global Observation Research Initiative in Alpine Environments (GLORIA, <http://www.gloria.ac.at/>) was conceived at the University of Vienna and established at field sites in Europe in 2001. GLORIA defines a protocol that can be applied to alpine summits anywhere in the world. The alpine zone is ideal for detecting biological effects of global climate changes. Human disturbance there is often minimal, it spans nearly all latitudes and elevations, and it samples the major climate zones of the world—maritime and continental, tropical, mid-latitude, and polar.

UNDERSTANDING THE ALPINE ZONE

The story begins with the question of why there is an alpine zone. Understanding the environmental stresses on alpine plants and their adaptations is the foundation for viewing their responses. The alpine zone is defined as that above the upper tree line—a remarkably consistent elevation in a given region, with the trees dropping out completely over elevation increases of just feet. Without the absence of trees there would be no alpine zone. Why should trees meet such a limit to their growth? Answering this question requires understanding how temperature limits plant cell growth, and how it limits tree growth.

Plant cell metabolism is very temperature sensitive, slowing to almost no cell growth at about 42° to 46° F. If the daily mean air temperatures (the average for the day) averaged over the growing season falls much below about 44° F, trees can no longer subsist. That is a global observation, consistent over different taxonomic families, elevations,



There are currently five areas in California where alpine plant survey work is being conducted as part of the international GLORIA Project.

growing season lengths, latitudes, and precipitation regimes.

Tree foliage is effectively cooled by the air flow. Tree root zones are shaded by the crowns and remain close to the average air temperature. So in effect a tree experiences a cold temperature limit dictated by average air temperature. Average temperature in the lower atmosphere

declines steadily with increasing altitude. Therefore, above tree line elevation, the growing season is simply too cool to sustain tree growth.

But other types of plants persist in the alpine zone, in spite of cooler air temperatures there—plants with the same temperature-limited basic metabolism as trees. How do plants that live above the tree line do it? The secret lies in their form and stature, allowing them to be warmer overall than air temperature would indicate.

The low stature and compact form of alpine plants reduce cooling from the air flow and allow absorption of sunlight to warm above-ground plant parts. Foliage of alpine plants can be sun-warmed above air temperature by some 36° F (so the temperature of an alpine plant might be well over 80° F on a 50° F day). The typically sparse distribution of alpine plants leaves much ground (usually over 50%, often 80% or 90%) exposed to solar heating, and their forms transmit more heat to

A team hiking to the Dunderberg target region in the central Sierra Nevada. Photograph by Catie Bishop. All other photographs by the author, except as noted.





Alpine flowers. CLOCKWISE FROM UPPER RIGHT: Cushion Townsend daisy (*Townsendia condensata*), Sierra penstemon (*Penstemon heterodoxus*), Pacific hulsea (*Hulsea algida*), cushion buckwheat (*Eriogonum ovalifolium*), White Mountain buckwheat (*Eriogonum gracilipes*).

the ground than do raised crowns. Consequently their root system temperature is above the average of that for shaded sites. In effect, even though alpine plants grow at a higher elevation than trees, they experience a warmer microclimate.

As beautifully adapted as they are, alpine plants still live at the edge of adequate warmth and they benefit from the lack of competition from the cold-limited trees, so they are quite vulnerable to temperature changes. Alpine plant ecosystems are also dependent on snow distribution. Snow shelters many of them from extremes of winter cold and desiccation. Late-season snowfields retard growth until they melt, and upon melting release a flush of nutrients and water. Alpine vegetation patterns are strongly con-

trolled by the distribution of snowfields.

It is expected that at least two variables related to climate change could significantly affect alpine ecosystems—warmer temperatures, and amounts and patterns of precipitation and snowmelt. Warmer temperatures can raise the tree line, and will raise the elevations at which a variety of alpine and subalpine plants can be more competitive. Less snow or more snow, and changes in patterns of snow deposition and melt schedule can also alter alpine plant distributions.

GLORIA IN CALIFORNIA

GLORIA began in California in 2004 due to the tireless efforts of Connie Millar of the Pacific South-

west Research Station, USFS, and was the location of the first project sites in the Western Hemisphere. Millar remains the force behind all of the California projects and is also a contributor to other North American sites.

Each GLORIA project is organized around a “site” called a target region (TR), and includes a group of three or four summits, spaced in elevation from the highest peaks down to near tree line. California GLORIA summits now number 18, in 5 TRs, from Langley Peak in the southern Sierras to the Carson Range near Lake Tahoe, and at several locations in the central White Mountains. A team of volunteers, students, and agency employees (who have been granted release time from their normal duties to help) are conduct-

ing studies of the alpine ecosystem and its changes. CNPS volunteers have been consistent and important contributors to the project.

Surveys will be repeated at five-year intervals to measure change in the alpine flora. The information that is gathered will be shared globally, as it is at sites in other countries around the world.

THE GLORIA SURVEY PROTOCOL

The summit-centered GLORIA protocol outlines a set of survey plots (successively smaller plots within larger ones) that occupy the slopes of the four main compass directions (N, E, S, and W) on each peak. The plots lie in two elevation bands: the uppermost band takes in the five meters (16.4 feet) in elevation just below the peak, and the lower band lies between five and ten meters (33 feet) below the peak.

The materials required to conduct GLORIA surveys have purposely been kept low-tech and therefore are usable worldwide regardless of local resources. A compass, tape-measure, and a string-level (a builder's level that is attached to a string) are all that are needed for surveying. Colored string marks the plots, and pin flags have various uses. A one-meter-square quadrat frame with 100 cells is used for the finest-scale observations. All reference points are defined by compass direction and distance from the "high summit point."

Information collected includes each species present (including voucher specimens on the first survey); its degree of cover (as a measure of each species' abundance and its influence on available space, light, air, and water); and the cover of other elements such as rock or soil. The amount of rock and soil indicates the potential for expansion of plant cover, and plant cover may change as climate changes (see protocol details, page 6).

Enhancements to the basic GLORIA protocol have been developed in California. One of them, the "California method," is now an option in the international protocol. The observation provides much better quantitative data on plant cover over an area that samples much of the variation on the summit. It covers a larger area than the one meter by one meter quadrats, but is not subject to the errors of visual estimates of plant cover on the large survey plots.

The White Mountain Research Station is now a GLORIA World Master Site, where many studies of alpine ecology complement the basic GLORIA surveys. These additional studies encompass extended plant surveys, tree line and shrub line mapping, small-scale temperature modeling, insect monitoring, alpine meadow flora, and periglacial processes (freeze-thaw cycles). A set of weather stations now extends from the base of the White Mountains to the highest summit, providing a direct measure of the climate there over a range of elevations—important information to relate to any observed ecosystem changes.

LOOKING BELOW THE SUMMITS

A major addition to the summit surveys are the "downslope sur-

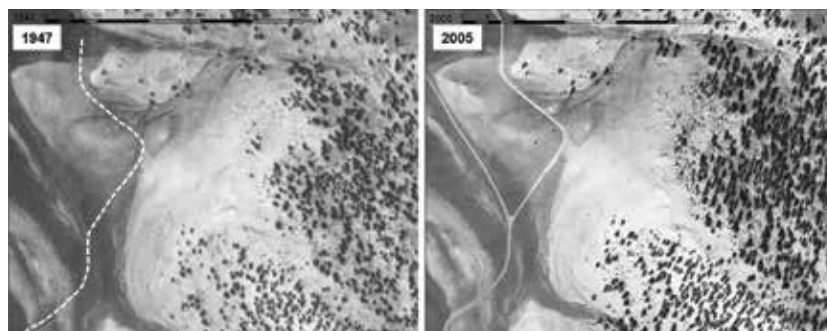
veys," observations that cover the alpine zone *below* the GLORIA summits and provide a more comprehensive view of the alpine ecosystem throughout its entire elevation span. To date, such surveys have been conducted on four major slopes, collectively spanning the elevation from White Mountain Peak at over 14,000 feet down into the bristlecone-limber pine woodland at 10,800 feet (see protocol details, page 8).

The data gathered from the slopes reveals flora that could potentially be moving up toward the summits in response to warming. It shows the distribution of each species by elevation at a given time. Comparing this with the same species' elevation distribution at a later time (for example, ten years later) can produce an extremely useful measure of just how much the elevation distribution of that species has shifted over time, very possibly rising as the world warms.

EARLY RESULTS

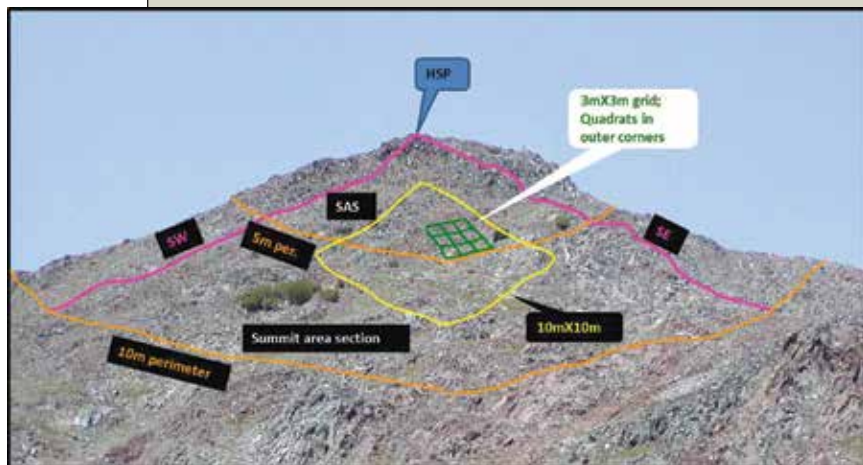
What have we learned so far? The initial baseline surveys cannot of themselves reveal change. But they have provided useful and detailed information on the species that are present, their relative abundance, and their detailed distributions on summits and slopes of the alpine zone in California.

Upper edge of bristlecone-limber pine woodland at Patriarch Grove in the White Mountains, 1947 and 2005. Dashed line on 1947 photograph indicates road trace corresponding to road in 2005 photograph. Note the many young bristlecone pines within and beyond the woodland in the recent photograph. Most of the global warming in this period took place after 1970. Photographs courtesy of Daniel Pritchett of the White Mountain Research Station.



ELEMENTS OF THE GLORIA PROTOCOL

The main objective of the GLORIA protocol is to record the plants that grow on the summit, to note roughly where they are distributed around the peak, and to estimate how much area each species covers. That requires looking at both large-scale and small-scale plots, and on the differently-oriented slopes. The plots are outlined with colored string, and field workers examine each plot carefully for the plants that occur there.



A diagram of the survey plots as they would appear on the south slope of this summit (HSP is the high summit point). Orange marks the perimeters at the 5-meter and 10-meter levels; pink marks the boundaries of the south-slope plots; yellow is the California Method diamond; green is the grid that locates the one-meter quadrats.

square meter of each quadrat. The photos also document the plants and their coverage, as well as the survey system reference points for placing resurveys.

To learn how the actual temperatures and snow cover are changing, a temperature recorder is buried ten centimeters deep on each aspect. Temperature is recorded approximately hourly for several years. The recorder is then dug up, and the records are recovered. The soil-temperature curve has a narrower daily temperature range than the surface-temperature curve, but has a similar average. Changes in average air temperature will be reflected in soil temperature. But when snow covers the ground, the soil temperature remains essentially constant at 32° F, and in that way reveals precisely the periods of snow cover.

A set of survey plots is laid out on the slopes of the four main compass directions or “aspects” (N, E, S, and W). They lie in two elevation bands: the uppermost band spans the five meters in elevation just below the peak, and the lower band lies between five and ten meters below the peak.

In each summit area section (SAS)—the area on one aspect and within one elevation band—the plant cover is visually estimated. In the 1m x 1m quadrats (outlined with a frame containing 100 cells), cover is estimated by noting the occurrence of each species in each of the cells. Each group of four quadrats is centered on a main compass direction at the 5-meter perimeter.

Over 60 photographs are taken on each summit, from broader photos of the SAS to the

BELOW LEFT: Identifying plants. BELOW RIGHT: Searching for inconspicuous plants. Photographs by Scott Sady/TahoeLight.com.

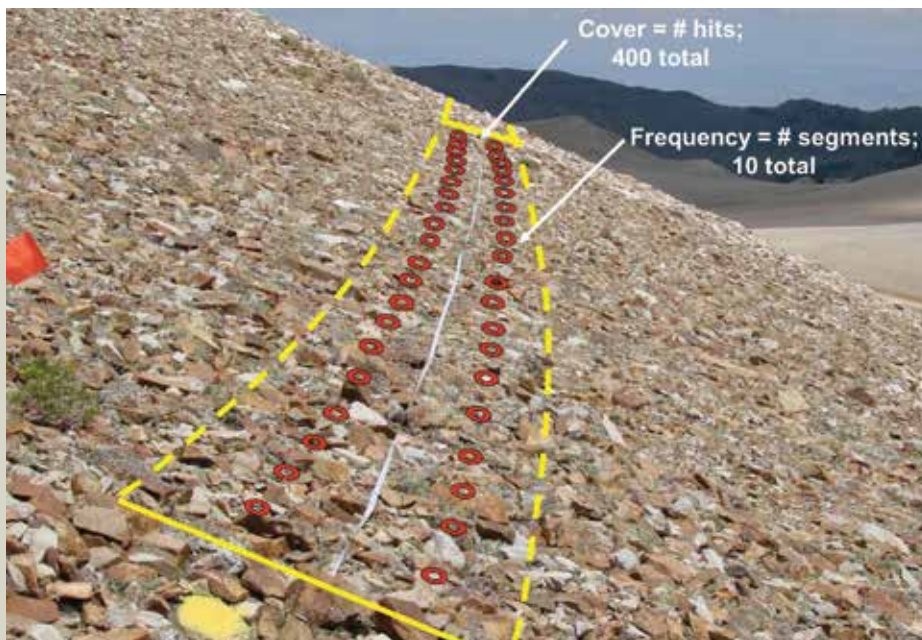


AN ADDITIONAL PROTOCOL: THE CALIFORNIA METHOD

A 10 X 10-meter “diamond” is centered in each aspect on the 5-meter perimeter. Within the plot, 400 sample points set on a half-meter grid produce useful quantitative data on plant coverage at the mid-scale (surveys prior to 2009 used 100 points). Estimating plant cover visually is difficult, especially for plants that have low cover values, and such estimates are of very limited accuracy. The quadrat measurements are much more accurate than visual estimates, but they cover only small areas. The 10m X 10m areas yield good accuracy over intermediate areas.



TOP: Taking data on the quadrat grid. • ABOVE LEFT: Documenting photograph points. • LEFT: Leveling the string from which to determine the 5-meter and 10-meter perimeters. Photographs by Catie Bishop. • ABOVE: Measuring the distance to reference points, which are used to guide the placement of resurveys.



Outline of one segment, 1 meter wide and 10 meters long, centered on the white tape, of the 100-meter belt transect at that elevation. All species are noted within the segment. Sample point positions for plant species or cover type are indicated on this photograph with red circles. "Frequency" refers to the total number of segments a species occurs in; "Cover" refers to the number of sample points that contact a given species or cover type.

DOWNSLOPE SURVEY PROTOCOL

Downslope surveys are conducted on some of the slopes below the GLORIA summits, into the subalpine woodland. Meter-wide belt transects along the elevation contour are spaced every 25 meters (82 feet) in elevation. Each transect is 100 meters long (100 square meters total area), divided into 10-meter segments. All species present in each 10-meter segment are recorded. At sample points spaced every half meter (400 for the entire transect) the plant species or other cover type is identified. The downslope transects duplicate, in area and sampling density, the 10m X 10m California-method plots on the summits.

LEFT: A pointer that marks two sample points, one at each end, is moved along and placed every one-half meter along the tape. •
BELOW: Botanists look closely for small plants, since it is easy to miss some of the Alpine species, which can be quite tiny.

In California, four of five target regions have been resurveyed, and two of the downslope surveys in the White Mountains have been repeated. Many of the repeat surveys show increased species richness. The recent downslope resurveys also showed an increase in the number of annual species (perennial habit is best suited to the demands of the alpine environment, and alpine annuals are uncommon).

However, that may be due, in part, to a wetter-than-normal year.

Findings over the ten years from 1994–2004 from the European Alps have shown reductions in cover of the highest elevation species (those in the zone of permanent snow, or the "nival" zone), with lesser reductions and some increases within the alpine subzones below that. These changes show that the highest plants are losing ground to plants from lower elevations, at least over a recent decade.

Even if the changes observed in the GLORIA resurveys are significant, it is not possible to attribute change over five years to long-term climate trends. Inter-seasonal variation can easily affect the flora represented in a given year. The value of the current comparisons is that they demonstrate the potential of



the protocols to reveal change. However, only changes in a direction consistent with a warming world, sustained over two or more decades, will indeed be compelling evidence.

Current data is also being compared to earlier botanical data from the White Mountains. For example, the uppermost occurrence on granitic substrates of dwarf sagebrush (*Artemisia arbuscula*) as reported in 1961 has been compared to the recent upper shrub line surveys and downslope surveys. Based on those observations, which span a 50-year interval, this species' upper limit has

risen 500 feet, and several common alpine plants have been reduced in cover wherever the *Artemisia* has encroached. Aerial photo comparisons from the late 1940s into the 2000s show bristlecone pine woodland filling in along its upper margins and young trees spreading upslope.

Much remains to be learned, and only time will reveal long-term change. But the baseline data being established, and the early look at changes, are an important contribution to assessing the impacts of climate change on the alpine ecosystem across the world.

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The team is finishing up its work on the summit. Strings are wrapped on cardboard holders, data books carefully packed away. We enjoy last views of the magnificent landscape, and begin the hike down. Beginning with a few morning cumulus over the highest peaks, the clouds have now become tall and massive, bright against the mountain sky. A faint roll of thunder is heard from just a few miles away. It is good to be on our way down.

Back at camp we'll finish up some challenging plant identifications and file the data sheets. We'll gather the equipment for the next day's work, and vow to begin early enough to finish before storms end the field day.

MANAGING A MOUNTAIN: THE SAN BRUNO MOUNTAIN HABITAT CONSERVATION PLAN

by Patrick Kobernus

In 1982, the first Habitat Conservation Plan (HCP) in the nation was approved for San Bruno Mountain. Over the past 30 years most of the mountain, approximately 2,830 acres (82%), has been conserved as habitat for three endangered butterfly species, wildlife, and plants; and approximately 350 acres (10%) of the mountain has been developed. An additional 260 acres (8%) of land remains undeveloped, and it is likely that a majority of this land will ultimately be set aside as

conserved habitat.¹ As of 2012, most of the development on the mountain has been completed.

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

panding populations of invasive species, continue to overtake grassland habitat on the mountain. The future conservation of the endangered species and their habitats, now more than ever, depends upon implementation of a more comprehensive habitat management program to protect these species for future generations.

¹ Most of the remaining “unplanned parcels” will likely be conserved due to these lands being located on very steep slopes with no infrastructure (roads, utilities) for development. The HCP requires that a minimum of 40% of this land be dedicated as conserved habitat.



The San Bruno Mountain Habitat Conservation Plan—adopted in 1982 and the first HCP in the nation—is responsible for protecting host plants for three endangered butterflies, and conserving the area’s diverse native flora and fauna. All photographs by the author unless otherwise indicated.

MOUNTAIN FLORA AND FAUNA

San Bruno Mountain is located in northern San Mateo County, adjacent to San Francisco. It consists of approximately 2,830 acres of open space, and is bordered by the urban and suburban portions of Daly City, South San Francisco, Colma and Brisbane. Though it is isolated by urbanization, the mountain is considered the northernmost part of the Santa Cruz Mountains.

The famed botanist James Roof asserted that San Bruno Mountain supports one of the last and the most expansive areas of a unique and highly diverse grassland and shrubland flora, which he referred to as “Franciscan” (Edwards 2000). This Franciscan

flora was once common throughout the hills of San Francisco but has been almost entirely destroyed in the city by development and planting of nonnative trees.

The grassland on San Bruno Mountain is actually a combination of different types of grasslands intergrading and sharing some of the same wildflower and shrub associates. Grassland types vary on the mountain depending on elevation, exposure, and soil type. The dryer southern exposures tend to have stands of purple needle grass (*Nassella pulchra*), while the more fog-shrouded grasslands near the summit are dominated by California fescue (*Festuca californica*), red fescue (*F. rubra*), and Idaho fescue (*F. idahoensis*). There are also stands of California oat grass (*Danthonia californica*), blue wild rye (*Elymus glaucus* var. *glaucus*), Pacific reed grass (*Calamagrostis nutkaensis*), June grass (*Koeleria macrantha*), and tufted hair grass (*Deschampsia cespitosa* ssp. *holciformis*).

As a biologist hired to monitor the three endangered butterfly species on San Bruno Mountain for 13 years, I can attest to its unique beauty. Each spring and summer, I would hike the mountain repeatedly while I recorded my observations of the mission blue, San Bruno elfin, and callippe silverspot butterflies, and the status of their grassland habitats.

The San Bruno elfin's host plant, Pacific stonecrop (*Sedum spathulifolium*), grows in coastal prairie and on rocky outcrops and roadcuts. The Callippe silverspot's host plant, Johnny jump up (*Viola pedunculata*), grows in coastal prairie and in nonnative annual grasslands. The mission blue's host plants, silver lupine (*Lupinus albifrons* var. *collinus*), var-



TOP: A freshly emerged male mission blue butterfly (*Icaricia icarioides missionensis*), found in San Bruno Mountain's grassland habitat. It is an endangered species. • MIDDLE: A mission blue larva feeding on silver lupine (*Lupinus albifrons* var. *collinus*) on the west peak of San Bruno Mountain. • BOTTOM: A San Bruno elfin larva foraging on the flowerheads of its host plant, Pacific stonecrop (*Sedum spathulifolium*) near the summit of San Bruno Mountain.

ied-colored lupine (*L. variicolor*), and summer lupine (*L. formosus* var. *formosus*) grow within coastal prairie, nonnative annual grassland,

rocky outcrops, roadcuts, and on cut slopes.

The mountain is not only home to three endangered butterfly species but also supports a wide diversity of other native flora and fauna. Many varieties of wildflowers can be found on the mountain, including coast rock cress (*Arabis blepharophylla*), Pacific stonecrop, varied-color lupine,

Johnny jump up, goldfields (*Lasthenia californica*), shooting stars (*Dodecatheon hendersonii*), blue larkspur (*Delphinium decorum*), farewell to spring (*Clarkia rubicunda*), and owl's clover (*Castilleja densiflora*), among many others. Each patch of grassland is a uniquely beautiful "natural garden" that has been constructed through the forces of nature and time. Each March through June, the grasslands and wildflowers emerge and change into

new combinations of color and beauty as the season progresses.

There are several rare plant species including two that are state and/or federally listed, San Bruno Mountain manzanita (*Arctostaphylos imbricata*) and San Francisco lessingia (*Lessingia germanorum*). There are also several California Rare Plant Rank 1B species (formerly CNPS List 1B) such as Montara manzanita

(*Arctostaphylos montaraensis*), Pacific manzanita (*Arctostaphylos pacifica*), Diablo helianthella (*Helianthella castanea*), San Francisco spineflower (*Chorizanthe cuspidata* var. *cuspidata*), and San Francisco campion (*Silene verecunda* ssp. *verecunda*). Other rarities include an arachnid, incredible harvestman (*Bank-sula incredula*); a solitary bee (*Dufourea stagei*); and several range-limited endemic plants.

Plant communities on the mountain include northern coastal scrub,

coast live oak woodland, coastal terrace prairie, freshwater marshes and seeps, central coast riparian scrub, nonnative gorse and broom scrublands, nonnative eucalyptus forest, and nonnative annual grassland. The most dominant vegetation on the mountain is northern coastal scrub and nonnative annual grassland.

FIRST HABITAT CONSERVATION PLAN IN U.S.

Since 1982 the mountain has been the site of the first Habitat Conservation Plan (HCP) in the nation. HCPs were created as a mechanism to balance private property rights and endangered species protection, by allowing limited “tak-

This mechanism has been used as a tool for settling land disputes by allowing landowners to economically develop portions of their properties, while simultaneously ensuring long-term protection of endangered species through dedication of conservation areas, habitat management and monitoring, and/or other mechanisms. As of 2010, over 700 HCPs have been permitted in the U.S. by the U.S. Fish and Wildlife Service (USFWS 2010).

The primary purpose of the San Bruno Mountain HCP is to protect the grassland habitat that supports the three endangered butterfly species, while allowing limited development to occur. Prior to the formation of the HCP, approximately 1,950 acres of land on San Bruno Mountain had been purchased and/or donated to create the San Bruno

Mountain State and County Park. This land contained virtually the entire habitat for the San Bruno elfin butterfly on the mountain. However, it did not include the prime habitat areas for the mission blue and callippe silverspot butterflies, which were located on the eastern portions of the mountain.

The HCP provided a mechanism by which an additional 800+ acres of habitat would be conserved and added to the Park, and all of the con-

served land within the park would be managed and monitored for the endangered species as well as for other native flora and fauna. Within the current 2,830-acre conservation area, approximately 90% of the mission blue and callippe silverspot butterflies’ habitat, and 100% of the San

Bruno elfin butterfly’s habitat has been protected.

The development permitted through the HCP is primarily relegated to the lower slopes of the mountain, thereby protecting the majority of higher quality butterfly habitat on the upper ridges and hilltops. For the callippe silverspot, this was critical, because this species requires hilltops for mate selection. Male callippes stake out territories on the highest hilltops or ridgelines available to encounter and attract females for mating.

The conservation areas also included protection of several rare plant species, with the exception of most of the San Francisco lessingia and San Francisco spineflower populations, which are located on private property on the west side of the mountain. These populations are still extant, however development and invasive species are potential threats.

The HCP specified the importance of management and monitoring of the butterflies’ habitat and provided a funding mechanism to support these activities—an annual monetary assessment on every residence and business that is built within the HCP boundary. This assessment rises with the annual inflation rate, and has provided a consistent level of funding since the creation of the HCP.

The HCP fund is managed by the HCP Trustees (the City Managers of Daly City, Brisbane, and South San Francisco, and the San Mateo County Manager). Monitoring and habitat management is implemented by San Mateo County Parks Department, and implementation of the plan is overseen by the U.S. Fish and Wildlife Service.

THREATS FROM INVASIVE SPECIES

In 1982, an assortment of aggressive invasive plant species were



View of housing development and mission blue butterfly host plant, silver lupine (*Lupinus albifrons* var. *collinus*) on the southeast ridge of San Bruno Mountain. Development is no longer the most serious threat to the grassland habitat on the mountain. A greater threat is coastal scrub succession and the expansion of invasive species.

ing” (destruction) of endangered species and their habitat, provided that the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild, as specified in section 10(a)(1)(B) of the federal Endangered Species Act.

identified and mapped on the mountain. Gorse (*Ulex europaeus*), the most aggressive of these plants, was introduced to the mountain in the 1930s and by 1982 had expanded to cover several hundred acres of the mountain. Based on the rate of expansion of this plant and that of other invasive weeds, combined with illegal off-road vehicle use and coastal scrub succession, it was estimated that the habitat for the endangered butterfly species on the mountain could be completely wiped out within 50 to 200 years (San Bruno Mountain HCP Steering Committee 1982).

As a result, the funding and

implementation of ongoing habitat management with an emphasis on controlling invasive species became an important component of the San Bruno Mountain HCP. Due to the lack of information on the feasibility of habitat restoration at the time of the inception of the HCP, the HCP's primary goal has been focused on the conservation and management of existing habitat for the butterflies (San Bruno Mountain HCP Steering Committee 1982).

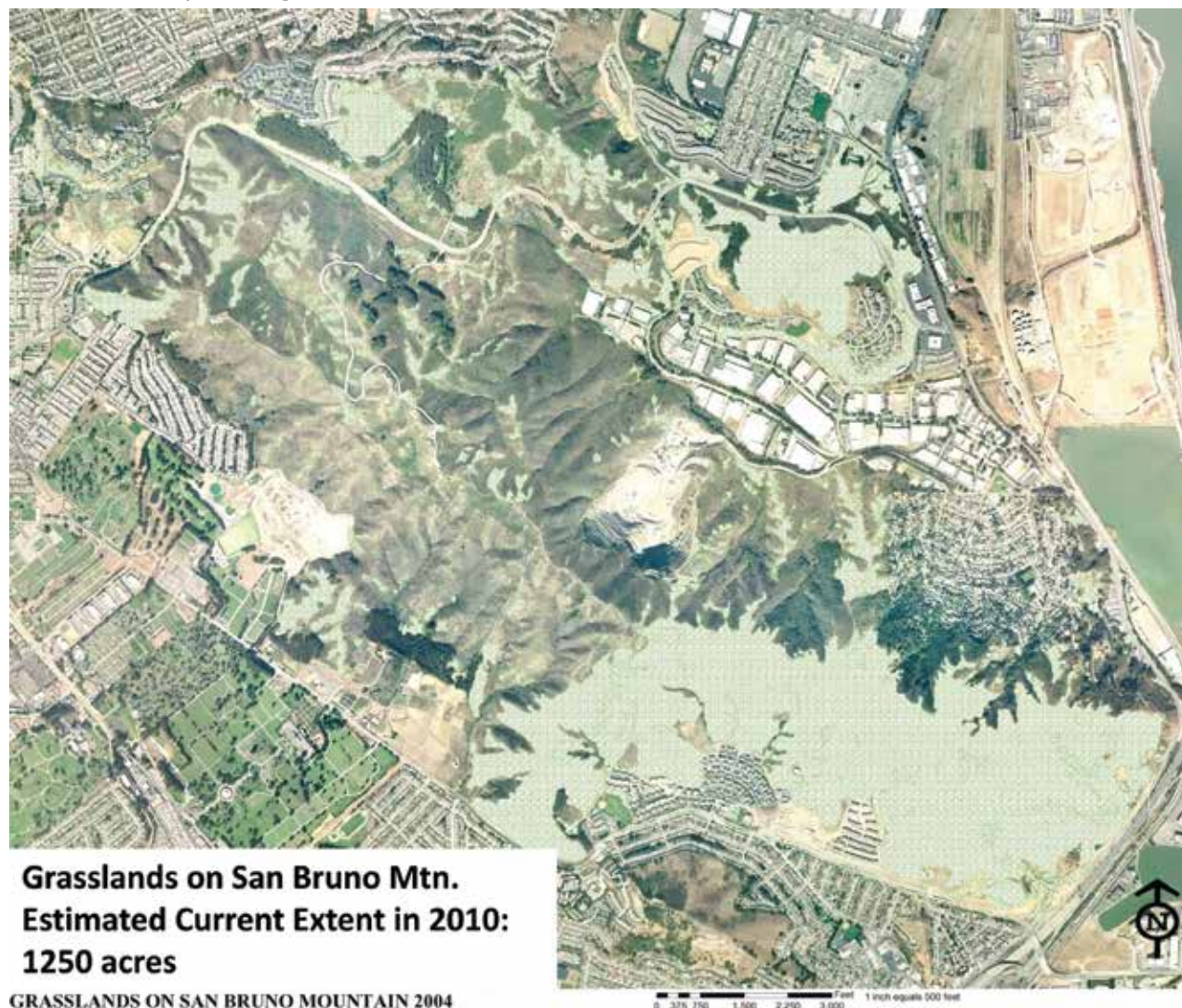
Though the HCP has often been criticized for the lack of restoration work that has been conducted, the strategy of focusing efforts on protecting the existing habitat has

proven to be successful in maintaining most of the habitat for the endangered species over the 30-year span of the HCP. While the reductions of large infestations has been effective, it is the less noticeable habitat maintenance work that is done year in and year out by HCP work crews and volunteer groups that serves to protect the majority of the butterfly habitat on the mountain.

HABITAT RESTORATION

Restoration of mission blue and callippe silverspot habitat is required by the HCP within areas that were disturbed by grading activi-

Extent of grasslands on San Bruno Mountain as mapped in 2004. Map produced by TRA Environmental Sciences and provided courtesy of San Mateo County Parks Department.





ties adjacent to the developments. These areas have steep slopes that were engineered to protect against landslides. Restoration of butterfly habitat has not been successful on most of these slopes, due to the difficulty in establishing native plants in poor soil conditions. This is especially true for the host and nectar plants for the callippe silverspot butterfly. Propagating and replanting of the callippes' host plant Johnny jump up has shown to be expensive, with very little success to date. Johnny jump up is difficult to grow under nursery conditions, and has had a very low survival rate when transplanted into restoration sites. For the mission blue however, its host plants (especially silver lupine) have been re-established on several restoration slopes because these plants are adapted to disturbed rocky slopes with thin or poor soil conditions.

CURRENT THREATS AND MANAGEMENT

While efforts have been successful in reducing the large, woody invasive species on San Bruno Mountain, control work has been less effective at stemming the tide of coastal scrub succession. An independent analysis of almost 20 years of butterfly data collected over the course of the HCP revealed that the overall distribution of the mission blue and callippe silverspot butterflies remained stable. However, geographic areas of concern were identified for each species.

For the period between 1982 and 2004, San Bruno Mountain lost an estimated 122 acres (8.6%) of grassland habitat. This was primarily due to coastal scrub succession within the HCP conservation area (San

Mateo County Parks Department 2008). This corresponds to a loss of over five acres of grassland per year. The expansion of coastal scrub vegetation and corresponding loss in grassland has been documented in many regions of California (Murray 2003, McBride and Heady 1968), and is often the result of the removal of grazing and/or burning from a grassland ecosystem.

Historically cattle grazing and brush burning by local ranchers resulted in the control of coastal scrub vegetation on San Bruno Mountain, but also facilitated the spread of invasive plant species. Invasive grasses such as riggut brome (*Bromus diandrus*), velvetgrass (*Holcus lanatus*), and invasive herbaceous weeds such as fennel (*Foeniculum vulgare*), wild radish (*Raphanus sativus*), and oxalis (*Oxalis pes-caprae*) have proliferated because of the ability of these species to rapidly expand into grasslands (San Mateo County Parks Department 2008). Atmospheric sources of nitrogen pollution (smog) may also be contributing to the spread of these invasive grasses and weeds within the grasslands (Weiss 2006).

As more and more weeds proliferate and die back, the resultant accumulation of live and dead biomass (thatch) reduces the amount of light reaching the soil surface, suppressing the growth of native grassland plants. Increased moisture retention from the shade created by thatch may also facilitate the expansion of coastal scrub into the grassland areas. Furthermore, where invasive control work has been done for decades, there is a significant build-up of thatch from old stalks of fennel, broom, and gorse plants that were left to decay in place.

The level of thatch within the

grasslands on San Bruno Mountain was evaluated in 2002 using live and dead above-ground biomass measurements. Values measured within the grasslands on the south slope of the mountain prior to experimental grazing treatments, showed live and dead above ground biomass levels of 5,000 to 9,000 lbs/acre. A large proportion of this was from thatch. As a comparison, the recommended ranges for Residual Dry Matter (live biomass) in coastal prairie grasslands with minimal woody plant cover ranges from 1,200 to 2,100 lbs/acre (UC Davis 2002).

The reduction in wildfires, removal of grazing animals in the early 1960s from the mountain, and atmospheric nitrogen pollution are all likely factors contributing to the proliferation of invasive plants, build-up of thatch, and brush succession on the mountain.

FUTURE MANAGEMENT

The San Bruno Mountain HCP has been an experiment—the first of its kind—to protect endangered species habitat while allowing limited development. For 30 years the plan has been a qualified success in that all three of the endangered butterfly species on the mountain continue to be locally abundant. However, management of the conservation areas will need to adapt to changing conditions and address problems such as coastal scrub succession and invasive weeds in a more comprehensive way. The 2008 San Bruno Mountain Habitat Management Plan spells out in detail the priority areas to protect, the current and emerging threats to the mountain's habitats, and the methods for monitoring and management to address these threats.

FACING PAGE, TOP: Buckeye Canyon in 1986. This photograph was taken approximately 25 years after cessation of cattle grazing on San Bruno Mountain. • BOTTOM: Buckeye Canyon in 2006. This photograph was taken approximately 45 years after the cessation of grazing. Coastal scrub vegetation is overtaking grasslands at a rate of approximately five acres per year. Photographs courtesy of TRA Environmental Sciences and San Mateo County Parks Department.



View of the ridge above Owl Canyon near the summit of San Bruno Mountain. The area contains prime grassland habitat, including native wildflowers and shrubs, for the Callippe silverspot and San Bruno elfin butterflies, both endangered.

Until 2010, threats to native habitats on San Bruno Mountain could not be addressed comprehensively given the existing management budget. However, as a result of an agreement reached between developers, the city of Brisbane, San Mateo County Parks Department, and the U.S. Fish and Wildlife Service, an additional four million dollars will be generated through development fees and placed into an endowment for the mountain. Once collected, these funds would increase the HCP annual budget for habitat management by two to three times its former level. These funds need to be used to manage more grassland areas on the mountain.

With accelerated changes ex-

pected to occur from global climate change, it is important to preserve as much potential grassland habitat as possible to buffer the endangered species from occasional large-scale declines in habitat quality. For example, in the extremely wet El Niño year of 1998, the numbers of mission blue butterflies on San Bruno Mountain declined markedly in areas where silver lupine was the dominant host plant. Silver lupine experienced a widespread die-off due to a fungal infestation brought on by the excessive wet soil conditions. This impact was observed throughout the range of the species (including the Marin headlands and at Twin Peaks, San Francisco).

In contrast, habitat areas on San

Bruno Mountain that supported the alternative host plant summer lupine were unaffected by the fungus, and mission blue butterfly numbers in these areas remained stable. In the subsequent 14 years, silver lupine plants have rebounded significantly, as have the mission blue numbers in the areas impacted by the fungus. Protecting areas of different habitat quality, slope aspect, and within different microclimates is important because habitat quality can be expected to fluctuate over time, due to plant senescence and climatic factors, and these fluctuations may become more extreme in the future.

While prescribed burning may continue to be difficult to imple-

ment on San Bruno Mountain due to public safety concerns, grazing and/or mowing should be implemented to reduce vegetation fuel loads between parkland areas and homes and businesses. Stewardship grazing or mowing of 100–500-foot buffer zones on regular intervals would reduce fuel loads near populated areas and could potentially allow for the safe use of controlled burns in some areas of the mountain. Also, grazing or mowing within lower elevation areas between parklands and developments would not impact the more intact stands of coastal prairie, which are more concentrated on the upper slopes of the mountain.

Grazing, mowing, and/or burning will need to be applied to address scrub succession and invasive weed infestations on San Bruno Mountain. These tools will need to be used in combination with other weed control methods to manage areas effectively. There must be a prescriptive approach that is tailored in timing, duration, and frequency to each area of the mountain, depending upon the grassland type, surrounding terrain, presence of rare and endangered species, and public safety concerns.

CONCLUSIONS

Over the years, the San Bruno Mountain HCP has received a substantial amount of criticism from environmental groups regarding the lack of successful habitat restoration on the mountain. In contrast, resource managers have emphasized the positive aspects of the HCP and how it has worked to protect the endangered species habitat and native plant communities. The reality is that both groups are right. The restoration work has been largely unsuccessful on the graded slopes, while the habitat management has been successful in protecting the endangered species populations within the conservation areas.

The primary focus of environ-

mental groups has been on fighting development on San Bruno Mountain, under the assumption that development is the major threat to the endangered species. In reality, though, the permitted development has impacted approximately 10% of the mountain and was relegated to lower slopes, generally of lesser habitat value. The development is now nearing completion. The only way to protect the endangered species and the plant communities of San Bruno Mountain for future generations will be to manage the remaining conserved habitat more effectively.

The 2008 Habitat Management Plan for San Bruno Mountain established a goal of maintaining between 1,200–1,800 acres of native and non-native grassland on the mountain. Currently the area of grassland is approximately 1,250 acres, but it is decreasing at a rate of approximately five acres per year. Slowing the rate of coastal scrub succession and increasing the amount of grassland will require that brush control programs be implemented sooner rather than later.

The San Bruno Mountain story is not unique: brush succession and invasive species have been negatively impacting grasslands and meadows throughout California for several decades. The San Bruno Mountain HCP is unusual, however, in that it has had a mandate and funding to address these issues for 30 years. It will take a coordinated effort on the part of biological monitors, habitat managers, oversight agencies, environmental groups, and the community to work cooperatively and creatively to ensure that the mountain's endangered species and unique Franciscan flora are protected for the next 30 years.

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View southeast from block F8 of Griffith Park (see Figure 2) showing downtown Los Angeles (at right) and the Los Angeles River (center).

RARE PLANTS OF GRIFFITH PARK, LOS ANGELES

by Daniel S. Cooper

Rising more than a thousand feet off the floor of the Los Angeles Basin, Griffith Park divides the eastern San Fernando Valley from the coastal plain of Los Angeles and protects more than 4,000 acres of rugged slopes and canyons at the eastern end of the Santa Monica Mountains. Although portions of the park are heavily used, with golf courses, grassy picnic areas, and other attractions situated mainly at the park's borders, its rug-

ged interior is still surprisingly wild, owing to both its steep topography and lack of established trails.

WILDFIRE PROVIDES IMPETUS FOR NEW RESEARCH

On May 8, 2007, an arson-caused wildfire burned about 20% of the park, essentially the entire southeastern corner, threatening

such landmarks as the Griffith Observatory and the Los Angeles Zoo, none of which sustained damage. Just a few weeks earlier, on March 30, an arson fire had swept up toward the northwestern corner of the park, burning a large area of high-elevation chaparral atop Cahuenga Peak, the highest point in the eastern Santa Monica Mountains. While these fires radically altered portions of the park's vegetation—at least temporarily—their more lasting

contribution may have been the increased awareness they elicited from local conservationists and city staff alike, most of whom had never explored the park. Suddenly, the park seemed like a worthy subject of immediate ecological exploration, perhaps because it was almost completely reduced to ash-covered slopes.

Just prior to the fires and continuing to the present, a collection of neighborhood groups and the Los Angeles/Santa Monica Mountains Chapter of CNPS funded several projects aimed at gathering baseline biological data on its plants and animals. These were carried out in conjunction with the development of a wildlife management plan funded by the City of Los Angeles (Cooper and Mathewson 2009). While the flora of the Santa Monica Mountains as a whole has been well documented (Wishner 1997; Gibson and Prigge 2003; California Native Plant Society, undated), that of the far eastern end of the range is comparatively less well-known than the large, protected areas to the west such as Topanga Canyon State Park and the Santa Monica Mountains National Recreation Area.

Aside from scattered references (e.g., McAuley 1985), the flora of Griffith Park had never been synthesized, although dozens of specimens had been collected here since the mid-1800s, mostly prior to 1950 (Consortium of California Herbaria 2011). The one available checklist of the plants of the park (Brusha 2003) does not differentiate between planted and naturally occurring taxa, and presents just a fraction of the true species diversity. Currently an as-yet unpublished checklist of the park's flora stands at more than 500 species vouchered or photographed (Cooper, forthcoming). This is nearly half the known flora of the Santa Monica Mountains and includes 350 natives. Still, the park has apparently never been a popular place for botanizing, probably

because of its rugged topography and the fact that most readily accessible hiking areas (mainly fire roads) have been degraded by weed abatement practices and non-native vegetation.

SURVEY LAUNCHED

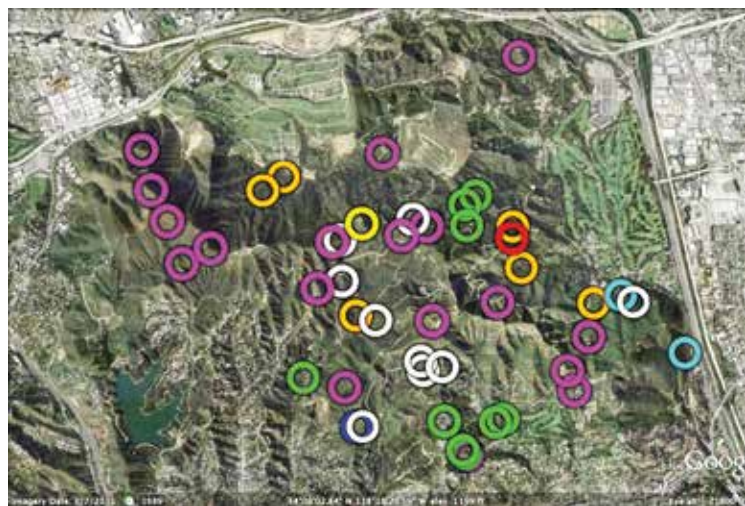
To remedy this information gap and to identify critical areas for plant conservation, an informal, volunteer-based "Griffith Park Rare Plant Survey" was launched in spring 2010 (Cooper 2010). The botanical history of an area can be a challenge to uncover, even for trained researchers. Most parts of California remain very poorly known botanically, including sites within urban areas. Often there are a few local experts who have botanized in an area and have kept at least some field notes (or today, digital photographs), and can help put together a list of species likely to occur based on their experience in the region. Such observations may be supplemented by plant collections in local herbaria, which are often the only record of species long gone from urban sites such as native wildflowers.

Through my own fieldwork conducting wildlife surveys in the park since 2007, I was able to identify key habitat features most likely to hold rare or interesting plants, such as rock outcrops and remote canyons. To begin the task of locating rare and significant species and populations, a list of target species was developed with the help of Richard Fisher, Bart O'Brien, and Carl Wishner, local botanists familiar with the flora of the Santa Monica

Mountains. Included in this list were both CNPS rare taxa (California Native Plant Society 2010), as well as a group of species we felt were significant, either because they are rare in the region, or because if found, they would represent disjunct occurrences from populations farther west in the Santa Monica Mountains, or to the north in the Verdugo and/or San Gabriel Mountains.

I also searched for taxa known in the area only from historical collections (Consortium of California Herbaria 2011), though some of these were likely collected in areas no longer undeveloped (e.g., the Los Angeles River and "Providence Ranch," since converted to Forest Lawn Memorial Park). A small group

Figure 1. Locations of Rare Plants in Griffith Park

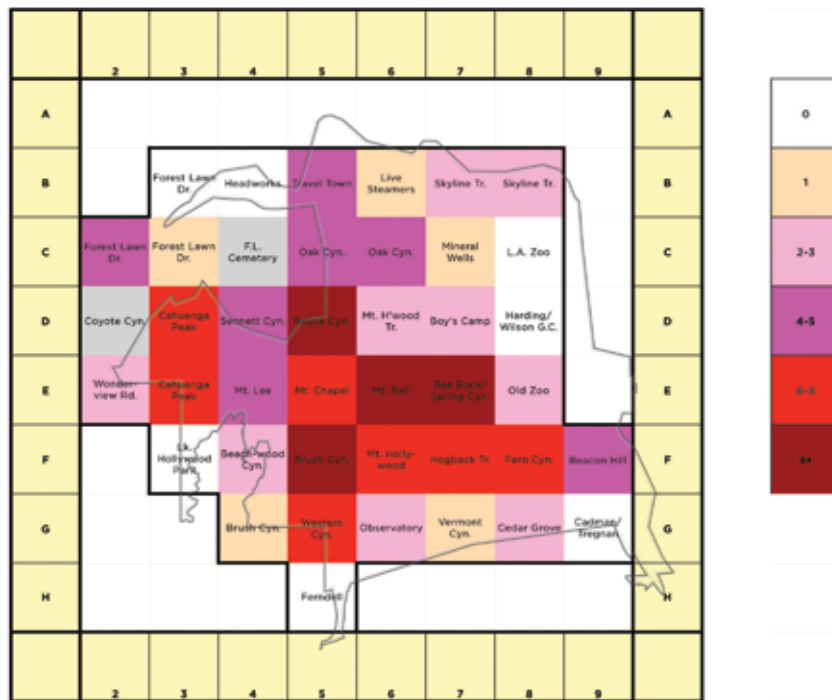


KEY:

- Green: Nevin's barberry (presumed planted)
- Magenta: Plummer's mariposa lily (generalized locations; plant is very widespread)
- White: Catalina mariposa lily
- Yellow: Slender mariposa lily
- Dark Blue: Clay bindweed
- Light Orange: Humboldt lily
- Light Blue: Hubby's phacelia
- Red: San Gabriel Mountains leather oak (pending further identification)

of volunteers used this species list, along with a map of the park (Cartifact, Inc. 2007) that had been divided into 40 survey blocks, and

Figure 2. Distribution of Rare and Locally Rare Plant Species in Griffith Park, by Survey Block



Outline of park is drawn in gray. This grid system follows that used by Cartifact, Inc. (2007) for a Griffith Park map, and notable natural and physical features are listed within each block. The colors correspond to the number of rare species found within each block, as indicated by the key on the right. For example, pale pink blocks had two to three rare species, while the darkest red blocks had nine or more.

sent me photos and notes from their forays throughout spring 2010.

RARE SPECIES FINDINGS

From this effort, 13 rare species (California Rare Plant Ranks 1, 2, and 4) were identified as occurring or having occurred in or adjacent to Griffith Park. Of these, nine were found to be extant (still in existence), and four are known only from

historical specimens (Table 1). (A description of the California Rare Plant Ranks, formerly the CNPS Lists, is available at <http://www.cnps.org/cnps/rareplants/ranking.php>.) Of the four species believed extirpated from Griffith Park, only one, the Brewer's redmaids (*Calandrinia breweri*), has been collected recently in the region near the park (Verdugo Mountains); the remaining species are apparently very rare

in the Los Angeles area if they persist at all.

Three species of mariposa lily occur in the park, and exhibit an interesting, non-overlapping pattern of occurrence, with Plummer's mariposa lily (*Calochortus plummerae*) by far the most common. Hundreds of these spectacular pink and yellow lilies were encountered on thin, gravelly soil along ridges, often in association with yucca (*Hesperoyucca whipplei*), giant stipa (*Achnatherum coronatum*), coast buckwheat (*Eriogonum fasciculatum*), and chamise (*Adenostoma fasciculatum*). They were often found along small trails and footpaths (including equestrian routes), where this activity appeared to limit non-native grasses, among other plants, that might otherwise overtake the lilies.

Catalina mariposa lily was found in pockets of grassland on moist, heavy clay soil near the south-central area of the park, with two large populations discovered that exceed 100 plants. Finally, the slender mariposa lily (*Calochortus clavatus* var. *gracilis*) was discovered prior to the start of the survey, in a single patch of fewer than 10 individual plants in a grassy opening in chaparral on a remote peak near the center of the park. No other populations of this stunning yellow lily were encountered, despite much searching.

Humboldt lily (*Lilium humboldtii* var. *ocellatum*) appears to be confined to just four oak-shaded canyons in the park, with most plants (50+ individuals) located in Brush

LEFT: Plummer's mariposa lily is found frequently on steep ridges on eroding soil throughout Griffith Park, Los Angeles. All photographs by the author unless otherwise specified. • MIDDLE: Chaparral pea emerging atop Caluenga Peak after 2007 fire in Griffith Park. • RIGHT: The rare Humboldt lily is found beneath oaks in several deep canyons in Griffith Park. Photograph by Gerry Hans.



TABLE 1. SPECIAL STATUS PLANTS AT GRIFFITH PARK

Species	Legal status	Representative specimen ¹	Park status (40 survey blocks)
Nevin's barberry <i>Berberis nevinii</i>	Federal: Endangered State: Endangered CA Rare Plant Rank 1B.1	SBBG37272	Probably introduced; found in 5 survey blocks
Brewer's redmaids <i>Calandrinia breweri</i>	CA Rare Plant Rank 4.2	JEPS17234	Historical specimen(s); no modern record
Catalina mariposa lily <i>Calochortus catalinae</i>	CA Rare Plant Rank 4.2	RSA15196 ("Cahuenga Pass")	8 survey blocks; heavy clay soil
slender mariposa lily <i>Calochortus clavatus</i> var. <i>gracilis</i>	CA Rare Plant Rank 1B.2	(photograph only)	1 survey block, < 10 plants
Plummer's mariposa lily <i>Calochortus plummerae</i>	CA Rare Plant Rank 1B.2	LA29033	13 survey blocks, gravelly ridges
Clay bindweed <i>Convolvulus simulans</i>	CA Rare Plant Rank 1B.2	UCR216375	1 survey block, < 10 plants
many-stemmed liveforever <i>Dudleya multicaulis</i>	CA Rare Plant Rank 1B.2	RSA397814	Historical specimen(s); no modern record
large-leaved filaree <i>Erodium macrophyllum</i>	CA Rare Plant Rank 4.2	RSA390952 ("Providencia Ranch")	Historical specimen(s); no modern record
southern California black walnut <i>Juglans californica</i>	CA Rare Plant Rank 4.2	JEPS58691	Common park-wide; not mapped
Humboldt lily <i>Lilium humboldtii</i> var. <i>ocellatum</i>	CA Rare Plant Rank 4.2	(photograph only)	6 survey blocks, mesic canyons
Hubby's phacelia <i>Phacelia cicutaria</i> var. <i>hubbyi</i>	CA Rare Plant Rank 4.2	UCR209589	2 survey blocks, sedimentary rock
Cooper's rein-orchid <i>Piperia cooperi</i>	CA Rare Plant Rank 4.2	RSA382793 ("Providencia Ranch")	Historical specimen(s); no modern record
San Gabriel Mountains leather oak <i>Quercus durata</i> var. <i>gabrielensis</i>	CA Rare Plant Rank 4.2	RSA652868	1 survey block

¹ Location is "Griffith Park" unless otherwise indicated.
SBBG = Santa Barbara Botanic Garden
JEPS = Jepson Herbarium, UC Berkeley

RSA = Rancho Santa Ana Botanic Garden Herbarium
LA = UCLA Herbarium
UCR = UC Riverside Herbarium

Sources: Consortium of California Herbaria 2011; Cooper 2010.



Dwarf brodiaea, a locally rare plant otherwise unknown in the eastern Santa Monica Mountains, was discovered just outside the park boundary in 2010.

Canyon in the southwest corner. Hubby's phacelia (*Phacelia cicutaria* var. *hubbyi*) was found on exposed, eroding sedimentary deposits at the far southeast corner of the park, on soil probably deposited by the ancient Los Angeles River that flows nearby. Thousands of these plants bloom in early spring in the understory of open black walnut woodland. The tiny clay bindweed (*Convolvulus simulans*) was found by a volunteer in 2010 on a moist, grassy slope on heavy clay near the southwestern border of the park just north of Hollywood, a site that also supports the only park population of chocolate lily (*Fritillaria biflora*).

Nevin's barberry (*Berberis nevinii*) is arguably the most famous rare plant in the park, and also the most problematic. Most stands (dozens of plants each) occur in two populations. Scattered plants located since 2007 have all been along major roads (strongly suggesting a horticultural origin), or just down-slope of established populations. Whether plants at Griffith Park originated from locally-collected seed decades ago—possibly from now-extirpated native populations in the Los Angeles area—it seems likely that the current population is not naturally-occurring (USFWS 2009). Still, Griffith Park is within the historical range of the species and all plants occur in a low-elevation, arid chaparral community with a species composition very similar to known natural occurrences.

Another difficult-to-assess rare plant in the park is the San Gabriel Mountains leather oak (*Quercus durata* var. *gabrielensis*, California Rare Plant Rank 4.2), which is known from a single collection in 1991. However, more study and collection of various scrub oaks in the park are needed, particularly since Griffith Park may lie within an introgression zone between the flora of the Santa Monica and San Gabriel Mountains. This variety appears to be otherwise unknown in the Santa Monica Mountains.

A map showing the distribution of the above rare species in the park is provided in Figure 2 on page 20.

LOCALLY RARE SPECIES

Several locally rare species were found in substantial populations in Griffith Park. Both Nevin's brickle-bush (*Brickellia nevinii*) and Ft. Tejon milk-aster (*Stephanomeria cichoriaceae*) are frequent on rock outcrops and roadcuts throughout the park and even in surrounding residential areas to the south. Eastwood's manzanita (*Arctostaphylos glandulosa* ssp. *mollis*), chaparral pea (*Pickeringia montana*), and interior live oak (*Quercus wislizenii* var. *frutescens*) occur high atop Cahuenga and Burbank peaks within a dense chamise-manzanita chaparral above the 1,600-foot elevation level, with smaller numbers of manzanita and a single clump of interior live oak near Mt. Hollywood.

"Moss gardens," where soil has collected at seeps on rock faces, support a variety of bryophytes, ferns, and rare annuals at Royce Canyon and east along the north side of Mt. Bell, including California saxifrage (*Saxifraga californica*), Peninsular onion (*Allium peninsulare*), Fremont star-lily (*Zigadenus fremontii*), and (Royce Canyon only) a white-flowered form of Cleveland's shooting-star (*Dodecatheon clevelandii*). A few areas of private land adjacent to the park were found to be rich in scarce

flora, and more probably await discovery. The only known population of dwarf brodiaea (*Brodiaea terrestris* var. *kernensis*) in the eastern Santa Monica Mountains (A. Gibson, pers. comm.) was also discovered by a volunteer during the survey.

Uncommon species reaching a local distributional limit near the park include erect goldenaster (*Heterotheca sessiliflora* var. *fastigiata*), the *latifolium* subspecies of the widespread California fuchsia (*Epilobium canum*), and valley cholla (*Cylindropuntia californica* var. *parkeri*). A few common wildflowers in the park show more of a San Gabriel Mountains affinity, including Canterbury bells (*Phacelia minor*), one of the most abundant spring annuals in the park, becoming much more localized farther west in the Santa Monica Mountains.

The population of southern California black walnut (*Juglans californica*) in the park is so large that it was not mapped during the survey. Black walnuts form a continuous woodland/high shrubland on sedimentary soils in the southeastern corner of the park, and this is also a dominant species in the chaparral that cloaks the northern slope of the park.

PATTERNS OF DIVERSITY

Although areas at the lowest elevations at the perimeter of the park tended to support fewer target species, several featured a handful of locally rare species. Important populations, including the only known local occurrences, were found at multiple and scattered locations, making it difficult to declare a given area unimportant for any rare plant. Not surprisingly, the fewest target species overall were found in the northeastern corner of the park. This area that has probably seen the most intensive human-caused impacts over the years, including the construction of a large landfill in the

1950s, the installation of a vast network of metal irrigation pipe designed for fire control (but never functional), and widespread planting of eucalyptus and pines, ostensibly for “beautification” starting in the early 1900s.

It also became clear in our survey that most scrub-covered slopes in the park were largely devoid of rare plants, with diversity mainly confined to microhabitats such as seeps in deep canyons, sandy/gravelly ridges, moss gardens, rock outcrops, and patches of grassland on wet clay soils. Areas of the park that combined these features predictably supported both a high diversity of rare species and large populations of them.

The identification and documentation of these microhabitats are critical to making management decisions that benefit biodiversity, and

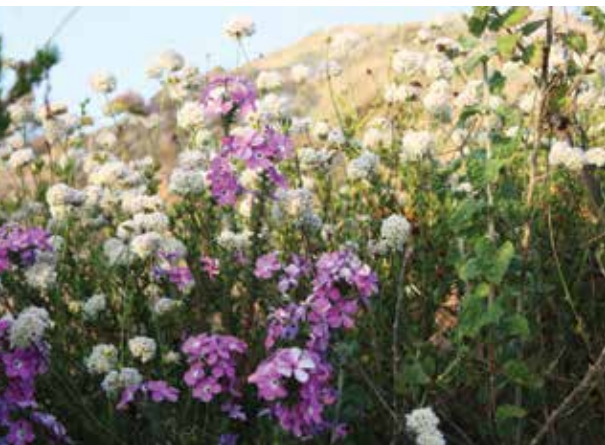
the distribution of rare and localized plants can be an important first step in a site’s conservation. The involvement of local volunteers not only contributes information to this process, it helps ensure that the human community will be invested in resource conservation in “Hollywood’s backyard.”

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Nevin’s barberry, one of the rarest plants in California (in the wild), thrives in Griffith Park, although the entire population is suspected to have been introduced decades ago. It is a large shrub found very locally on loose, gravelly soils within chaparral, and is endemic to southern California. Photographs by Gerry Hans.





ABOVE: "Moss gardens," or patches of moist soil within rock outcrops, are key areas for rare plants at Griffith Park. • LEFT: The prickly phlox (*Leptodactylon californicum*) occurs as scattered plants within the park, mainly in small openings in arid scrub on eroding ridges and slopes. Its bright pink flowers are unmistakable in spring. • BOTTOM LEFT: The striking Catalina mariposa lily (*Calochortus catalinae*) is one of three species of *Calochortus* in the park, and is found amid grasses on patches of heavy clay soil, especially those that stay moist through the spring.

(CCH). 2011. Data provided by the participants of the Consortium of California Herbaria. <http://ucjeps.berkeley.edu/consortium/>.

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A PLEA TO PROTECT WALKER RIDGE

by Stephen W. Edwards

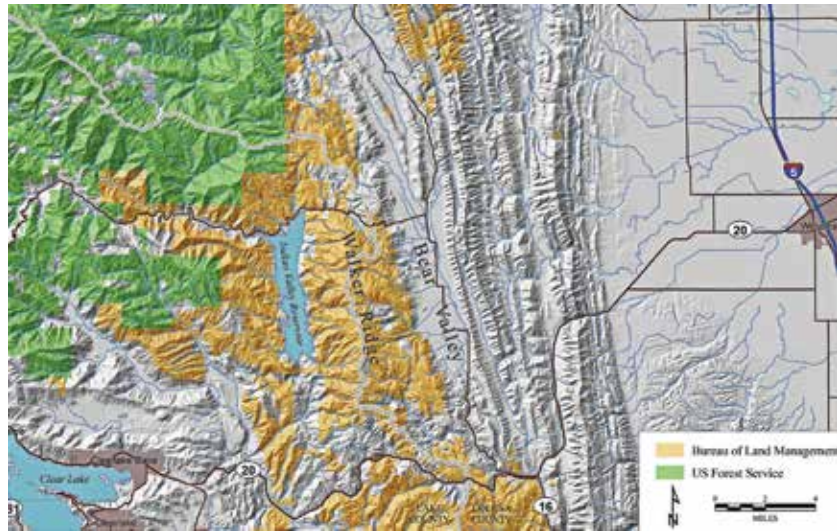
(Editor's Note: The following article is an abbreviated version of a longer article that appeared in The Four Seasons, Journal of the Regional Parks Botanic Garden, Volume 14, Number 1, October 2011.)

Walker Ridge, on the boundary of Lake and Colusa counties between Clear Lake and the town of Williams, forms an inseparable unit with Bear Valley, which adjoins the ridge to the east. The valley—thanks to the dedication of generations of ranchers and timely action of conservation organizations—displays in good years by far the best remaining panoramas of Northern California's field wildflowers. No other area comes close.

Sediments on the valley floor are strongly influenced by the magnesium-rich, calcium-poor ultramafic rocks of Walker Ridge, and this almost certainly contributes to the wildflower displays. The ridge and the valley have been a combined destination for wildflower lovers, researchers, and university class study for decades. Visiting the one almost always entails visiting the other because the contrast between their natural histories is fascinating. The valley with its vast, flowery panorama is made all the more enchanting by the bold backdrop of Walker Ridge.

OF NATIONAL PARK QUALITY

Walker Ridge and Bear Valley together are clearly of national park quality. The Carrizo Plain National Monument, which includes the plain as well as parts of the Temblor and Caliente ranges in Southern California, is an excellent analogy. It is a



Map showing the proximity of Walker Ridge to Bear Valley. Source: Gregory Gallagher.

park celebrated principally as a remnant of the wildflowers of the San Joaquin Valley as Thomas Jefferson Mayfield and John Muir described them (1850s and 1860s respectively). So it is with Bear Valley and Walker Ridge, which are to the original, unspoiled Sacramento Valley of the early 1800s what the Carrizo Plain National Monument is to the San Joaquin Valley.

That is why I have long felt that Walker Ridge—most of which is under the jurisdiction of the Bureau of Land Management (BLM)—and parts of Bear Valley that might one day be in public ownership, should become a national monument. Walker Ridge preserves much of one of California's three greatest serpentine terrains (the others are The Cedars in Sonoma County and the Trin-

Green's butterweed (*Senecio greenei*), an orange-hued serpentine endemic found on Walker Ridge, bears some of the most striking flower heads of any sunflower. It has stubbornly resisted all attempts by horticulturists to propagate it. Also pictured is common woolly sunflower (*Eriophyllum lanatum*). Photograph by Craig Thomsen.





ABOVE: Serpentine scree slopes along the crest of Walker Ridge are precious preserves for rare, unusual, and beautiful plants. The proposal for a wind farm on the ridge includes an array of giant wind turbines, along with attendant roads, trenches, etc. Photograph by Phil Van Soelen, 2009. • RIGHT: Sky lupine (*Lupinus nanus*), creamcups (*Platystemon californicus*), purple owl's clover (*Castilleja exserta*), and in the distance, tidy tips (*Layia* sp.), on the floor of Bear Valley, with Walker Ridge in the background, April 1995. Photograph by Stephen W. Edwards.

ity ultramafic sheet around Mt. Eddy in Siskiyou County), and these are three of the greatest serpentine areas on earth. Walker Ridge is a living classroom of inner coast range natural history, from which one can gaze eastward at Sierran snows and the Pleistocene volcanoes of the Sutter Buttes, westward to the Clear Lake volcanic field, and north to the snow-capped peaks of Mendocino National Forest.

It makes sense to imagine Walker Ridge and parts of Bear Valley as California Serpentine National Monument. Serpentinite, which, owing to its fortunate chemistry, accounts for a greatly disproportionate amount of high-quality California wildflower habitat, has not received adequate recognition at a federal (or state) level. Walker Ridge offers an opportunity to rectify that insufficiency and, at the same time, provide a park of surpassing beauty and fabulous biodiversity that could be enjoyed by all.

IMPENDING DEVELOPMENT THREAT

At the time of this writing, plans are underway by a Canadian energy company to develop an extensive and elaborate array of giant wind

turbines, with all their associated equipment, facilities, pads, yards, and roads, along the serpentine summit of Walker Ridge. Those familiar with the biology and scenery of Walker Ridge know that it is the last place in California that should be considered for any kind of intrusive development, and that is not merely owing to its richness. Accessibility is another critical factor. Here one can easily drive to many spectacular habitats, and the whole area is only one to two hours by car from major population centers and universities.

UNPARALLELED RICHNESS, BEAUTY

It has long been known that serpentine meadows on Walker Ridge are the place to go for great displays of flowers after Bear Valley has largely dried up. The ridge also of-

People make pilgrimages to Walker Ridge to see the rare serpentine milkweed (*Asclepias solanoana*). It can be found only on sliding scree, through diligent searching. Its low, ground-hugging habit makes it intolerant of competition. Photograph by Stephen W. Edwards.



fers many open serpentine scree slopes decorated with striking flowering gems that cannot endure competition on less severe sites. (Scree is a gravely deposit that forms on hillsides where bedrock is weathering not far below the surface.) Many of these plants, too, can be enjoyed in flower in summer. Road banks themselves, and natural benches above them, are full of gorgeous plants. Many of these plants may be difficult for anyone with mobility issues to find or reach away from the road. Serpentine chaparral also contains in its understory and rocky openings a host of exciting plants. Streams that cut serpentine gorges along and near Bartlett Springs Road cascade over travertine benches and



bring clear, cool water to lush and extraordinarily diverse riparian vegetation that includes other, equally beguiling wildflowers. The botanical richness of Walker Ridge is too great to enumerate. There are several running plant lists, and they all keep growing as new discoveries are made.

Walker Ridge is not comprised entirely of serpentinite. Much of the southern half north of Highway 20 is on Great Valley Sequence sandstones. These support a more common, less diverse chaparral and woodland. Nevertheless, the huge fire of 2008 burned much of this part of the ridge, creating the conditions for sheets of wildflowers, and exposing all kinds of lovely plants

that botanists had driven by for decades.

Walker Ridge is one of the greatest places left in California. Is this where we would choose to build a conglomeration of huge (nearly 400 feet tall) wind towers? Would we scrape off the serpentinite and rare plant jewels for yards, pads, trenches, and tarmac? Do we want to widen Walker Ridge Road for oversized trucks, grade away its rich road banks, replace tranquility and natural beauty with fluster and rush, oversight, devastation, and weeds?

Walker Ridge is rich in wildlife—foothill yellow-legged frogs seem to inhabit every serpentine stream—and there is important archaeological evidence of native

Americans. Tuleyome, a conservation organization centered in Woodland, has been working hard to preserve Walker Ridge as part of the proposed Berryessa-Snow Mountain National Conservation Area. At the same time, the California Native Plant Society has formally proposed that the BLM make the ridge an Area of Critical Environmental Concern. I am proposing national monument status, but, whatever the name, the critical thing is that the dignity of Walker Ridge be recognized with the honor it deserves.

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SERPENTINE SOILS AND WHY THEY LIMIT PLANT SURVIVAL AND GROWTH

by Earl B. Alexander

Serpentine evolves from pristine ultramafic rocks formed beneath the oceans. Rocks which contain high levels of iron and very high levels of magnesium are alien on the continents, where there is more calcium in the rocks than magnesium.

Serpentine soils are those that develop from the weathering and disintegration of ultramafic rocks. They inherit much of their mineral composition and chemistry from those rocks. Serpentine soils are so different from others that relatively few plants are adapted for survival in them. Ultramafic rocks and soils cover only about 1% of the land area in California, yet 12% of the endemic species in the state are restricted to serpentine soils (Safford et al. 2005). How are ultramafic rocks and serpentine soils different from non-ultramafic ones, and why are serpentine soils so difficult for plants to cope with?

ELEMENT ABBREVIATIONS

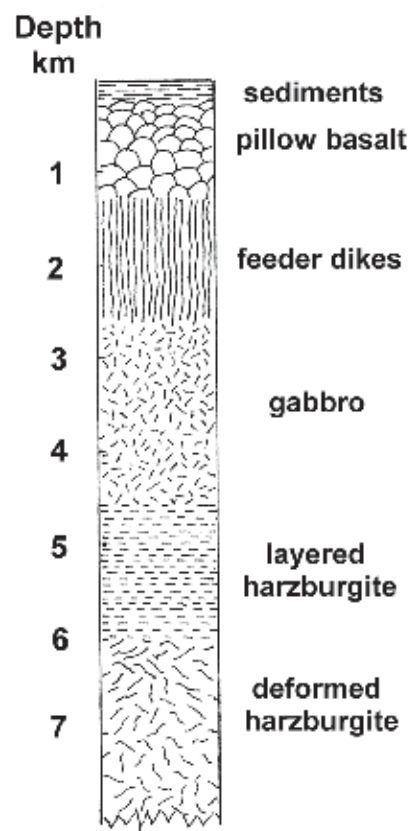
C	carbon
Ca	calcium
Co	cobalt
Cr	chromium
H	hydrogen
K	potassium
Mg	magnesium
N	nitrogen
Ni	nickel
O	oxygen
P	phosphorous
S	sulfur

ROCKS FROM WHICH SERPENTINE SOILS DEVELOP

Serpentine is ecological jargon for *ultramafic rock*. The common ultramafic rocks in California are peridotite and serpentinite. Peridotite is the ultramafic rock produced by crystallization of magma beneath the oceans, and serpentinite is produced by the hydrothermal alteration of peridotite. Serpentine was designated the state rock in California before geologists decided to call the rock *serpentinite* and restrict *serpentine* to the name of the dominant mineral in serpentinite (Wagner 1991).

The story of ultramafic rocks and serpentine soils begins in the mantle. The mantle is between the core and the crust of Earth. Geologists believe that the composition of the upper mantle is comparable to that of lherzolite, which is a type of peridotite. Below the oceans, partial melting in the upper mantle produces a magma that has more of the elements with larger cations (positive ions), such as potassium and calcium, and less of the elements with smaller cations, such as magnesium, than in lherzolite.

Much of the magma rises through the ocean crust at spreading centers, or ridges, and flows outward under seawater, cooling rapidly to form rounded blobs of lava that become a distinctive feature of *pillow basalt*. Magma that does not rise to the top of the ocean crust cools more slowly and forms gabbro, an intrusive igneous rock that is the equivalent of basalt, an extrusive igneous rock. Beneath the gabbro, residue from partial melting in the upper mantle forms harz-



Ophiolite, which consists of basalt, feeder dikes, gabbro, and harzburgite (peridotite). Serpentine forms by alteration of the minerals (olivine and pyroxenes) in peridotite.

burgite, which is another type of peridotite. It is in harzburgite that the elements with smaller cations such as magnesium, chromium, manganese, iron, cobalt, and nickel are concentrated following partial melting of lherzolite. The sequence of rocks from basalt, through a swarm of dikes that have fed basalt upward, and gabbro to harzburgite, is called *ophiolite*.

Ophiolite is produced near the centers of large blocks of ocean crust called plates. The ocean plates move away from the spreading centers toward continental plates. Along the

way, the ophiolite cools, and sediments accumulate on the ocean floor. As the ophiolite cools, it becomes heavier. By the time spreading ocean crust reaches a continent, it is generally cool and heavy enough to sink under the edge of the continental plate into the mantle, a process called *subduction*.

Subducted plates sink for many millions of years, and some ophiolite may reach depths of about 410 kilometers near the bottom of the upper mantle. Sediments are commonly scraped off of the plates and accumulate in long trenches where the plates sink beneath continental margins, with some sediments being dragged under continental margins and plastered against the continental crust, *underplating* it. Plates that have lost their sedimentary cover

sink to depths where they begin to melt. Partial melting of the plates and adjacent continental crust produces magmas that may rise to the surface and form volcanoes. Such volcanoes that skirt the Pacific Ocean comprise a volcanic chain aptly called the *ring of fire*. The Cascade Mountain Range from Lassen Peak in Northern California to Mount Baker in Washington is a link in this chain of volcanoes.

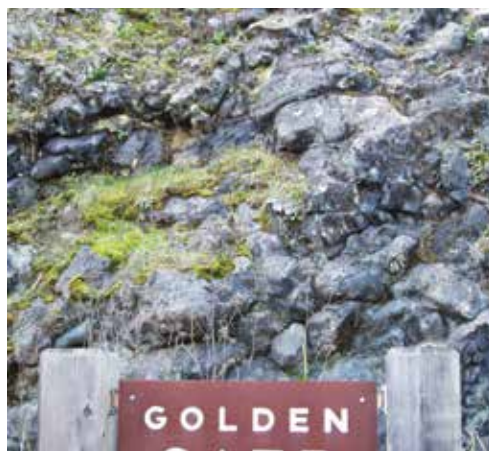
The ultramafic rocks in subducted ophiolites must reach the ground surface to produce serpentine soils. Rocks can be raised to the surface by faulting, or the rocks can be folded and rocks in the folds exposed by erosion of the overlying rocks. The California Coast Ranges are comprised largely of the Franciscan complex of accreted oceanic

terrane, and ophiolites have been thrust over them. Granitic bodies called plutons, and volcanic deposits are commonly added to accreted terranes after the terranes are attached to a continent. The Sierra Nevada batholith is an amalgamation of many plutons, for example, and volcanic rocks in the Coast Ranges, such as those of Mount St. Helens, postdate accretion of the Franciscan complex.

Most peridotite (mainly harzburgite) that we see in California has been at least partially altered to serpentinite. The alteration, a process called serpentinization, begins under the ocean and continues even after harzburgite has been incorporated into the continental crust. Serpentinization is a low temperature process (< 550° C) in which

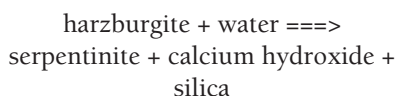
The Lassics barren on the boundary between Humboldt and Trinity Counties. Beyond the barren there is an open Jeffrey pine forest on moderately deep serpentine soils on the right, in contrast to a dense mixed conifer forest on nonserpentine soils on the left. All photographs by the author.



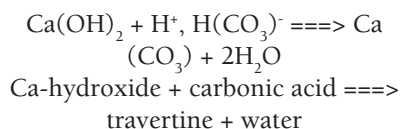


LEFT: Travertine draped over the rocks and forming a small pool where alkaline water produced from the serpentinization of peridotite emerges from the ground, Sonoma County. • MIDDLE: Pillow basalt downstream from the outlet to Nicasio Reservoir, Marin County. • RIGHT: Serpentinization in an exhumed rock.

water is added to the olivine and pyroxenes in harzburgite, and some calcium and silicon are lost from pyroxenes:



The water that reacts with harzburgite generally lacks carbon dioxide; its main role is to provide oxygen and hydroxyl ions used in the formation of serpentine, which contains more of these than the minerals in harzburgite. Water left over from the serpentinization process contains calcium and is alkaline (pH > 11). It is responsible for converting some of the gabbro and basalt in ophiolites to calcium silicate (rodingite). Water from the serpentinization of harzburgite that flows from the rocks to the ground surface reacts with bicarbonates in meteoric water (water that has gained carbon dioxide in the atmosphere or soils) to precipitate the calcium and form travertine. Note that carbon dioxide dissolved in water reacts with it to form carbonic acid that dissociates into hydrogen (H^+) and bicarbonate ($\text{H}(\text{CO}_3)^-$) ions:



PLANT GROWTH ON SERPENTINE SOILS

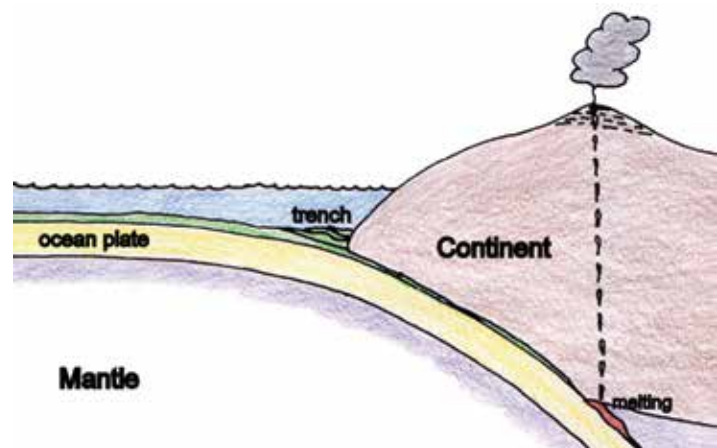
Serpentine soils are those that have peridotite or serpentinite parent materials. These two parent materials commonly produce soils with different physical properties, but the plants appear to respond more to the chemical properties that are similar for soils developed from either parent material. Serpentine soils have a broad range of depths and water-holding capacities, as do soils with most other kinds of parent materials (Alexander et al. 2007). Therefore, we can concentrate on the chemistry to learn why plants respond differently in serpentine soils than in other soils.

The main elements required by plants are H, C, N, O, Mg, P, S, K, and Ca. The first four of these elements are in atmospheric gases, or water, from which plants obtain them either directly or indirectly. Elements for which plants are dependent on the soil parent materials are mainly Ca, Mg, K, and P. Because Mg

concentrations are very high and Ca concentrations are very low in serpentine soil parent materials, the Ca/Mg ratios are very low compared to those in average continental crust and soils.

The very high Mg concentrations, relative to Ca, limit plant uptake of Ca from soils. High Mg (and low Ca) concentrations in plants interfere with metabolic processes that require Ca, excluding plants that have not developed mechanisms to deal with these Ca/Mg imbalances. If supplemental Ca is added to a serpentine soil, P becomes a plant growth-limiting element. Plants commonly respond favorably to the

A pictorial view of serpentinization. Water has entered along fractures in peridotite and caused serpentinization, which diminishes from the fractures toward cores that are only slightly serpentinized peridotite.



AID TO TERMINOLOGY

accreted – added to a continent

cations – positively charged ions

gabbro – intrusive (produced below ground) equivalent of extrusive basalt

harzburgite – ultramafic rock produced from lherzolite (defined below) beneath ocean crust

hyperaccumulators – plants that accumulate more than 0.1% by weight of nonessential elements (e.g., Ni or Co)

lherzolite – ultramafic rock believed to reflect the composition of the upper mantle, lherzolite yields plutonic (intrusive) harzburgite, plus intrusive gabbro and extrusive basalt

mafic lava – molten rock, or magma, that flows over the surface of the earth and cools to form basalt, an aluminum silicate rock with large concentrations of alkaline earth cations (Ca and Mg) and iron

ophiolite – a section of the Earth's oceanic crust and upper mantle that has been uplifted and exposed above sea level

peridotite – ultramafic rock formed by crystallization of magma under the ocean

pillow basalt – mafic lava that flows over the seafloor and cools to solidify in large blobs resembling pillows

pluton – a body of rock (see plutonic rock) formed at depth

plutonic rock – rock that crystallizes slowly from magma at great depths to form crystals visible without magnification

pyroxenes – magnesium silicate minerals, lacking aluminum

serpentine – dominant mineral in serpentinite (and previously the name of the rock)

serpentinite – a greenish metamorphic rock consisting largely of serpentine

subduction – sinking or pushing of an oceanic plate beneath another plate

terrane – alien crustal block that has an origin different from that of adjacent rocks

trichomes – hairlike appendages to plant epidermal cells

ultramafic rocks – rocks consisting mainly of magnesium silicate minerals, with much iron substituting for some of the magnesium

vacuoles – spaces within cells that are filled with liquids

addition of N to serpentine soils, but the same is also true for plants growing in other kinds of soils.

The elements that are much more concentrated in serpentine soils than in others may be toxic to plants. These elements are Cr, Ni, and Co. Some plants such as Sargent cypress (*Cupressus sargentii*) and leatheroak (*Quercus durata*) have developed mechanisms to deal with

elevated concentrations of these elements. They may selectively exclude the elements from root uptake, confine them to roots, or accumulate them as chelated forms or precipitates in the vacuoles of epidermal cells in leaves or concentrate them in trichomes on the leaves.

Plants that accumulate hundreds of times more of an element than most other plants are called hyper-

accumulators. There are hundreds of plant species that hyperaccumulate Ni, and a few that hyperaccumulate Co. There are only two Ni hyperaccumulating species in California, and both are in the mustard (Brassicaceae) family: milkwort jewel flower (*Streptanthus polygaloides*) and two varieties of alpine pennycress (*Noccaea montana*) (Reeves et al. 1983). The only Co hyperaccumulating species are found in Africa.

Plants that thrive on serpentine soils have unusual capabilities to utilize calcium when the alkaline earth elements are dominated by magnesium, and to tolerate concentrations of cobalt and nickel that are toxic to most plants. Plants of intertidal zones are also adapted to grow in soils with low Ca/Mg ratios, but they do not have to cope with potentially toxic concentrations of cobalt and nickel. Although relatively few plants are adapted to grow in serpentine soils, many of them cannot compete with other plants on nonserpentine soils and thus are endemics confined to serpentine soils.

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SERPENTINE ENDEMISM IN THE CALIFORNIA FLORA

by Hugh D. Safford

Ultramafic “serpentine” soils and rock outcrops support an exceptionally high number of endemic plant taxa in California, far out of proportion to their limited representation on the California landscape. California “endemic” plant taxa are species, subspecies, and varieties that are re-



stricted in their range to California; ultramafic endemics are only found on ultramafic soils. About 11% of the taxa found on the California Rare Plant Rank 1B (formerly CNPS List 1B, critically rare taxa) are either strictly or broadly endemic to ultramafic substrates. Rare native taxa that are not serpentine endemics also find important habitat footholds on ultramafic substrates, where they can escape competition from more aggressive, often non-native species.

WHAT ARE SERPENTINE SUBSTRATES?

By definition, ultramafic rocks are igneous and metamorphic rocks that contain less than 45% by weight silica (SiO_2) or, alternatively, support a mineral content that is greater than 90% “mafic” (i.e., magnesium and iron silicate minerals like olivine, pyroxenes, or hornblendes) (Ehlers and Blatt 1982). Ultramafic rocks originate primarily in the earth’s mantle, and find their way to the surface by way of plate tectonics and mountain building, and subsequent erosion of overlying geologic layers.

Ultramafic rocks and the soils that develop on them (often colloquially called “serpentine” after their most important mineral constituents) are characterized by critically low levels of most principal plant nutrients (nitrogen, phosphorus, potassium, calcium), exceptionally high levels of magnesium and iron, and a suite of highly toxic trace elements including chromium, nickel, and cobalt (Alexander et al. 2007). In all, ultramafic rocks occupy an

area of approximately 2,300 square miles in California (Harrison et al. 2000), which makes up around 1.5% of the state’s area. However, as Earl Alexander notes in the accompanying article, inexactitude in mapping may inflate that area somewhat.

NUMBERS AND TYPES OF SERPENTINE PLANTS

Serpentine endemism is a key component of the diversity of the California flora (Raven and Axelrod 1978, Kruckeberg 2002, Safford et al. 2005). In 2005, we carried out an assessment of serpentine endemism in the California flora (Safford et al. 2005). We found that of the 1,416 endemic species listed in *The Jepson Manual*, 1st edition (Hickman 1993), about 176 could be ranked as either “strict” or “broad” serpentine endemics (“strict” having over 95% of its occurrences on serpentine soils and “broad” having over 85%). This constituted about 12.7% of the California endemic flora.

Since the 2005 analysis, many changes have occurred in the taxonomy and classification of the California flora, and a surprising number of new species have been described. Information from the Consortium of California Herbaria (CCH, <http://ucjeps.berkeley.edu/consortium/>) records, *The Jepson Manual*, 2nd edition (Baldwin et al. 2012), and the scientific literature was used to decide how to rank newly described, combined, or split taxa with respect to their preference for serpentine soils.

This new information shows that approximately 243 taxa are endemic

Some of the more striking serpentine forbs include (TOP TO BOTTOM): Indian Valley brodiaea (*Brodiaea coronaria* ssp. *rosea*), San Luis mariposa lily (*Calochortus obispoensis*), and talus fritillary (*Fritillaria falcata*). All are restricted to a handful of outcrops in the North or South Coast ranges. Photographs by Rick York, Bob Case, and John Game.

TABLE 1. NUMBERS OF SERPENTINE ENDEMIC AND NEAR ENDEMIC TAXA FOR PLANT FAMILIES WITH AT LEAST THREE ENDEMIC TAXA ON ULTRAMAFIC SUBSTRATES IN CALIFORNIA

FAMILY	SERPENTINE AFFINITY SCORE			Total taxa ¹
	Strict endemics	Broad endemics	Near endemics	
Asteraceae	26	11	8	105
Brassicaceae	19	3	4	37
Polygonaceae	11	8	3	41
Liliaceae	6	6	3	37
Apiaceae	7	3	3	32
Orobanchaceae	7	3	0	19
Linaceae	8	1	0	14
Ericaceae	5	3	2	15
Alliaceae	4	3	4	24
Fabaceae	4	3	3	24
Polemoniaceae	6	1	1	18
Boraginaceae	6	0	5	24
Caryophyllaceae	5	1	3	18
Lamiaceae	4	2	3	17
Campanulaceae	3	2	3	13
Crassulaceae	5	0	2	13
Cyperaceae	2	3	2	11
Onagraceae	3	2	2	13
Rhamnaceae	4	1	1	15
Agavaceae	3	1	0	6
Convolvulaceae	1	3	1	6
Rubiaceae	3	1	0	8
Themidaceae	2	2	3	10
Montiaceae	0	3	2	16
Plantaginaceae	1	2	2	15
Poaceae	1	2	0	18
Totals (all families)	164	79	72	661

Families are ordered by their relative numbers of serpentine endemics (strict plus broad endemics). Strict endemics have >95% of their documented occurrences on ultramafic substrates; broad endemics (>85%-94.9%); near endemics (>75%-84.9%). The latter group is the transitional group from "strong indicators" to broad endemics in Safford et al. (2005).

¹Total of all taxa in our database, from strict endemics to indifferent taxa.

to ultramafic substrates in California, including 176 full species. These numbers are very close to our 2005 numbers (246 taxa, 176 full species), although some of the names have changed, some taxa were dropped from the list, and some new taxa were added. In addition, due to changes in taxonomy and two decades of additional field collection, the estimated number of plant species endemic to California has actually dropped to 1,315 (Baldwin et al. 2012), so the contribution of serpentine endemism to the California endemic flora has risen to 13.4%! Table 1 provides a summary of serpentine endemic richness in California. Altogether, the families in Table 1 contribute almost 90% (216 of 243) of the total serpentine endemic diversity in California.

Asteraceae is the top family in all categories listed, while second and third place are held by Brassicaceae and Polygonaceae. Figure 1 plots the families listed in Table 1. The first eight families include more than 50% of the taxa in my endemic database. Asteraceae includes about 15% of the serpentine endemic taxa in the list, a similar proportion to its contribution to the total California endemic flora. Five of the next six families (all but Orobanchaceae) are substantially overrepresented in the serpentine flora, which means they have been important evolutionary sources of new species on serpentine soils.

The most diverse genera of serpentine endemism are listed in Table 2, topped by *Eriogonum* and *Streptanthus*, and followed by *Hesperolinon* and *Arctostaphylos*. The genera in Table 2 include more than 50% of the total taxa endemic to serpentine soils in California. Basically, most of the serpentine endemic plant diversity in California is driven by only a few dozen genera (in only a few dozen families) that have evolved many species on serpentine (and sometimes other harsh) substrates.

Probably the flagship for serpen-

tine endemic plants in California is the genus *Streptanthus* (Brassicaceae), which includes at least 16 plant species or subspecies that are strictly or broadly endemic to serpentine soils. *Streptanthus* (commonly called the “jewelflowers”) is an example of a neoendemic taxon, a relatively recently evolved plant group that continues to actively generate new species. Examples include Socrates mine jewelflower (*Streptanthus brachiatus*), which is restricted to a few ser-

pentine locations at the junction of Lake, Napa, and Sonoma counties, and milkwort jewelflower (*Streptanthus polygaloides*), a species from the Sierra Nevada which has evolved the rare ability to hyperaccumulate nickel, a highly toxic heavy metal that is usually deadly in the concentrations found in the plant.

Of the 243 serpentine endemics identified in the updated assessment, 86% are forbs (210 out of 243), with one-third of those being annuals and two-thirds perennials (Figure 2). Some of the more charismatic forbs are in the old lily family, now split into numerous families. Examples pictured are Indian Valley brodiaea (*Brodiaea rosea*), San Luis mariposa lily (*Calochortus obispoensis*), and talus fritillary (*Fritillaria falcata*), all of which are restricted to a handful of ultramafic outcrops in the North or South Coast Ranges.

Graminoids (grasses, sedges, and rushes), shrubs, and trees comprise only 14% of the endemic serpentine flora (Fig. 2). Leather oak (*Quercus durata* var. *durata*) and musk brush (*Ceanothus jepsonii*) are serpentine endemic shrubs that often grow together in the North Coast Ranges. One of the few tree taxa that is a serpentine endemic is Sargent cypress (*Hesperocyparis sargentii*), which is found from Mendocino

FIGURE 1. CALIFORNIA PLANT FAMILIES WITH AT LEAST THREE SERPENTINE ENDEMIC TAXA, AS A PERCENTAGE OF THE TOTAL CALIFORNIA SERPENTINE ENDEMIC FLORA

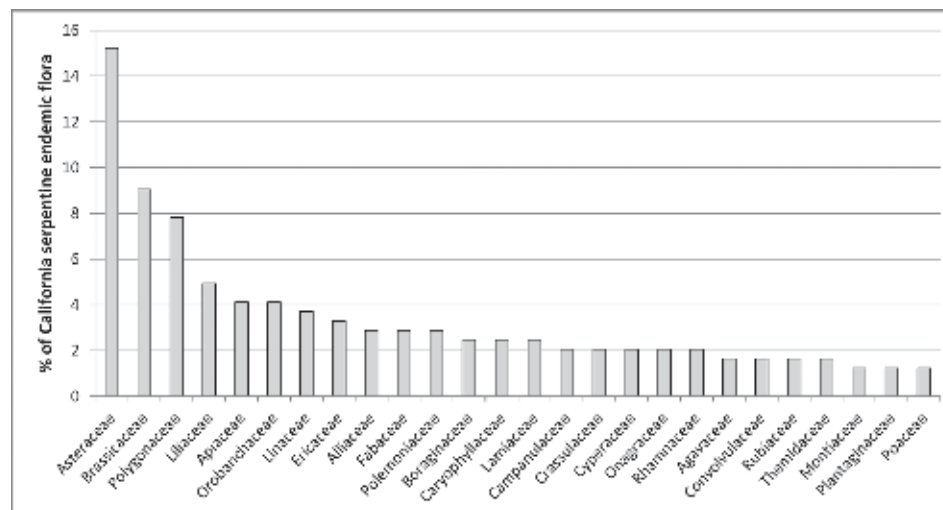


TABLE 2. GENERA WITH AT LEAST FOUR SERPENTINE ENDEMIC TAXA IN CALIFORNIA

Genus	Family	Endemic taxa
<i>Eriogonum</i>	Polygonaceae	16
<i>Streptanthus</i>	Brassicaceae	16
<i>Hesperolinon</i>	Linaceae	9
<i>Arctostaphylos</i>	Ericaceae	8
<i>Allium</i>	Alliaceae	7
<i>Lomatium</i>	Apiaceae	7
<i>Packera</i>	Asteraceae	6
<i>Calochortus</i>	Liliaceae	5
<i>Carex</i>	Cyperaceae	5
<i>Cordylanthus</i>	Orobanchaceae	5
<i>Calystegia</i>	Convolvulaceae	4
<i>Castilleja</i>	Orobanchaceae	4
<i>Cirsium</i>	Asteraceae	4
<i>Erigeron</i>	Asteraceae	4
<i>Fritillaria</i>	Liliaceae	4
<i>Galium</i>	Rubiaceae	4
<i>Harmonia</i>	Asteraceae	4
<i>Lessingia</i>	Asteraceae	4
<i>Minuartia</i>	Caryophyllaceae	4
<i>Monardella</i>	Lamiaceae	4
<i>Phacelia</i>	Boraginaceae	4

County to Santa Barbara County, mostly at sites with moister soils or periodic summer fog.

Since most ultramafic outcrops are very limited in size, many serpentine endemic plant taxa also have small geographic ranges. Combined with the occurrence of many serpentine outcrops in populated (and growing) coastal and foothill urban and suburban areas, this has led to an overrepresentation of serpentine endemic plants among the state's endangered, rare, and sensitive plant taxa (CNPS *Inventory of Rare and Endangered Plants*, <http://www.rareplants.cnps.org/>).

The conservation status of the taxa in my database has not yet been updated, but in 2005, 186 (77%) of the taxa in the endemic category (strict plus broad endemics) were included in the CNPS *Inventory of Rare and Endangered Plants* (Safford et al. 2005). California Rare Plant Rank 1B, which includes federal and state threatened and endangered taxa, as well as taxa that CNPS believes warrant listing due to their rarity, included 105 serpentine endemics.

Serpentine endemics listed as federal or California endangered include Tiburon Indian paintbrush (*Castilleja affinis* ssp. *neglecta*), which is restricted to a couple of ultramafic outcrops in the north San Francisco Bay Area; coyote



ceanothus (*Ceanothus ferrisiae*), found only in the low mountains southeast of San Jose; and Kellogg's buckwheat (*Eriogonum kelloggii*), which grows only at the top of Red Mountain in Mendocino County.

WHERE SERPENTINE ENDEMICS ARE FOUND

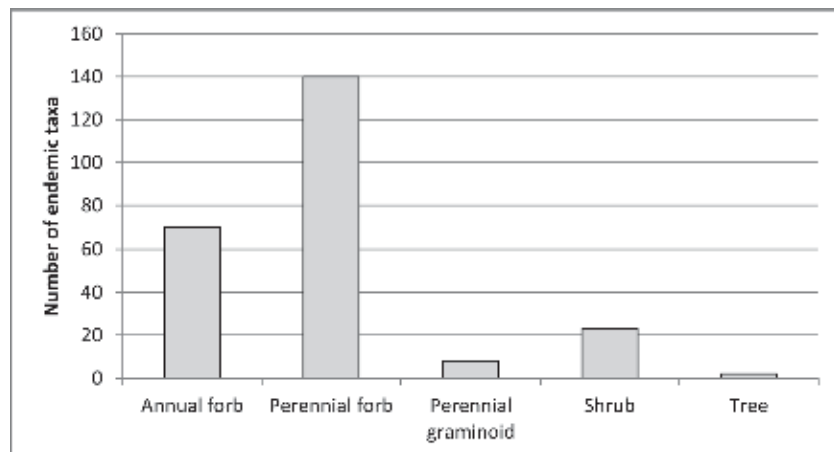
Harrison et al. (2006) carried out a detailed statistical analysis of the factors influencing the geographic distribution of serpentine endemism in California. They found that *local richness* (the number of serpentine endemic plants) is primarily driven by an interaction between the re-



All three of these serpentine endemic species are listed as federal or California endangered. TOP TO BOTTOM: Coyote ceanothus (*Ceanothus ferrisiae*), Kellogg's buckwheat (*Eriogonum kelloggii*), Tiburon Indian paintbrush (*Castilleja affinis* ssp. *neglecta*). Photographs by Neal Kramer, Steve Edwards, and Kaylea Eickhoff.



FIGURE 2. LIFEFORMS OF SERPENTINE ENDEMIC PLANT TAXA IN CALIFORNIA



gional richness of endemics (i.e., there are more species to choose from in a diverse region) and *local environmental factors* such as overstory (shrub and tree) cover, litter cover, the rockiness of the soil, and soil chemistry.



Localities that have rockier soils have higher richness of endemics, while overstory cover, litter cover, and the relative balance of soil magnesium versus calcium have curvilinear (“hump-shaped”) relationships to local endemic richness, such that high and low values of these variables support less richness and intermediate values support higher richness.

Many, if not most, serpentine endemics are confined to ultramafic habitats (Harrison et al. 2006)

The greatest number of serpentine endemics in California are to be found in the Klamath and North Coast Ranges. ABOVE: Flame ragwort (*Packera greenei*), one of the few orange-flowered members of the sunflower family. Photograph by Dick O'Donnell. • LEFT: Siskiyou inside-out flower (*Vancouveria chrysantha*), a shrub. Photograph by David McClurg.

precisely because the harsh rocky substrates allowed them to escape competition (Brooks 1987). At the same time, some ultramafic sites are too harsh even for serpentine endemics (Harrison et al. 2006). Due to their low soil nutrient status, ultramafic outcrops tend to support relatively slow growing vegetation and low levels of plant biomass. In California, with its Mediterranean-like climate and frequent fires, ultramafic outcrops tend to burn less often than surrounding, more fertile substrates (Safford and Harrison 2004). Thus serpentine areas may provide refuge from both biotic competition and ecological disturbances like fire (Safford and Mallek 2010). The abundance of serotinous conifers like knobcone pine (*Pinus attenuata*, not an endemic) and Macnab cypress (*Hesperocyparis macnabiana*, a broad endemic) on serpentine soils is probably primarily due to the lower frequencies of fire in these locations. (Serotinous co-

nifers are those whose cones only open and release seed at high temperatures, usually during fires.)

Figure 3 portrays the distribution of serpentine endemic taxa by geographic region. The center of serpentine endemism in the California Floristic Province is in the North Coast and Klamath Ranges of northwestern California (and southwestern Oregon, not included here). In addition, most serpentine endemics are found in habitats below 1500 meters (5,000 feet) (Figure 4).

At the regional scale, Harrison et al. (2006) found that serpentine endemic richness is best explained by a model including regional precipitation and regional vegetation productivity, the area of ultramafic rock in the region, and how long the ultramafic rocks have been available for plant colonization. Regions with higher endemic diversity were those with higher precipitation and (regional) productivity, more ultramafic rock, and longer availability

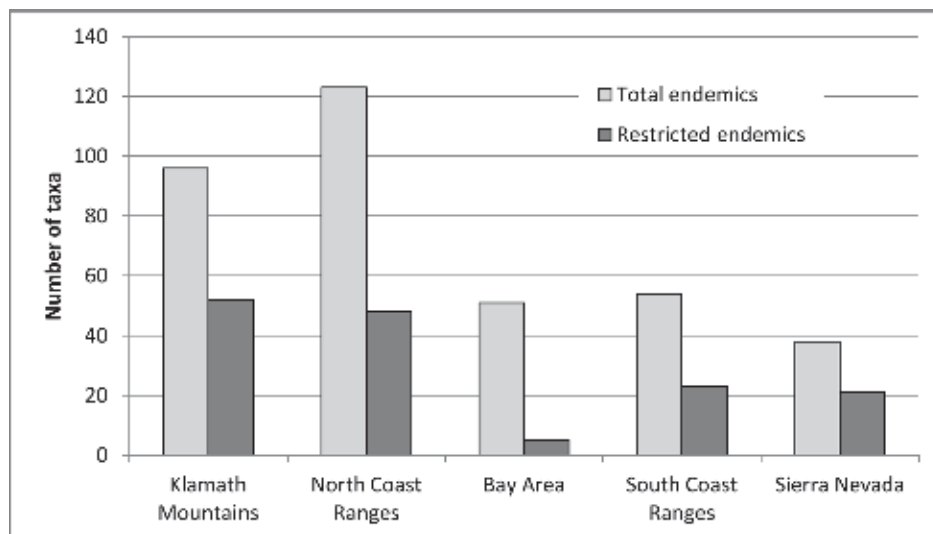
of ultramafic substrates for colonization.

This helps to explain the patterns in Figs. 3 and 4, as the Klamath and North Coast Ranges are the wettest part of California, and support the most extensive ultramafic outcrops and oldest serpentine soils in the state. Examples of interesting Klamath and North Coast Range serpentine endemics include serpentine milkweed (*Asclepias solanoana*), surely one of the strangest looking plants in the California flora; flame ragwort (*Packera greenei*), occasionally found on nonserpentine soils and one of the few orange-flowered members of the sunflower family; and Siskiyou inside-out flower (*Vancouveria chrysantha*), a shrub whose strange flowers resemble the shooting star.

Reduced richness of endemics at higher elevations is due principally to the relatively limited areas of ultramafic rocks above 1,500 meters, but probably also to reduced productivity connected to lower temperatures and a shorter growing season. That said, there are some high elevation serpentine endemics in California, including Trinity buckwheat (*Eriogonum alpinum*), and Mt. Eddy draba (*Draba carnosula*), both found about 2,100 meters (7,000 feet) in the Scott Mountains west of Mt. Shasta.

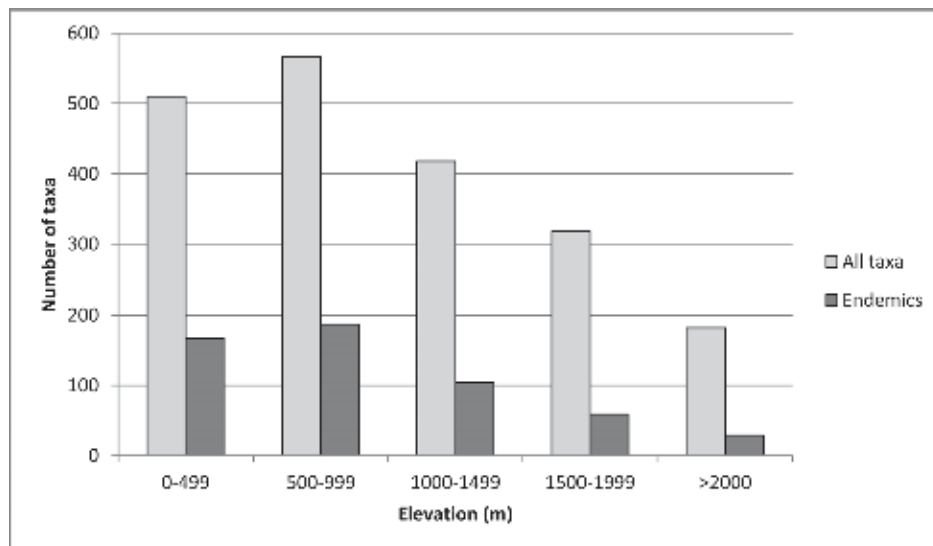
In summary, the “average” California serpentine endemic species is a dicotyledonous, perennial forb from a short list of plant families and genera, rare enough to be listed as warranting conservation concern, and restricted (primarily) to ultramafic soils because the difficult environment filters out faster-growing competitors. The highest levels of endemic richness on ultramafic substrates in California are found on relatively harsh (although not extreme) soils in areas of relatively high precipitation and vegetation productivity, at low to moderate elevations, in regions where large areas of ultramafic rocks have been

FIGURE 3. GEOGRAPHIC DISTRIBUTION OF SERPENTINE ENDEMIC TAXA IN CALIFORNIA



“Total endemics” includes all California serpentine endemic taxa present in a given region. “Restricted endemics” includes only those taxa restricted to a given region.

FIGURE 4. ELEVATIONAL DISTRIBUTION OF SERPENTINE ENDEMIC TAXA IN CALIFORNIA, AS WELL AS ALL TAXA IN THE SERPENTINE AFFINITY DATABASE



Taxa are counted in every elevational belt where they occur.

available for long enough periods of time to provide for the evolution of a large species pool of serpentine-adapted plant taxa.

Recent research on the effects of current and projected future climatic trends on narrowly distributed endemic plants (Damschen et al. 2010) suggests that we should be worried about the long-term prospects for many of California’s serpentine endemics. The extreme warming

that is projected for the 21st century is especially likely to impact plants whose habitat is restricted to disjunct patches of soil scattered across the landscape. It will be expensive and both logistically and politically difficult to conserve serpentine endemic taxa on a species-by-species basis. Conservation of the remaining significant areas of unprotected serpentine habitat, especially in and around urban and suburban areas in



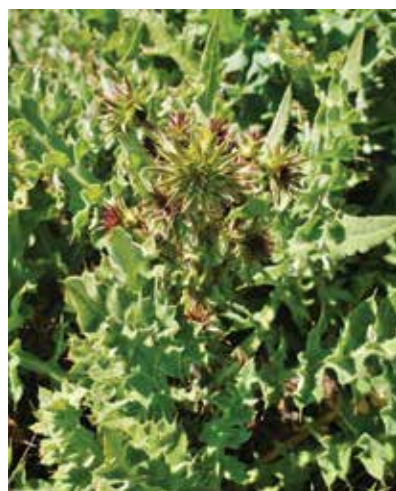
The genus *Streptanthus* and genus *Eriogonum* top the list of those containing the greatest number of serpentine endemic species in California. Pictured are (CLOCKWISE FROM TOP LEFT): Socrates mine jewelflower (*Streptanthus brachiatus*), milk-wort jewelflower (*Streptanthus polygaloides*), and Trinity buck-wheat (*Eriogonum alpinum*). Photographs by Dick O'Donnell, Bob Case, and Julie Kierstead Nelson.

the Bay Area, southern North Coast Ranges, and Sierra Nevada foothills, would be a good—although certainly not sufficient—alternative.

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TOP: Mt. Eddy draba (*Draba carnosula*) is among the comparatively few serpentine endemics found above 7,000 feet. Photograph by Steve Matson. • BOTTOM LEFT: Stebbins' tarweed (*Harmonia stebbinsii*) is an endangered species found on shallow, rocky soils, and is on California Rare Plant Rank 1B.2 (formerly CNPS List 1B.2). Photograph by Julie Kierstead Nelson. BOTTOM RIGHT: There are three varieties of fountain thistle found in and around seeps and streams. All are strict serpentine endemics. This is *Cirsium fontinale* var. *campylon*. Photograph by Bob Case.

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The Joshua tree (*Yucca brevifolia*) is the ubiquitous tree of the Mojave Desert. This specimen is growing in Red Rock Canyon State Park in the eastern Mojave next to fourwing saltbush (*Atriplex canescens*). The Mojave is home to many plant galls, including some of the newly discovered ones mentioned in this article. All photographs by the author except as noted.

PLANT GALLS: DESERT TREASURES

by Ron Russo

In 1962 a colleague and I drove to the Mojave Desert from Sacramento for our first botanical collecting trip to this area. Sometime in the middle of the night, as we were driving downslope into northern reaches of the desert, I woke up from a deep sleep in the passenger seat to see the strangest looking plants I had ever seen.

There they were within the peripheral glow of the headlights, alien forms that turned out to be Joshua trees (*Yucca brevifolia*), Spanish bayonets (*Yucca baccata*), and bladder pods (*Isomeris arborea*) dotting the upper elevations of the Mojave Desert. As it was to the earliest explorers when they landed on the shores of North America, this was

the New World to me, full of wild creations and countless new discoveries.

Even though nearly 50 years have passed and I now feel comfortably familiar with many of the plants of the Mojave and Sonoran Deserts, I still feel the excitement of venturing into the “New World” each time I enter this unique ecosystem. And

with each trip, I encounter new species that only stir the imagination of what is yet to be discovered. Over these many years, I have made hundreds of pilgrimages to these deserts in search of plant galls—tumor-like growths on plants induced by invading organisms to house their larvae, in the case of insects—and to study seasonal changes to the plants that host them.

Plant galls are specific in size, shape, and color to each species of insect that induces them. Furthermore, gall insects have evolved strictly dependent on either a genus of plants or a species within. A new species of gall midge, for example, was discovered in 2004 on desert holly (*Atriplex hymenelytra*) that does not occur on any other host plant. The exact mechanism(s) responsible for species-specific designs in plant galls and species-specific host selection has yet to be uncovered. To date, I have found 101 species of these gall-inducing insects that are dependent on desert plants during their lifecycles. And of these, 38 were previously unknown to science.

Some shrubs support relatively large numbers of gall insects. For example, at least 16 species of gall midges are found only on the leaves and flowers of creosote bush (*Larrea tridentata*). The creosote stem gall midge (*Asphondylia auripila*) induces the largest gall, about the size of a golf ball, on these resilient shrubs, and it was ground and smoked by the Sere Indians of the Southwest. Finding other species, however, like the galls of the creosote antler gall midge (*A. digitata*) that look like tiny moose antlers, or the galls of the leaf club gall midge (*A. pilosa*), takes careful and disciplined observation.

My next favorite among desert hosts is rabbitbrush (*Chrysothamnus* spp.), which is host to 15 species of gall insects, including a few new species. One such new species, found in 2004, induces a cotton-like terminal flower gall on rubber rabbit-

brush, (*C. nauseosus*) in the northern Mojave. Later, I found the same gall insect on yellow rabbitbrush (*C. viscidiflorus*), closer to our home at the time in Mount Shasta, which allowed me to make weekly visits over a period of several months and collect the galls at just the right moment to successfully rear the adult midges. These were later identified as a new species of midge in the genus, *Rhopalomyia*. Rabbitbrush also plays host to one of the rarest and strangest interrelationships in the insect world where the gall midge (*Rhopalomyia bigeloviae*) induces a gall in the gall of the bubble gall tephritid (*Aciurina trixa*). These “endogalls” as they are called, represent the ultimate to me in micro-niche evolution.

Another strange occurrence involves Cooper's boxthorn (*Lycium cooperi*). I had been studying a particular small group of plants near Halloran Pass off Highway 15 east of the small desert community of Baker. For three years I had collected elliptical stem galls belonging to a new species of moth, trying to rear the adults (later identified as *Gnorimoschema* sp.). During these three years, the stem galls were the only galls found on the specific shrubs being examined quarterly. Then, seemingly out of nowhere, dozens of cabbage-like bud galls appeared one spring. While I could not locate shrubs nearby from which they may have spread to these new hosts, they certainly must have been in the region. It took another year for me to rear the adults and have them identified as a new midge species in the genus *Contarinia*.



TOP: Desert holly (*Atriplex hymenelytra*) is widespread across the deserts into Utah and New Mexico. Its normal white color is offset in spring when large, bright pink, cotton-candy-like galls develop from some of its buds. • BOTTOM: Creosote bush (*Larrea tridentata*) is favored by many plant galls.

Several rather innocuous looking shrubs also support gall insects. The relatively unassuming burroweed and related ragweeds (*Ambrosia* spp.) support at least seven species of gall midges, while the various saltbushes and shadscales (*Atriplex* spp.) support eight species. Other desert plants that also sup-



ABOVE: At least 16 species of gall midges (flies) are found only on the creosote bush, including *Asphondylia auripila*, which induces a gall about the size of a golf ball. This midge occurs throughout the range of creosote bush in the southwest. This gall was ground and smoked by the Sere Indians of Arizona. LEFT: The gall *Asphondylia digitata*, often described as looking like moose antlers, is commonly found on creosote bush. • BELOW LEFT AND RIGHT: The tiny creosote stem gall midge (about .15 inch), and an equally small wasp (about .18 inch) emerging from a beaked twig gall. Both insect photographs by Peter J. Bryant.



port gall insects include: bladder sage (*Salazaria mexicana*), indigo bush (*Psoralea arborescens*), golden-bush (*Ericameria cuneata*), cheesebush (*Hymenoclea salsola*), desert broom (*Baccharis sarothroides*), brittlebush (*Encelia* spp.), Mormon tea (*Ephedra* spp.), horsebrush (*Tetradymia* spp.), and catclaw (*Acacia greggii*).

In 2009, a midge was reared from a bristly tubular gall on catclaw that, according to Dr. Raymond Gagné, a leading gall midge taxonomist, was so astonishingly different from all other known species, it would likely require the description of a new genus and, perhaps, a new family. How many other great surprises are out there?

But of all the interesting desert plants that have drawn my attention, it is the desert oaks that have dominated much of my field time these last several years. Muller's oaks (*Quercus cornelius-mulleri*) and Palmer's oaks (*Q. palmeri*) have become a fount of new discoveries. Not only do they share species more common to their northern relatives, but they also host several recently discovered species.

While there is a small cluster of Muller's oaks in Joshua Tree National Monument, a much larger and contiguous stand of these oaks occurs in the Northern Santa Rosa Mountains just southwest of Palm Desert. These trees support several species of cynipid wasps including the beaked twig gall wasp (*Disholcaspis plumbella*), and the saucer gall wasp (*Andricus gigas*), more commonly associated with related white oaks of the Central Valley and surrounding foothills.

Muller's oaks, however, have yielded several new species not seen elsewhere. Some of these may prove to be the elusive and currently unknown alternate generations of known species. Specifically, cynipid wasps exhibit a rare phenomenon where a spring bisexual generation alternates with a summer-fall gen-



TOP LEFT: *Rhopalomyia* sp. on rabbitbrush. This unique flower gall, a new species of *Rhopalomyia*, was discovered on two different species of rabbitbrush, one in the northern Mojave and the other in Northern California. • ABOVE LEFT: One of the strangest interrelationships in the Mojave has one insect inducing a gall in the gall produced by another insect. Pictured here is *Aciurina trixa* on rabbitbrush with the endogall of *Rhopalomyia bigeloviae* protruding. • ABOVE RIGHT: Cooper's boxthorn, *Lycium cooperi*, is widespread throughout the desert's sandy and rocky flats and washes east into Utah and Arizona. This shrub also supports a new species of stem-galling moth, *Gnorimoschema* sp.

eration of females only. Many species are currently known only by the adults from one generation, while others may be completely new

to science. Such is the mystery that surrounds what I call the melon gall, the lobe gall, and the lemon gall found only on Muller's oaks thus

far, all of which I have reared for identification.

Even though Palmer's oaks are closely related to canyon live oak



New gall species encountered by the author. LEFT: *Contarinia* sp. on Cooper's boxthorn (*Lycium cooperi*). The gall, which looks like a head of cabbage, was found in the eastern Mojave. • MIDDLE: *Rhopalomyia* sp. on desert broom (*Baccharis sarothroides*). The galls of this new species of *Rhopalomyia* are heavily parasitized (94%) by torymid wasps in one area in the northeastern Mojave. • RIGHT: New gall species on catclaw (*Acacia greggii*). The life cycle of this midge and many other gall insects in the desert is controlled by major rain events that influence the development of new buds.



(*Quercus chrysolepis*) and huckleberry oak (*Q. vaccinifolia*) and share some of their gall associates, Palmer's oaks support an interesting group of largely unknown new species, unique to them. While five species have been reported on Palmer's oaks, five additional new species were discovered just in 2009.

What drives my seemingly endless quest for new plant galls is the



perhaps unanswerable question of how many other species might be discovered with a concentrated, long-term effort. The notion that Palmer's oaks, Muller's oaks, and desert scrub oak (*Q. turbinella*) as well as other desert shrubs and trees could support dozens of new species, as well as unknown alternate generations, is the magnet that continues to lure me back.

My work in the desert over all these years documenting the occurrence of gall-inducing insects and mites has not been what I would call earth-shattering, but it does reveal a tiny facet of desert life not previously well understood. When you consider a shrub like rabbitbrush or creosote bush and take into account all of the associate species dependent on it—the pollinators, leaf-eating caterpillars, leaf miners, nectar thieves, and the complex mix of several species of gall insects—you have a biological universe within a single shrub.

Then when one considers the ramifications of the presence of a single species of gall insect with all of its predators, parasites, their parasites, and the insects that eat gall tissue exclusively, the importance of these species in the grand web of desert life staggers the imagination. By recognizing this tiniest of threads, we might just better understand the whole fabric of desert life. Clearly, the biological diversity and the nature of interrelationships in the desert are far more complex than we currently understand. And it is this complexity that makes the risk of losing species and systems that we don't even know exist that much more critical and irreversible.

A couple of years ago I found myself standing next to a Palmer's oak, at the head of a canyon in late March, buffeted by a stiff, cold wind, chilled and hungry, wondering what I was doing there. And then a small, green, lumpy gall I had never seen before caught my eye. After all these years, the Mojave and Sonoran



TOP: The beaked twig wasp gall (*Disholcaspis plumbella*) occurs on scrub oak (*Quercus berberidifolia*) elsewhere in the state, but also occurs on Muller's oak (*Q. cornelius-mulleri*) in the desert. • MIDDLE LEFT: New species of bud gall on Muller's oak. The galls of this new species produce males and females in the late spring, which suggests there is an alternate generation later in the summer consisting only of females. • MIDDLE RIGHT: The lobe gall, a new species, was first found in the northern Santa Rosa Mountains above Palm Desert on Muller's oak in 2009. Normal anthocyanin pigments found in plant tissue may be concentrated in specific areas, as in certain galls, where the red-orange is expressed. How and why this happens and what role the gall insect plays remain a mystery. Photograph by Joyce Gross. • BOTTOM: Plant gall seekers are continually rewarded with new finds, such as this small, green, "lumpy" gall discovered by the author in 2010.

THE PALMER'S OAK MYSTERY

One of the grand mysteries that has puzzled me for years, until just recently, is the occurrence of the same cynipid gall wasps on Palmer's oaks that are widely separated by hundreds of miles. I examined three Palmer's oaks, for example, at the head of Short Canyon in the Owen's Peak Wilderness on the eastern side of the southern Sierra Nevada Mountains that were reported to me back in 2008 by Joyce Gross (who works for the U.C. Berkeley Natural History Museums and is an avid wildlife photographer).

These three trees stood by themselves, with the nearest Palmer's oaks over 100 miles away to the south in the southern New York Mountains. The next nearest stand of these oaks occurs in the Santa Rosa Mountains, southwest of Palm Desert. Yet, all three stands of oaks share exactly the same species of cynipid wasps. How could this happen? There is no way that these weak-flying wasps could have migrated across the vastness of the Sonoran and Mojave Deserts and colonized these new hosts, so how did they establish themselves on their hosts?

The most likely answer came with the discovery of a clone of Palmer's oaks in the Jurupa Hills, just east of Mira Loma and north of the Santa Ana River. A team of scientists from U.C. Davis and U.C. Riverside, led by Drs. Mitchell Provance and Andrew Sanders, discovered a genetically identical clone of these oaks that they estimated to have started growing during the late Pleistocene Era over 13,000 years ago. These researchers think that climatic conditions at the time were more favorable to the growth of *Quercus palmeri* and that their range was more contiguous, at least in Southern California.

With a warming trend developing since the last glacial period, the range of this oak and perhaps other relic populations like singleleaf pinon (*Pinus monophylla*) have dramatically shrunk, leaving small, disjunct groups of these trees scattered in California. The idea of Palmer's oaks existing in a more contiguous range is supported by the occurrence of the same species of cynipid wasps now found in these relic groups of trees. Had Palmer's oaks existed in a broader range, such as from the interior mountains of Southern California across what is now the Mojave Desert to the southeastern Sierra Nevada Mountains, then the occurrence of the same species of cynipid wasps from west to east seems more plausible. Such is the case with the occurrence of the exact same species on blue oak (*Q. douglassii*) along the Central Valley foothills from Redding to Bakersfield.

The small, dependent populations of gall wasp species on Palmer's oaks have existed generation after generation for thousands of years on a single host tree or small groups of trees.

These isolated, relict populations of Palmer's oaks have now become islands in a sea of desert life. While we have managed to travel into space, the grand vastness of the unknown remains nearby in the Mojave and Sonoran deserts.

Deserts remain the "New World" to me, revealing exciting discoveries with each trip.

The discovery of new plant galls in the Mojave is a reminder of how

much we still have to learn about the fabric of desert life.

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Five new gall species have been discovered on Palmer's oak since 2009. Palmer's oak fuzzy gall wasp (*Trichoteras burnetti*) and Lyon's gall wasp (*Heteroecus lyoni*) (TOP AND MIDDLE) were previously known, but the horn gall (BOTTOM) is a new species.

LEARNING TO READ A LANDSCAPE

by Phil Van Soelen

Being able to “read” a landscape is my personal goal when gardening with natives. In practice, this means placing plants in locations that approximate their native and natural needs. Doing so greatly increases their chances of survival over time—and even thriving—without the constant input of water or other resources such as fertilizers and pesticides. If a plant we’ve placed in our garden thrives without too much attention from us, then we’ve done our homework well.

WHAT IT MEANS TO PONDER

To read a landscape successfully requires the ability to patiently observe what is happening over time,

both in the wild and in one’s own garden. As a naturalist and gardener, that has become second nature to me, but it is a skill anyone can learn. It also requires some understanding of natural history—of phenomena such as sun exposure, landforms, and drainage patterns. Sometimes at the nursery I talk with people who have little idea what the sun does in their garden, or how that changes through the seasons. It’s also important to know the contours of your land and how it drains. You probably won’t make wise gardening decisions without that knowledge.

As a society we have generally lost this skill and knowledge, largely because so many people lack any sort of personal relationship with nature. Acquiring these skills was necessary for our ancestors; their

survival often depended upon them. For instance, by observing, our ancestors were able to recognize drainages where water persists just below the surface in the dry season. This would have allowed them to spot the combination of soil, moisture, and exposure to the sun that favors edible roots and bulbs or that might provide a life-giving drink of water in times of need.

So how does one develop such skills in today’s world? Over time I have taught myself to hone my own observational skills for native plant gardening by “reading” the landscape in the wild. I attempt to understand the patterns I observe in nature and to cultivate the patience to look deeply by questioning what I see.

For instance, why does a particular species grow on a ridge as



LEFT: Ferns, manzanitas, dudleyas, and the winter’s flowing water in author’s drainage ditch. These native plants are chosen to function as and to evoke a wild seasonal stream in Sonoma County. They deal with shallow soils, no irrigation, and six months of drought, each in their own way. Photograph by the author. • BELOW: Silver-gray dudleya (*Dudleya brittonii*), red fuchsia flowering gooseberry (*Ribes speciosum*), yellow western buttercups (*Ranunculus occidentalis*), and baby-blue-eyes (*Nemophila menziesii*) bloom on this seasonally moist bank in the author’s garden. All exist with infrequent to no summer irrigation. Photograph by Saxon Holt.



opposed to lower down? So often in California you will see a hillside where there is oak woodland, then grassland, and then chaparral. Through years of experience observing wild landscapes, I know that the oak woodland is growing where there is a deeper soil profile with less sun exposure, whereas the chaparral is usually growing in more rocky soil and has a high sun exposure. And grasslands are somewhere in between. One of the things I enjoy about hiking is constantly watching the landscape change as you walk through it, and trying to interpret what is going on.

This ability to ponder what is happening in nature was a skill that was honed throughout human history, but today only a comparatively few develop it. In nature, I find myself encouraged to ask questions about what causes whatever it is I'm seeing. Why does a plant grow there? What do the bees or hummingbirds feed upon in the spring versus in the summer or fall? Are birds making use of my garden? How do the roots from different plants compete with each other? How does cold fall down on the land from above? How does water flow across the land? Our gardens encompass an incredibly complex system of such interactions.

Ultimately, reading a landscape is about developing a relationship with nature, a process I find satisfying and that eventually becomes second nature. Once one begins to acquire this observational knowledge, it proves extremely helpful in guiding one's gardening choices about what plants to select and where to place them in the home garden. The same process can then be used to evaluate how well they respond, and to modify future gardening choices.



Native animals are often seen as pests, but they can function in a native plant garden much as they do in the wild, with a certain beauty and harmony.

APPLYING THE SKILLS

For example, in my Sebastopol garden, the previous owners had installed French drains that channeled the water into one corner of the garden. This produced an ugly drainage ditch, sometimes full of rushing water in the winter, but bone dry all summer long. I had to contemplate that as a design challenge. How would I use plants to soften the ditch, to camouflage it?

My solution was to create a fern-lined seasonal stream by planting California polypody (*Polypodium californicum*)—a native fern one sees in nature along streams and canyon walls, and that goes summer dormant—on both sides of the drainage ditch. When the ditch dries up each summer, the fern tolerates that perfectly. I also planted several manzanitas (*Arctostaphylos manzanita* x

Arctostaphylos densiflora)—natural hybrids of the common manzanita and the Vine Hill manzanita—on the edge of the ditch, a species that is tolerant of moisture, good drainage, and summer dryness. What I've ended up with is a lovely seasonal creek of manzanitas and ferns that is well adapted to the changes of the seasons.

Another plant I've utilized in my garden is a dudleya hybrid (*Dudleya* x 'Frank Reinelt', also known as 'Anacapa') from the Channel Islands. It handles some of same issues in a different way. As a succulent, it tolerates our summer drought fine, but plumps up during the winter rains. I now have large drifts of this in much of my garden. It has created a lovely coastal bluff effect that needs virtually no supplemental irrigation.

OFFERING CUSTOMERS ADVICE

At the native plant nursery I co-own in northern California, customers often ask us for advice regarding what is the right plant for a particular site. Over time we have developed a series of questions we ask them in order to guide their choices (see sidebar). These are the same questions I almost unconsciously ask myself when placing plants in my own garden. For instance, customers may tell us their garden is primarily in shade. Most plant labels only differentiate between shade, partial shade or sun, or full sun. At first glance it would seem a fairly easy decision to place shade-loving plants in a shaded part of the garden. But to truly read a garden landscape in order to know what to plant and where

SOME QUESTIONS TO GUIDE THE NATIVE PLANT GARDENER

1. Where in the county is your garden (coastal, inland, in the hills, valley bottom)?
2. What is its sun exposure? (Are there trees or structures blocking the sun? Does it have open or dappled sunlight? What are its qualities of shade—bright, deep, etc.—and what is creating the shade?)
3. Are you going to irrigate, and how much, especially in the summer? How much available moisture already exists in places?
4. Are there deer or gophers in the area? (These are the two major pest animals in our county.)
5. What is the quality of the soil? (What color is it, i.e., dark chocolate brown, light beige, gray? You want to try and get some sense of whether it contains primarily clay, sand, or a mixture of the two, so you can help gardeners make intelligent plant choices based on drainage and soil types.)
6. Do you want primarily natives, or natives and non-natives that are drought tolerant?
7. Are you comfortable with silver-gray foliage, or do you prefer green and dark-green leaves? (This will have a major impact in terms of the plants I recommend.)
8. Do you like things very tidy and formal, or more naturalistic and informal?



Many of the same forces—substrate, nutrient flows, and exposure to sun—that operate on a larger scale in the home garden, also stratify and segregate vegetation patterns on the micro level, in this case lichens on a rock at the Pinnacles National Monument.

to plant it, we need considerably more information than that.

There are different degrees of shade, such as bright, high-canopy deciduous shade, versus deep evergreen forest shade. We need to know what type of shade exists in that particular spot in the garden. There are a number of other factors that also should be taken into account before making any planting decisions, such as the amount of available moisture, the type of soil and available nutrients, the proximity to large trees or shrubs, how much wind the site gets, and the angle and amount of sun exposure in different seasons.

So, for example, if a customer says she would like to plant trilliums or lilies in her garden—plants that want moisture and bright shade—we need to locate the low-



est garden spot where water collects naturally, and determine if it also provides other requirements of these plants, namely bright shade yet little or no root competition from other large plants or trees. Knowing what a plant requires for optimum health and being able to find the optimal location for it in the garden are key to creating a



Sun exposure, drainage patterns, existing vegetation, and soils all combine to make a rich and pleasing mosaic on Mount Diablo. Nature is the best instructor in planning our home gardens.

beautiful and successful native plant garden.

Observing one's own garden keenly throughout the seasons also reveals valuable information. As an example, many shade tolerant plants are deciduous (they lose their leaves seasonally) or herbaceous (they go dormant back to their roots). They survive the darkest days of winter in

a dormant state and leaf out just as the angle of the sun raises enough to provide adequate light for photosynthesis. This allows planting in areas darkened by the low angle of the sun in the winter—more so than many evergreen plants would tolerate—yet it still allows them to receive bright shade or sun in summer.

There are many reasons people

garden. But for me, perhaps the most compelling is being able to recreate outside my home the appealing intimacy I sometimes experience when I'm in the wild, the feeling that "this spot feels so right." The ability to read a landscape makes this possible.

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DEVELOPING A SUSTAINABLE MIX FOR SEED GERMINATION USING LOCAL MATERIALS

by Jackie Bergquist Salas, Michelle Laskowski, Brianna Schaefer, and Betty Young

The Golden Gate National Parks Conservancy's Native Plant Nurseries are charged each year with the production of 150,000-200,000 native plants grown from watershed-specific seed, which are used in restoration projects throughout this national park. The Nurseries' goal is to produce plants in the most ecologically sustainable manner possible. This commitment includes considering the ecological footprint of each product used in plant production.

The main products used during the production process are seed germination media, used in 16" x 16" x 2" flats, and potting media for growing seedlings that have been transplanted into their final containers.

Peat moss has been a major component of both media. Unfortunately, peat moss—one of the most common amendments in germination and growing media—is harvested on a scale much faster than peat bogs replenish themselves and as such, is not very renewable (Priesnitz 2007). Additionally, peat moss is harvested and shipped from Canada. Coconut fiber (coir), another substitute for peat moss, is shipped thousands of miles to reach our nurseries in the San Francisco Bay Area. Shipping either peat or coir uses a large amount of fossil fuel.

Due to these ecological and environmental concerns, the regular potting medium used at the Nurseries was converted to a compost-based

blend produced within the park in 2003. With careful control of the compost quality, transplanted and mature native plants have performed very well in this compost-based mix. However, so far we have been unsuccessful at formulating a seedling germination medium.

For the past few years, with financial support from the Presidio Trust, we have been trying to develop an alternative seed germination medium with a rate of germination similar to that of the commercial peat moss-based medium, while using local sustainable amendments.

In 2009, after a review of experimental literature, we chose compost, partially boiled rice hulls (a by-product of California's agriculture indus-

TABLE 1. GERMINATION TRIAL MEDIA RECIPES

Ingredients	Trial Medium #1		Trial Medium #2		Trial Medium #3	
	Percentage	Amounts	Percentage	Amounts	Percentage	Amounts
Sifted Compost	33.30%	12 L	33.30%	12 L	25%	9 L
Boiled Rice Hulls	0%	0 L	33.30%	12 L	25%	9 L
Earthworm Castings	33.30%	12 L	0%	0 L	25%	9 L
Perlite, fine grade	33.30%	12 L	33.30%	12 L	25%	9 L
		36 Liters		36 L		36 L
Fertilizers added to all trial mixtures:						
Oyster Shell	6.00%	23g				
Soybean Meal	11.70%	45g				
Iron Sulfate	2.30%	9g				
Gypsum	4.40%	17g				
Sustane™ 4-6-4	75.60%	291g				
Total	100%	385g				
Trial Medium #4 – Control. Commercial medium (Sungro Horticulture Sunshine Formula 5), includes Canadian sphagnum peat moss, fine perlite, gypsum, dolomitic lime, and a low fertilizer charge. Results of our trial media were measured compared to this mix.						

try), and earthworm castings as local and sustainable materials that could potentially provide the basic properties of a successful growing medium (Hidalgo et al. 2009, Hoitink et al. 1997, Evans R.Y. 2006, Merhaut 2006, Evans M. 2008, Merca 2009). Since performance of rice hulls in germination media was unknown, perlite was added as a porous/structural component to maintain sufficient aeration in the mix.

Media mixtures were prepared to test the amendments in different combinations (see Table 1, Germination Trial Media Recipes). Samples of the media were then sent to an independent laboratory for analysis of their physical and chemical properties. Flats were sown with three species of seed chosen for their varying characteristics: California aster (*Symphotrichum chilensis*, also known as *Aster chilensis*), blue wild rye (*Elymus glaucus*), and sticky monkeyflower (*Mimulus aurantiacus*). These seeds were sown in random on standardized and grid patterned germination flats that received intermittent mist set at a temperature of 65°F (18.33°C). Flats were monitored to note the date of germination, potential mortality, and/or the date seedlings were large enough to transplant. This data was collected three times a week for seven weeks.

The results of the 2009 trial show that the control peat-based mixture produced the highest germination rate, fewest weeds (germinating from weed seeds in the various amendments), lowest overall mortality rates, and largest fresh and dry weight of roots and shoots. Trial Mix #1, which was equal parts earthworm castings, compost, and perlite, and Mix #3 comprised of these ingredients plus boiled rice hulls seemed to perform nearly equally well. Mix #2, equal parts rice hulls, compost, and perlite, lacked nutrient and water holding capacity, and did not perform well in comparison



to the other media evaluated (see Table 2, Results). Although the control medium performed best in terms of percentages, statistical data revealed no significant difference between the germination rates of Mix #1, #3, and the control medium. However, the germination rates in Mix #1 and Mix #3 were only around 75% of the germination rate of the control peat-based mixture.

In regard to physical properties, Mix #1 was dense and became water logged, while Mix #3 with compost and rice hulls had better drainage, but did not supply nutrients quickly enough to the seedlings, delaying growth. The earthworm castings in Mix #1 and #3 contained weed seeds that had to be pulled. While the rice hulls break down slowly, holding their shape in



TOP: Developing a sustainable mix for seed germination using local materials. Left to right: Mix #1 (earthworm castings, perlite and compost), Mix #3 (earthworm castings, perlite, compost, and boiled rice hulls), Mix #2 (compost, boiled rice hulls and perlite). All photographs by Jackie Bergquist Salas. • MIDDLE: Flats of each mix planted with three native species, including sticky monkeyflower, blue wild rye, and California aster, six weeks after sowing. Clockwise from top left: Mix #3, Mix #2, Mix #1, and Control. • BOTTOM: Preferred experimental mix: Mix #1 after seven weeks.

TABLE 2. RESULTS OF EXPERIMENT BY SPECIES AND MIX

Averages		Germination %	Mortality % of seedlings	Number Harvested	Root Fresh Weight	Root Dry Weight	Shoot Fresh Weight	Shoot Dry Weight	Root: Shoot Ratio
Mimulus	Mix # 1	53.54%	2.57%	16.00	0.46	0.16	3.83	0.53	0.30
	Mix # 2	25.25%	42.03%	4.33	0.01	0.10	0.03	0.04	n/a
	Mix # 3	35.35%	27.37%	9.67	0.53	0.11	1.96	0.31	n/a
	Control	52.53%	3.67%	17.00	0.59	0.30	6.55	0.91	0.33
Aster	Mix # 1	23.23%	0.00%	7.67	2.52	0.43	8.68	1.02	0.54
	Mix # 2	35.35%	25.47%	8.67	0.81	0.18	1.48	0.29	0.48
	Mix # 3	41.41%	18.07%	11.00	3.55	0.56	8.02	0.78	0.71
	Control	52.53%	0.00%	14.67	15.54	2.03	29.46	4.05	0.53
Elymus	Mix # 1	60.61%	6.20%	18.67	15.86	2.88	30.40	5.63	0.53
	Mix # 2	57.58%	7.70%	17.67	3.92	0.84	5.03	1.06	0.85
	Mix # 3	63.64%	3.10%	20.33	14.68	3.08	20.62	3.95	0.83
	Control	71.72%	0.00%	23.67	91.65	13.29	48.53	9.49	1.38

the medium, the absence of earthworm castings in Mix #2 created a nutrient poor mixture for developing seedlings.

The results of this trial show that with minor adjustments, compost, earthworm castings, and partially boiled rice hulls can perform well when combined to make a germination medium. Our next experiment will be to modify Mix #3 with one part compost, one part earthworm castings, and two parts boiled rice hulls. This increase in rice hulls should improve drainage, and the exclusion of perlite will make it more sustainable. We will sift the amendments through 1/4" hardware cloth to provide a more uniform mix and adjust the fertilizers slightly for a quicker release.

We demonstrated that it is possible to make local sustainable resources compare favorably with conventional non-sustainable products. With some simple modification to the recipes, we are confident that we will soon be able to produce a sustainable germination medium for our Nurseries. We would appreciate

hearing from other nurseries or growers about how they have made their media more sustainable.

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Roger in 2011 at The Cedars with his beloved dogs, Serpentino (gray), Hortus (black), and Daisy (tan). The Cedars has been a focus of Roger's life since 1981 when he first entered its canyons. Photograph by David McCrory.

NEW CNPS FELLOW: ROGER RAICHE

by Phyllis Faber

Roger Raiche has made unusually extensive contributions to California botany in four distinct arenas. As a foremost California botanist, he has generously shared his extensive knowledge with many audiences, including numerous members of CNPS, and has discovered several new native species that have subsequently been named for him. As a gardener par excellence, for years he maintained the California Native section of the University of California Botanical Garden at Berkeley, and de-

veloped an extraordinary serpentine garden.

As a horticulturalist, Roger made extensive collections of native seed, always with precise collection data, collected numerous plant variants, and developed several interesting cultivars for gardens. And as a land protector of the best sort, he purchased a core area of "The Cedars," an extraordinary serpentine barren in Sonoma County in order to protect it. He has been host to many CNPS members and to fascinating and delightful chapter field trips to

The Cedars. In sum, Roger's life has been devoted to California's flora and to sharing his love for this flora.

Roger worked for 23 years at the U.C. Botanical Garden (UCBG) in Berkeley in charge of the 15-acre California Collection. He was the primary collector of that section for all those years and brought in thousands of wild plants during that time with precise collection data. He was also primary collector for the Gardens' Index Seminum or seed list that is put out every two years and goes to over 500 botanical institu-

tions around the world (for a total of ten lists during his tenure at the Garden). Although most of his collecting was done for UCBG, he conducted most of it on his own time.

Roger wrote a few articles over the years pertaining to natives, including an article in *Pacific Horticulture* in 1991 describing many of his cultivars. He also wrote a column called the “California Corner” for a monthly internal UCBG newsletter called the *UC Bee*, where he wrote about various things of interest happening in the California area. Roger was also on the Jepson Manual Horticultural Council, which helped prepare the horticultural entries for *The Jepson Manual* (1993) that Warren Roberts chaired. Roger com-

Roger with his business partner, David McCrory, at The Cedars. Photograph by Phil Van Soelen.



mented on numerous plant entries in that volume.

Perhaps Roger’s most impressive talent regarding native plants was his ability to find them, especially rare ones in the wild, as well as finding new ones. Three new taxa were named in his honor: Cedars fairy-lantern (*Calochortus raichei*), Raiche’s red ribbons (*Clarkia concinna* ssp. *raichei*), and Raiche’s manzanita (*Arctostaphylos stanfordiana* ssp. *raichei*). Roger was also very talented at finding variants that he thought might make interesting cultivars for horticulture, including around 20 that he named. Roger’s introductions of exceptional native plant cultivars frequently showed up for sale at the CNPS East Bay Chapter’s plant sales before they had received wider circulation. This certainly had the effect of supporting the chapter by making the sales more interesting.

Several native genera have been of special interest to Roger, especially *Arctostaphylos*, *Ceanothus*, and *Streptanthus*. He made many hundreds of herbarium specimens of those and other taxa over the years. This work helped to identify many new sites for existing and possibly some new taxa. In recent years, Roger collaborated with Dr. James Reveal of Cornell to publish two new taxa that occur at The Cedars, The Cedars buckwheat (*Eriogonum cedrorum*) and The Cedars ocean-spray (*Holodiscus dumosus* var. *cedrorus*).

Monocots also really interested him, and he was a major contributor to the CNPS book, *Wild Lilies, Irises, and Grasses: Gardening with California Monocots*, finally published in 2003 after 30 years of a working study group. Roger did the primary writing for Brodiaea, Dichelostemma, Trietleia, Fritillaria, and all the Grasses, Sedges and Rushes—a major component of the book.

One of Roger’s major obsessions has been the serpentine flora of California, and much of his collecting

has focused on plants growing on that substrate. Protecting and understanding an area in Sonoma County called The Cedars became part of his obsession, and he became a vigorous advocate for its conservation since 1983. He has led many field trips for CNPS to this site, as well as giving numerous slide lectures over the years pertaining to the native flora growing on this huge serpentine area which has been eroded into many deep narrow canyons. At least seven distinct plants are found only at The Cedars.

In 1999, Roger and his partner, David McCrory, purchased 520 acres in the heart of The Cedars. This allowed them to restore damaged areas, to continue with field trips, and to facilitate scientific studies. In 2011, in a collaborative effort with Save The Redwoods League, the State Coastal Conservancy, and the Gordon and Betty Moore Foundation, 500 acres of this important core area were purchased and transferred to BLM (Bureau of Land Management) to add to its Area of Critical Environmental Concern at The Cedars. Roger also helped the Sonoma Land Trust (SLT) develop its “Conservation Plan for The Cedars Area,” which will guide future conservation efforts of this region.

Warren Roberts, Superintendent of the U.C. Davis Arboretum (now retired), and former president of the California Horticultural Society, described Roger as follows:

Roger Raiche fell in love with the plants of California literally at first sight. Driving across the Sierra en route from his home town, Newport, Rhode Island, to his new life in California, he was struck by the beauty of our native manzanitas. He never got over it. His enthusiasm for the flora of his adopted home state has grown over the years, and for decades he has been one of California’s greatest advocates for the beauty and garden-worthiness of our native plants.



A vintage photograph of Roger back in 1987, standing in a chaparral (on Cow Mt. east of Ukiah) of the Raiche manzanita (*Arctostaphylos stanfordiana* ssp. *raichei*). The species was named in his honor that year by Walter Knight of the California Academy of Sciences. Photograph by Roger Raiche.

Phil Van Soelen, Cal Flora Nursery co-owner in Santa Rosa, and a past president of the Milo Baker Chapter of CNPS, made the following observation of Roger:

Roger really is a towering figure in horticulture in general, and California native plant horticulture in particular. I believe he took the mantle directly from Wayne Roderick. A state CNPS survey showed that, among all respondents who answered it, members' interest in gardening placed at the top of the list of topics. Certainly gardening with native plants was first developed and showcased to the public in botanic gardens, and Roger's contributions in that field are great. There really is no one else of his caliber and accomplishments. While he was at the Berke-

ley Botanic Garden, the California native area was transformed from a nice, rather unexceptional garden of natives to a very dynamic artistic and scientific creation. Roger has a very rare blend of exceptional artistic abilities as well as acute scientific perception and memory. He has always been extremely generous with his time and energy leading CNPS field trips. My business partner Sherrie Althouse said that Roger led the best field trips she has ever been on, and from my experience I would agree. His trips to the Cedars are legendary.

Roger Raiche has perhaps been one of the finest and most effective native plant advocates of this generation, and California has been fortunate to have his skills, energy, and devotion in understanding and ap-



Two of the 20 cultivars that Roger has propagated and named. TOP: 'Joyce Rose', a deep rose selection of the coast flowering currant, *Ribes sanguineum* var. *glutinosum*, which he named in honor of his mother, Joyce Rose Raiche.

MIDDLE: The magnificent burgundy leaf stream orchid, *Epipactis gigantea* f. *rubrifolia* 'Serpentine Night'. Both photographs by Phil Van Soelen. • BOTTOM: Roger has demonstrated an uncanny ability to find rare and new native plants in the wild. One of three new taxa named in his honor is The Cedars fairy-lantern (*Calochortus raichei*). Photograph by Roger Raiche.



preciating our native flora, making it known to others, and protecting it.

Phyllis M. Faber, 212 Del Casa Drive, Mill Valley, CA 94941, pmfaber@comcast.net

SCOTT FLEMING: 1923–2011

by John Danielsen

Scott, with his wife Jenny, was among the founding members of CNPS in 1965, and became a Fellow of the California Native Plant Society in 1985 (see the April 1985 issue of *Fremontia*). Scott was active in CNPS at the state level as treasurer and long-time legal advisor, where he

brought creative thinking to solve the Society's early financial growing pains, as well as negotiating the contract for CNPS to produce its first plant poster.

A lawyer by training, Scott used his skills to put together, with others, the Kaiser-Permanente

Health Program, and helped to found the Planning and Conservation League, where he worked tirelessly promoting conservation activities in California. Scott was an avid white water kayaker who also enjoyed hiking and camping. Scott and Jenny are survived by daughters India and Hilari as well as three granddaughters.

I first met Scott on one of our chapter's weekend hikes, hoping to discover the wonders of the Bay Area's native flora. We also discovered that we worked for the same company, Kaiser-Permanente of Oakland, and that our spouses were good friends. Scott and Jenny were a wonderful and inspiring team who warmly welcomed my wife Charli and me into their home and family.

They continued over many decades to provide this hospitality to other CNPS members from all over the state who were in need of a good sleepover while attending the many

chapter and state CNPS board meetings, or conservation strategy and planning sessions held in Berkeley or hosted at their home.

Scott loved to travel on field trips to the far corners of the state, and we shared this passion with Scott and Jenny. Scott also enjoyed sharing meals and conversation with friends, and he was an expert chef with his famous in-house smoke oven. When Scott decided to step down as state CNPS treasurer, he asked me to take on the treasurer position. He was always ready to provide good and insightful help as CNPS nearly doubled in size over the next few years. He was equipped with that unique quality to be able to listen carefully to what the problem of the moment appeared to be, rephrase it in a way that helped others understand, and then suggest creative solutions.

I often think of a raft trip we took down the Colorado River in the early 1990s. Scott and I hosted about 25 people on a two-week rubber raft trip through most of the white water available to boaters. We traveled in small rafts, each holding about five persons. At one point on the river we were faced with monstrous waves going over Lava Falls. Observing these from the banks of the river, one person commented, "Holy smokes, I am not going over those," to which Scott replied, "Watch me, I'm going over them in a kayak!" Well, we all watched Scott make it, so the rest of us followed, inspired by his example. Scott was capable, fearless, and expert on these trips, which were wonderful qualities to have in a friend and colleague.

Scott and Jenny loved to garden, although truth be told, Scott spent some of the garden time doing kayak rollovers in the family pool. While Scott was the prime builder of the

garden infrastructure, Jenny took the lead in acquiring the plants. Through this teamwork they created a home garden that remains one of the signature native plant gardens in the Bay Area.

The effort to create their garden, plant by plant and rock by rock over many years, also reflected the dedicated plant conservation ethic they both shared and engendered within CNPS. And as we remember our dear friends, one legacy of their love lives on in the beautiful garden they generously shared with all.

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Scott and Jenny in their Bay Area native plant garden.



Scott Fleming.



RALPH MILTON INGOLS: 1911–2011

by Leah Price Hawks

We have lost one of the finest conservationists that one could ever have known. Centenarian Ralph Milton Ingols passed away in Napa, California on July 11, 2011.

A product of Weed Patch in Kern County, California, Ralph was the youngest of seven siblings. He and his wife Evelyne were parents of the “Three J’s,” Janet, Jim, and Judy Ingols, to whom they were devoted. Their children joined them in a lifetime of outdoor activities, which cemented their interest in the environment as well as in education.

As a toddler, Ralph was often put on a blanket among the wildflowers and grasses in Weed Patch. His ground-eye view of the landscape left a lasting impression on him and was his earliest instructor in the natural world. At a young age, Ralph knew he wanted to become an educator, and later on he did.

He received his B.A. and teaching credential at U.C. Berkeley and then began a 35-year career—most of which was spent at St. Helena High School in the Napa Valley—teaching California and world history, world literature, public speak-

ing, and journalism. During this time he received his master’s degree and counseling certification at San Francisco State University. Ralph coached numerous sports including football, basketball, baseball, wrestling, and boxing. He also gave lessons to the school ski club at his cabin in the Sierra Nevada. Ralph and Evelyne were active in the Napa Valley Chapter of the California Native Plant Society, and for many years used their backyard to propagate native perennials for the chapter’s plant sales. After they both retired in 1972, the couple spent many years traveling throughout California, studying and collecting its native flora and gaining valuable knowledge and background in plant identification and propagation.

During this period, the Ingols and their friends first began discussing the creation of a public garden in the Napa Valley where visitors could learn about and enjoy California’s flora in protected surroundings. The idea of a garden that could be used as an outdoor classroom particularly appealed to the Ingols, since both were career educators.

By 1985, with the help of con-



Ralph Ingols in the mid-1950s at St. Helena High School, where he taught for over 30 years.

servationist friends, the Napa Valley Chapter of CNPS, and the Skyline Citizens Association, they founded the three-acre Martha Walker Native Habitat Garden, located at Skyline Wilderness Park, and became its first curators. Ralph and Evelyne were the driving force behind the new garden in its beginning years, and Ralph continued as curator emeritus after Evelyne’s death in 2000.

Those close to Ralph knew that he always had a broad vision for the

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ABOVE: The Ingols, both teachers, believed strongly in using the Martha Walker Garden as an outdoor classroom. Ralph, one of the garden's science docents, had a knack for sharing with students his love of plants and animals. • LEFT: Ralph with his wife, Evelyne, in the Sierra Nevada in the mid-1990s. The two were the driving force behind the creation of the Martha Walker Native Habitat Garden in Napa County.

Garden. "Future generations can enjoy what we prepare for them today!" was his motto. Thanks largely to his efforts, the Napa Valley Chapter established a science docent program there. Today that program ensures that young students who visit the Garden learn about its plants and wildlife.

Ralph spoke of a time, a hundred years from now, when this generation's grandchildren would also walk the paths of the Martha Walker Garden under his favorite trees. He willingly gave whatever he could in energy and resources to the community, and in particular to the Garden. This was his legacy.

In his later years, Ralph continued to make every effort to try new things at an age when most people consider their life's work finished. He wrote, planned, and organized the community to accomplish worthy goals, and in the process connected with others in every walk of life.

Ralph always spoke warmly of others he respected, whether community leaders, former students, volunteers, or youth, and never missed a chance to encourage others. In one way or another, Ralph was a mentor to everyone he met. He simply felt that it was within the capacity of each person to succeed, and he was capable of convincing generations of students and friends that this was so.

Over the past ten years Ralph published two books for his family: *The Ingols Cabin*, stories of family and student adventures in the Sierra, and *Why I Am Who I Am*, a biographical sketch of his life in California. He was a prolific writer, and

also finished five other books during this time, two with coauthors, including one about St. Helena High School, and another on Skyline Wilderness Park. Proceeds from the sale of his books go to support CNPS and the Martha Walker Garden.

Just a few years ago, Ralph received the Earl Thollander Conservation Award, presented annually by the Napa Group of the Sierra Club to an individual who has achieved excellence in conservation.

Perhaps one of Ralph's most impressive accomplishments was his having the Martha Walker Garden named a World Peace Garden in 2002, the first in the United States to receive that honor! (Each garden in the England-based World Peace Garden Project serves as a retreat for peaceful reflection on the beauty of nature and the ideals of living in harmony with others.) In 2010 Ralph attended the celebration of the Garden's 25th anniversary, and up until a few years ago, he also attended as many class reunions of his high school students as he could.

Ralph was planning for the future up until the day before he passed away, still making arrangements for the Garden to benefit in yet more ways through plantings, work parties, and proceeds from his books. "When people go into the Garden, I want them to see butterflies everywhere," he said. "I want to plant Dutchman's pipevine for them."

His friends in the Napa Valley Chapter are now working to make that dream come true. Additional milkweed to attract monarch butterflies and Dutchman's pipevine to attract the pipevine butterfly are just two of the species being dug in now, and a steering committee is planning a Ralph Ingols Butterfly Trail to be completed in 2012 to honor Ralph's dedication and vision for the Garden.

Leah Price Hawks, 1236 Second Avenue, Napa, CA 94558, leah7hawks@yahoo.com

LETTERS TO THE EDITOR

WETLANDS: MISPLACED EMPHASIS

Having studied the seasonal wetlands of Sonoma County's Santa Rosa Plain (SRP) for the last 27 years (consulting to developers, city, county, and state agencies, preserve proponents, nonprofits and landowners, and as a congressional appointee to the Sonoma County Vernal Pool Task Force, 1988-1992), I am glad to see the attention being paid to this unique area (see *Fremontia* Vol. 37, No. 4/Vol. 38, No. 1, pp. 40-43). However, I feel compelled to comment.

First, with regard to history, it should be noted that well before 1970, this region's broad valley of seasonal wetlands, perennial grasslands, oak savanna, and riparian forests had already been thoroughly (80-90%) chopped up, chopped down, converted to prunes, pears, grapes, dairies, mustard and annual grassland, and dewatered by roads, ditches, berms, buried drains, and engineered channels that flow straight to the Laguna de Santa Rosa. Up until the early 1980s, federal law allowed for the "minor fill" of up to one full acre of wetland under the "nationwide permit program," often with little or no significant mitigation.

Then, with probably less than 5% of the region's wetlands left, intense efforts were made over the last several decades to reduce, modify, and/or mitigate modern development's wetland impacts. For 25 years now, the U.S. Army Corps of Engineers has required at least 1:1 replacement of wetland functions, values, and acreage (essentially dictating new wetland construction). In addition, the U.S. Fish and Wildlife Service currently requires the provision of acreage or credits sanctioned as "Establishment" habitat, i.e., new physical habitat constructed and seeded with listed species.

The region's initial efforts toward rare plant translocation (e.g., Alton Lane) were conducted at the direction of, and in fact as a permit requirement of the California Department of Fish and Game. Hence, on the SRP, where

there is so precious little natural wetland habitat left—probably well less than 5%, and even that is severely fragmented—I believe we no longer even have the same underlying ecosystem within which to manage the remnants, and that continued habitat construction/restoration with rare plant translocation will likely be important parts of any hoped for recovery.

Wetland (and hence native pool flora) conservation on the SRP has already come a long way since the 1980s, thanks largely to people like Betty Guggolz and Nancy Harrison (both had been active members of CNPS) and others, plus a more active role by the agencies, specifically requiring compensatory mitigation. The results to date, while far from perfect, include the long-term preservation of more than 1,500 acres on more than 50 preserves.

Finally, while I encourage all scientific efforts on the SRP, I also believe that today's *main* challenge—

as it has been for decades—is simply to save as much suitable wetland-supporting land as possible (actual and potential), enhance it as needed, funded, and practical (including plant translocation), and lock it away. Do we need to improve our preserve management? Absolutely. Do we need more research? Always. I'm not sure if these are desperate times calling for desperate measures just yet, but in some respects it feels very close.

Charlie Patterson
Plant Ecologist, Lafayette, CA

NEED FOR SCIENCE-BASED CONSERVATION STRATEGIES: THE AUTHORS REPLY

We appreciate Mr. Charlie Patterson's perspective in his response to our article on the vernal pools of the Santa Rosa Plain in Sonoma County.

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While the plants of the Santa Rosa Plain are threatened by human impacts in many ways, they are also deeply valued by a large number of passionate local constituents that are eager to contribute to the conservation of the flora. We are aware of Mr. Patterson's experience with vernal pool mitigation efforts on the Plain, appreciate his genuine interest and concern for vernal pool communities, and welcome his outlook on our article. However, we respectfully disagree that our emphasis on science-based conservation and community involvement on the Santa Rosa Plain is misplaced, and we are eager to reiterate our position that scientific research is an essential part of ensuring the long-term survival of vernal pool habitat.

The additional history provided in Mr. Patterson's letter nicely comple-

ments our forward-looking perspective on vernal pool conservation on the Santa Rosa Plain. Indeed, habitat loss in the area began well before the early 1970s, yet the rapid urban expansion during 1970–1990 unequivocally pushed the threats facing native habitats in this region to a new level of urgency. As discussed in our original article, the accelerating loss of vernal pool habitat intersected with endangered species regulations during this time to prompt the regulation of vernal pool mitigation projects by CDFG and other agencies. In the meantime, a great deal of mitigation, translocation, and habitat loss occurred before the basic ecological requirements of vernal pool species were understood.

We fully agree with Mr. Patterson that our main challenge is to save as much suitable wetland-supporting

land as possible. But we regard science as the most effective means to determine what is "suitable." Scientists estimate that only 5–10% of California's original vernal pool habitat remains, and a great deal of recent conservation efforts have been channeled into mitigation, while destruction of natural habitat continues. But if man-made wetlands fail to provide sustainable conditions for translocated populations, then we are faced with the unfortunate reality that vernal pool mitigation may be a slow and expensive method for extirpating populations, and eventually the species that we aim to protect.

Mr. Patterson, who has personally been involved in numerous mitigation efforts, admits that the results of recent conservation efforts may be "far from perfect." But just how far? Are they too far to be an effective conservation strategy? Hopefully not, but we argue that mitigation decisions—and their consequences—should be more critically monitored, and more heavily researched. Vetted protocols, appropriate controls, adequate replication, and rigorous data analysis can facilitate the objective evaluation of the degree to which mitigated vernal pools are supporting sustainable vernal pool populations and communities. Furthermore, detailed studies of remnant populations are essential for determining the important biological processes influencing population growth and persistence in the fragmented context that now characterizes the vast majority of historic vernal pool habitat.

The problem, of course, is that thoughtful science and careful monitoring takes time, and often must operate at a slower pace than the pressures of development and the rates of habitat loss. Fortunately, there are conservation scientists willing to take that time in the Santa Rosa Plain. Hopefully, the practitioners of vernal pool mitigation and conservation will facilitate that research by sharing any monitoring data, releasing historical records, and facilitating site access, and will be eager to develop strategies that incorporate the insights from these projects.

Nancy C. Emery, Purdue University

Michelle Jensen, Ecologist,
Pepperwood Preserve

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MATERIALS FOR PUBLICATION

Members and others are invited to submit material for publication in *Fremontia*. Instructions for contributors can be found on the CNPS website, www.cnps.org, or can be requested from *Fremontia* Editor Bob Hass at bhass@cnps.org.

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Phyllis M. Faber is a past editor of *Fremontia* (1984–1999), and for many years also served as CNPS publications chair.

Leah Price Hawks was the editor for Ralph Ingols' books, and is coauthor of *Skyline Wilderness Park*, *Nature's Gift to Napa Valley*.

FROM THE EDITOR

It is timely that *Fremontia* carry an article concerned with climate change. Systematic observations of biological systems are yielding important insights about how they are responding to climate change. Measuring the ecological effects of climate change requires field observations that span decades, not months or years. So it takes quite awhile before scientists are able to gather sufficient data in order to draw meaningful conclusions.

Jim Bishop's lead article in this issue is about climate change. In it, Jim introduces us to a fascinating international research effort—the Global Observation Research Initiative in Alpine Environments (known simply as GLORIA). As he explains, alpine environments are particularly conducive to measuring the biological effects of global climate changes. This is because human disturbance in the alpine zone is generally minimal, alpine environments span nearly all latitudes and elevations, and they include the major climate zones of the world. The article then goes on to explain more about the alpine zone, and the environmental stresses on alpine plants and how they adapt.

The GLORIA project established its first field sites in Europe in 2001, and three years later the first field sites in the Western Hemisphere were set up in California. Jim is part of the California team of scientists and volunteers that is taking surveys at monitoring sites using the standardized international protocol so the results can be shared globally.

While data gathered so far is preliminary, it suggests that plant diversity is increasing in the alpine zone, which would be expected if average annual temperatures worldwide are warming. With GLORIA and similar projects, we stand not only to learn about the response of alpine plants to climate change, but to greatly expand our knowledge of high-elevation vegetation in California and worldwide.

—Bob Hass

(continued on inside back cover)