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California Native Plant Society

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CALIFORNIA NATIVE
PLANT SOCIETY

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Since 1965*

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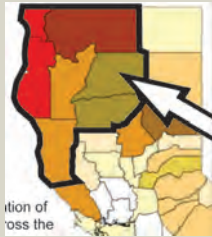
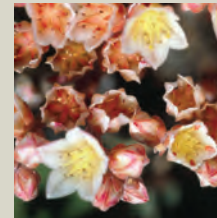
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CALIFORNIA BULBS' LOVE AFFAIR WITH NATIVE POLLINATORS *by Nancy Gilbert* 57

California's native bulbs, which are all-too-often overlooked in restoration projects and pollinator gardens, are magnets for a wide array of pollinators. The complex and fascinating pollinator partnerships of California's numerous bulb species are tuned to their co-evolution in our diversity of climates and habitats.

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THE COVER: *Lilium washingtonianum* subsp. *washingtonianum* (Sierra form). Photograph taken in Nevada County by Nancy Gilbert with art rendering in Photoshop by Ames Gilbert. Now that he is retired, Ames finally has the time to paint his favorite scenes from nature. "I use photographs as models for all my art. With my Intuos 4 tablet and pen, I can easily experiment with different layouts and then paint using virtual oils, watercolors, or other media; and blend layers with different effects—do things impossible in conventional art."

LETTER FROM THE GUEST EDITOR

by M. Kat Anderson

This double issue of *Fremontia* is devoted to the rich subject of California's native geophytes and their botany, ecology, conservation, horticulture, restoration, and history of use.

Bursting into bloom in the spring and then dying back to their underground storage organs during the drought of summer, our native geophytes exhibit a distinctive strategy of adaptation to California's Mediterranean climate. Where similar climatic regimes exist—such as southern Africa's Cape Region, and the Mediterranean region itself—geophytes are both diverse and abundant (see Philip Rundel's article).

With their typically showy flowers, geophytes are part of the seasonal wildflower displays that no doubt delight all members of CNPS. As abundant as species such as *Dichelostemma capitatum* and *Calochortus albus* can be in certain locales today, their populations and those of other geophytes were far larger and more widespread in the past. In the 1890s, botanist Carroll Dewilton Scott reported “tens of thousands of lavender mariposa lilies, often two dozen blooming on one square yard” on the mesas surrounding San Diego. As late as 1921, Washington lilies (*Lilium washingtonianum*) were so abundant in open Sierra Nevada forest understories that Willis Linn Jepson remarked that the plant “fills the Yellow Pine forest with a delightful fragrance.” Taking advantage of this abundance, horticulturists started harvesting and marketing some of these bulbs and corms as early as 1879, turning this endeavor into successful

businesses (see Dot Brovarney's article).

Population growth and land development after the Gold Rush, however, took its toll on California's geophytes, as it did for much of the state's biodiversity. Due to habitat destruction, competition from exotic plants, agricultural plowing, overgrazing by livestock, overharvest of bulbs and flowers for the horticultural trade, and fire suppression, geophyte populations all over the state have diminished. Today, many geophyte species are classified as endangered, threatened, or rare (see Dieter Wilken's article).

If we are to conserve the geophyte populations that remain—and begin to restore populations and former ranges—we must consider an important element of the reproductive biology of many geophytes: they can benefit from disturbance. Geophytes evolved in the context of predatory pressures from herbivorous animals. Rather than defend against herbivory by developing toxins in their storage organs, many

geophytes capitalized on herbivory by evolving palatable and segmented storage organs that increased the chances of dispersal. A mature bulb might be dug up and eaten by a ground sloth or flat-faced bear (in early California prehistory) or a black bear, deer, ground squirrel, or gopher (in more recent times), but some of its scales would be shed in the process, each growing into a new individual.

Another disturbance of potential benefit to geophytes is fire. Most geophytes require at least modest levels of sunlight and are suppressed by dense understory vegetation. Regular fires help keep habitats open and amenable to geophyte growth; they may also enhance nutrient cycling and help soils retain moisture. Geophytes often respond favorably to wildfire, controlled burns, and mechanical clearing (see the photo spread by Michael Kauffmann in the middle of this issue).

In his article, David Imper reminds us that because many of California's geophytes have evolved with disturbance in the form of herbivory and fire, simple black-and-white management solutions—such as the setting aside of wildlands and hands-off protection of existing populations—may not be enough. To incorporate both herbivory and fire into conservation strategies for geophytes, it may be necessary to actively involve humans.

Management and conservation of geophytes through direct human interaction with the plants begins with the recognition that California Indians have played a long and impor-

Bowltube or ground iris (*Iris macrosiphon*) with visiting male long-horned bee (*Eucera* sp.). All digital paintings in this article are by Ames Gilbert based on photographs by Nancy Gilbert.



tant role as consumers and stewards of native geophytes. Archeological research tells us that bulb use by humans goes back at least 10,000 years and coincides with the earliest human arrival in what is now California (see the articles by Kristina Gill and Eric Wohlgemuth). As described in the article by myself and Frank Lake, Indian harvest and management practices, which included both consumption of large quantities of bulbs and corms and regular burning of geophyte habitats, allowed geophyte populations to thrive and left an enormous bulb bank that remained well after White settlement put an end to those practices.

Gathering and harvesting of geophytes—along with other human-mediated disturbances like grazing and burning—must be carefully calibrated to avoid causing more harm than good. Arriving at the appropriate balance point becomes easier if we try to extricate ourselves from the polarized thinking that allows for only the two extremes of over-use and no use at all. In this, the Native Californian belief that humans are an integral part of nature provides helpful guidance, as does Indians' success in harvesting and replanting of cormlets and scattering seeds (see the articles by Kristina Gill and Brock Dolman).

Native management practices are not just echoes of the past. In partnership with NGOs, public lands agencies,

Brownbells (*Fritillaria micrantha*) and an early spring pollinator, striped mining bee (*Adrena* sp.).



St. Helena fawn lily (*Erythronium helenae*).

and universities, tribes such as the Amah Mutsun, Big Pine Paiute, Karuk, Mountain Maidu, and North Fork Mono are bringing back stewardship practices in their traditional homelands, both to provide foods and medicines for their people and to demonstrate the important beneficial role of humans in long-term geophyte restoration.

While the traditional ecological knowledge of California Indians is an important ingredient for building a geophyte conservation and restoration agenda for the 21st century, there is also a great need for more scientific research on geophyte reproductive biology and habitat requirements. For most geophyte species, we know very little about the recruitment of seedlings, plant longevity, flowering and fruiting phenology, and seed production. We are only beginning to understand geophytes' importance to our native pollinators (see Nancy Gilbert's article), their role as food for wildlife, and the part they play in providing other ecosystem services. At larger scales, we need studies that help us understand the modes of ecophysiological adaptation of geophytes to specific habitats and the relationship of population structure and size to different kinds of disturbance. With such knowledge, we can more finely tune management to the ecological requirements of the species.

Because so much wild land and suitable geophyte habitat is in private hands, geophyte conservation de-



depends on the public recognizing the value and significance of these plants.

Kathryn Kramer's article shows us that building a constituency on behalf of one of the rare geophytes—*Lilium parryi*, in her example—is one effective way of gaining citizen allies. And in offering suggestions for the propagation and culture of drought-tolerant geophytes in the backyard garden, Judith Lowry presents another strategy for raising the profile of California's geophytes.

Across from the State Capitol in Sacramento, at the entrance to the Stanley Mosk Library and Courts Building, sits an enormous statue in the image of Pomona—the Roman goddess of fruit trees, gardens, and orchards. The cornucopia she carries symbolizes food and abundance—



Henderson's fawn lily (*Erythronium hendersonii*) growing in Siskiyou County, CA.

for which California has become known. Reminding us that our cultivated fields are part of a much greater endowment of biodiversity that includes our native geophytes, the words *Floral Wealth* are carved below her throne. Let this special issue be an invitation to you, the reader, to get out this and every spring and summer to the hills, prairies, botanic gardens, and backcountry to witness and celebrate our great floral wealth, especially as it is expressed in our native geophytes. Be part of a new era of gardeners, conservationists, artists, researchers, gatherers, and restorationists to grow, protect, paint, study, dig, and restore native geophytes. No other plant group, in my mind, better encourages us to restore our direct relationship with the earth.

WHAT IS A GEOPHYTE?

by Philip W. Rundel and M. Kat Anderson

In the course of evolution, plant species have developed a myriad of adaptive morphologies that help them survive environmental stress. One such adaptation that has evolved multiple times in diverse lineages is the geophyte growth form where an underground storage organ allows the plant to die back to the ground and go dormant during unfavorable seasons for growth. Renewal buds associated with the storage organs allow a new cycle of leafing and blooming when favorable conditions return. Gardeners tend to lump most geophytes as “bulb” plants, but a broad definition of geophytes would include a morphologically diverse group of herbaceous species that have adapted differing forms of storage organs to accom-

plish the ecological role of survival over unfavorable seasons.

If we think about global ecosystems that experience seasonal stresses where the geophyte growth form may be successful, three biomes come to mind where these plants are conspicuous components of the flora. The first of these are arctic or alpine tundra with long cold winters. Underground storage organs allow plants to quickly develop vegetative tissues and flower in the short growing season. A second example can be seen in temperate deciduous forests where the understory is heavily shaded for the summer growing season. In these habitats, geophytes can resprout and flower in the late winter or early spring before regrowth of the tree canopy above.

The global sweet-spot for geophytes lies in the world's Mediterranean-type climate regions, where there is a predictable summer drought period when water is limiting for growth. Under these conditions, and with fire as a frequent component of the disturbance regime, the geophytic form of growth provides a highly successful plant strategy of survival. Mediterranean-type climate regions arguably represent the highest diversity of geophytes of any of the world's biomes.

True bulbs are technically stem tissue with succulent leaves or leaf bases serving as the storage organ. In function they have an upper and lower orientation, with a flat basal plate on the bottom that forms root tissues and a meristem at the top that

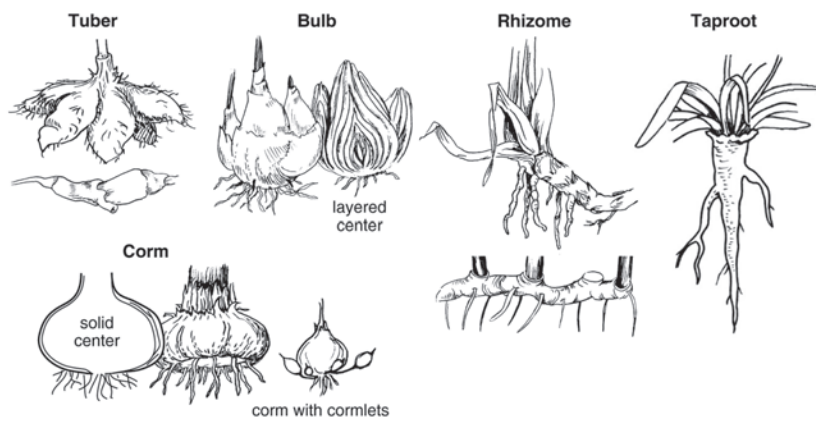


Illustration of the different types of underground storage organs that are characteristic of geophytes. Drawing by Claudia Graham. Illustration from *Tending the Wild*, 2005. Courtesy of the University of California Press, Berkeley, CA.

produces new stem tissue. Meristems on true bulbs also produce small bulb-lets which develop into new plants. A common example of a true bulb is an onion, and familiar garden examples include onions, tulips, narcissus, daffodils, amaryllis, and hyacinth.

Corms are similar in appearance to bulbs but are the basal tissue of the stem itself. As stems, corms have solid tissues in their internal structure, which distinguishes them from bulbs with their layered fleshy leaf bases. When a corm is cut in half, it shows solid tissue, while a true bulb is made up of layers. Typically the tissue of the corm is metabolized for aboveground growth and then reformed each year. Small cormlets or cormels produced around the central corm form a vegetative means of propagating the plants. Examples of geophytes with corms include many of our familiar Mediterranean garden geophytes such as brodiaea, gladiolus, and crocus.

There are other kinds of storage organs that can be found in herbaceous plants, and are variably in-

cluded as geophytes. **Rhizomes** are underground stems that grow horizontally just beneath the soil surface and sprout stems and leaves upward, and roots downward along their length. Unlike bulbs and corms, which are self-contained units, rhizomes have many growing points and can be propagated by cutting them into sections. Examples of geophytes with fleshy rhizomes include calla lilies, cannas, and bearded iris.

Two final groups of plants are technically geophytes but commonly excluded in a practical sense. **Tubers** are specialized underground storage organs that may originate from either stem tissues (e.g., tuberous begonias, cyclamen, yams, and potatoes) or root tissues (sweet potatoes, dahlia, anemone, and alstroemeria). **Taproots** are characteristic features of dicots, and in many species this taproot forms a fleshy storage organ, as in carrots, beets, and turnips.

All of this sounds easy, but as with many things the devil is in the details as to how to define geophytes in a practical sense. Since most of the

plants in the world with true bulbs and corms are monocots, many garden books restrict the term to the monocots, and more often the petaloid monocots as the geophyte group most commonly considered in horticulture. However, this definition excludes a group of familiar garden plants with fleshy rhizomes.

Many other questions arise at a practical level. Terrestrial orchids, being petaloid monocots, are sometimes included as geophytes but typically utilize rhizomes or aboveground pseudo-bulbs as storage organs. Are these geophytes? Can a geophyte be evergreen? An evergreen geophyte would seem contrary to the fundamental botanical definition of using an underground storage organ to survive unfavorable seasons, yet several South African and Southwestern Australian groups of geophytes include evergreen species. A familiar garden example with worldwide distribution is *Crinum* with a bulb, but the genus includes both evergreen and seasonal species. Examples of true bulbs are very few within the dicots, but one such case can be seen in the independent evolution of bulbs within *Oxalis* and the globular root tubers in many species of sundews (*Drosera*).

In the end, technical botanical definitions aside, geophytes can be defined in a number of practical manners so long as the intent is clearly stated. While underground storage organs have evolved independently in a number of morphological forms, the ecological function and adaptive strategy is much the same.

LEFT TO RIGHT: *Calochortus tolmei*, *C. tiburonensis*, and *C. luteus*—all with bulbs. Photographs by Morgan Stickrod.



MAKING SENSE OF GEOPHYTE DIVERSITY

by Philip W. Rundel

Our California gardens splendidly display flowering “bulbs” from around the world, but most of us have little knowledge of the home regions for these bulbs. Certainly California natives are among our choices but many of our bulbs come from other Mediterranean climate regions of the world. The five Mediterranean climate regions, characterized as global hotspots of biodiversity for their diverse floras, display a richness of geophyte species unparalleled in any other global biome. More than ten percent of all of the species in these regions can be classified as being geophytes. However, the diversity and family representation of geophytes varies greatly between regions.

My primary objective in this article is to provide an overview of the diversity of geophytes native to California, and in particular to the classic Mediterranean climate ecosystems of our woodlands and shrublands. Native California geophytes can form a wonderful and low maintenance addition to any native plant garden and deserve much wider use. In their book *California Plants for the Garden* the authors write, “If annuals are the ‘laughter’ of a garden, then bulbs are its ‘magic and promise.’” This is an apt description of our bulbs that sleep underground for half or more of the year and then magically appear with rains.

As described in a box earlier in this special issue, the term geophyte is used in multiple senses. A broad botanical definition would include herbaceous species with an underground storage organ that die back to ground level every year during the unfavorable season for growth. However, I am confining my discussion to what could be characterized



as the petaloid monocot geophytes or “bulb” plants that most of us visualize with the term geophyte. Although our California orchids could be classified as geophytes, they are excluded from consideration here.

A second goal of this article is to provide a brief description of the diversity of geophytes in the other four Mediterranean climate regions of the world. Increasing our collective understanding of the rich Mediterranean climate floras helps greatly in understanding this remarkable diversity as well as conservation of our own species.

THE DIVERSITY OF CALIFORNIA GEOPHYTES

The California flora includes a rich diversity of geophytes extending throughout the state. Overall, petaloid monocot geophytes as defined here total nearly 240 species or about five percent of the total native species in our state. More than 80 percent of this diversity is



TOP: *Brodiaea terrestris* (Themidaceae).
ABOVE: *Calochortus superbus* (Liliaceae).
Photographs by Eric in S.F.

contained in just two families that have their greatest importance in our woodlands and grasslands. The lily family includes 97 species, with almost half of these in *Calochortus*, or mariposa lily, a large genus with a distribution across the western United States and Mexico. The mariposa lilies, sometimes placed into their own family, come in a variety of colors with wonderful patterns of petal spots and glands. The name *Calochortus* is derived from Greek

and means “beautiful grass.” These other large genera of the lily family, more characteristic of wetter or cooler areas of California, include *Fritillaria* (19 species), *Erythronium* (16 species), and *Lilium* (12 species). These latter genera have distributions that range far outside of California to the Pacific Northwest, East Coast, and Europe.

Next to the mariposa lilies, the most familiar geophytes of our open woodlands and grasslands are members of six genera that form the Themidaceae, a group with a distribution centered in California, and sometimes placed as a subfamily within the Asparagaceae. The largest genera of these are *Brodiaea* (18 species), *Triteleia* (15 species), and *Dichelostemma* (five species). As with the mariposa lilies, native species in these genera adapt well to life in native plant gardens and can be easily propagated.

The second largest genus in California is *Allium* in the Alliaceae with 48 species, a group sometimes placed in a separate subfamily of the Amaryllidaceae. *Allium* forms a huge genus with hundreds of species extending across the Northern Hemisphere. The group includes the cultivated onion, garlic, scallion, shallot, and leek, as well as chives.

The iris family in California consists of two important genera, *Iris* (14 species) and *Sisyrinchium* (blue-eyed and yellow-eyed grass, eight species). Most of our native iris can be found along our Pacific Coast, where they are sometimes called grass iris because of their narrow leaves. Wild species and cultivars of pacific iris come in a remarkable diversity of colors. These plants were well known to Native Americans who used the strong leaf fibers for fish nets and rope. Our flora also includes *Olsynium douglasii*, the only North American member of a genus otherwise with a center of distribution in Chile.

The agave family in addition to including agaves and yuccas is home to five genera of geophytes, including two that are common in semi-arid and arid regions of our state. *Chlorogalum* species (soap root) are widespread in openings of chaparral shrublands. The large toxic bulbs of these plants contain saponins and were used by Native Americans to stun fish. *Hesperocallis undulata* or desert lily grows in large numbers on sandy plains and dry washes in our desert areas, and produced edible bulbs for Native Americans.

One of the oddest groups represented in our native flora is a single species of a serpentine grassland geophyte in the family Tecophilaeaceae, *Odontostomum hartwegii*. This small family of nine genera and 27 species is otherwise only known from Chile and South and West Africa.



TOP: *Iris douglasiana* (Iridaceae). Photograph by Penganum. BOTTOM: *Hesperocallis undulata* (Asparagaceae). Photograph by Jim Morefield.

MEDITERRANEAN BASIN

The Mediterranean Basin, by far the largest of the world’s Mediterranean climate regions, is home to a rich assemblage of geophyte species with no clear total number calculated. Species richness of geophytes increases from west to east, peaking in the uplands of Greece and Turkey. Many of the genera and species from this region are familiar in our California gardens today after a long history of introductions. Good examples include lily family members *Gagea* (200 species), *Tulipa* (120 species), and *Fritillaria* (130 species), all large and widespread Northern Hemisphere groups extending in range well beyond the Mediterranean Basin itself. *Allium* (Alliaceae) is well represented with many species all across the region.

In the Amaryllidaceae, daffodils (*Narcissus*) have their center of diversity in the Iberian Peninsula and occur across the Mediterranean Basin with more than 100 species. The commercial popularity of daffodils as cut flowers has led to the development of literally thousands of different cultivars. Also from daffodils there are several other smaller genera of amaryllid geophytes that grow well in California gardens, including *Leucojum*, *Galanthus*, and *Sternbergia*.

The iris family in the Mediterranean Basin is best known for irises (*Iris*) and crocuses (*Crocus*), both genera with more than 100 species. The former has a center of diversity in the basin but a broader Eurasian distribution. Three other genera in this family (*Gladiolus*, *Romulea*, and *Moraea*) show interesting examples of bimodal distribution between the Mediterranean Basin and the Cape Region, but with a South African center of diversity.

Another group of familiar geophytes widely distributed in the



TOP: *Narcissus poeticus* (Amaryllidaceae). Photograph by R. Hulhoven. • BOTTOM: *Gagea lutea* (Liliaceae). Photograph by J. Werther.

Mediterranean Basin and extending into temperate Eurasia can be seen in the genera *Scilla* (scilla), *Muscari* (grape hyacinth), *Hyacinthus* (hyacinth), and *Ornithogalum* (star-of-Bethlehem). These were once placed in the Hyacinthaceae, but are now considered to form a subfamily of Asparagaceae. The group among other traits is often characterized by fleshy leaves. This is an important group in the flora of the Cape Region.

Two geophyte groups present in the Mediterranean Basin are in families with centers of distribution in Southern Africa and Australia. These are *Cochicum* and *Androcymbium* in the Colchicaceae and *Asphodelus* in the Asphodelaceae.

CENTRAL CHILE

Petaloid monocot geophytes are well represented in Chile, including approximately 200 species, with many of these now becoming com-

mon in California gardens. The center of diversity for these species lies in the matorral shrublands and adjacent aridlands of central Chile. This region is famous for its magnificent *desierto florido* in infrequent years with good rainfall, where geophytes form some of the most spectacular wildflower shows. *Rhodophiala* (Amaryllidaceae, 30 species) resembles an amaryllis in appearance. Chilean species range in color from brick red to orange to yellow and can occur in remarkable densities. Much more delicate in appearance but often with mass flowering are species of *Leucocoryne* (Ama-

BELOW: *Crocus albiflorus* (Iridaceae). Photograph by N. Barbieri. • BOTTOM: *Hyacinthus orientalis* (Asparagaceae). Photograph by L. Kaffer.





TOP LEFT: *Rhodophiala phycelloides* (Amaryllidaceae). Photograph by G. Hudepohl. • TOP RIGHT: *Leucocoryne vittata* (Amaryllidaceae). Photograph by P. Novoa. • ABOVE: *Rhodophiala bagnoldii* (Amaryllidaceae). Photograph by G. Hudepohl. • FACING PAGE, TOP: *Leucocoryne coquimbensis* (Amaryllidaceae) with *Cistanthe longiscapa* (Montiaceae). Photograph by G. Hudepohl.

ryllidaceae, 49 species) with blue, white or lilac flowers held in umbels. The foliage is long and slender and with a scent of onions. *Leucocoryne* and a number of less well-known Chilean genera are allied with *Allium* and would be classified ei-

ther in the Alliaceae or in the allium subfamily of Amaryllidaceae.

It is impossible to talk about Chilean “bulbs” without including *Alstroemeria*, which forms the largest genus in the alstroemeria family (Alstroemeriaceae). Although some-

times called Peruvian lilies, the Chileans take offense at this since the center of distribution is in central Chile. *Alstroemeria* (36 species) lack bulbs or corms, and reproduce from root tubers. This morphology helps make them aggressive colonizers that may form dense stands along open roadsides.

The iris family is presented in Chile with the widespread genus *Sisyrinchium* along with a group of closely related but less well-known small genera. As described above, Chile has two genera and about nine species of the disjunct family Tecophilaeaceae. It is home to a single species of Asphodelaceae, the monotypic *Pasithea caerulea*. The lily family, a Northern Hemisphere group, is absent from Chile.

CAPE REGION OF SOUTH AFRICA

While the geophyte flora of the eastern Mediterranean Basin is remarkable in its diversity, the mother lode of global geophytes can be found in the Cape Region of South Africa and adjacent desert areas of the winter rainfall Succulent Karoo. The vascular plant flora of the Cape Region is the richest of all five regions at any unit of spatial scale, with a flora of about 9,000 species in an area half of the size of California. The flora of geophytes totals more than 1,500 species, or about one in six species. On a relative ba-



sis for the entire flora, this proportion of geophytes is three times the abundance of geophytes in either California or Chile.

The iris family forms the dominant Cape family with 27 genera and more than 700 species. Remarkably, the small area of the Cape Re-

gion is home to one-third of all the iris family species in the world. Notable genera, many of which are familiar in California gardens, include *Babiana* (49 species), *Geissorhiza* (83 species), *Gladiolus* (110 species), *Ixia* (50 species), *Moraea* (123 species), *Romulea* (64 species), *Sparaxis* (15 species), and *Watsonia* (33 species). All of these genera exhibit species with a marvelous diversity of growth form and flower color.

The second largest family of geo-

BOTTOM LEFT: *Alstroemeria magnifica* (Alstroemeriaceae). Photograph by P. Novoa. • BOTTOM RIGHT: *Paspheca caerulea* (Asphodelaceae). Photograph by P. Pelsner.





TOP ROW, LEFT TO RIGHT: *Babiana sambucina* (Iridaceae). Photograph by S. Shebs. • *Ornithogalum dubium* (Asparagaceae). Photograph from Wikipedia Commons. • SECOND ROW, LEFT TO RIGHT: *Romulea rosea* (Iridaceae). Photograph by A. Massyn. • *Moraea papilionacea* (Iridaceae). Photograph by A. Massyn. • BELOW: *Brunsvigia bosmaniae* (Amaryllidaceae). Photograph by H. van Zijl.



phytes in the Cape Region is the Asparagaceae with 17 genera and more than 250 species. The majority of these were once placed in the *Hyacinthaceae*, including *Lachenalia* (80 species), *Ornithogalum* (43 species), *Albuca* (28 species), *Massonia* (four species), and the familiar *Clivia* that is so common in our shade gardens. *Veltheimia capensis* is often grown in Southern California gardens.

The amaryllis family also forms a rich group of Cape Region geophytes with 19 genera and 111 species. The family includes many unusual geophytes such as *Haemanthus* (11 species), *Cyrtanthus* (22 species), *Brunsvigia* (nine species), and *Boo-phane* (two species). Some of these taxa that flower in the late summer or fall when the plants are leafless, as famously seen in *Brunsvigia bosmaniae*. *Agapanthus*, widely planted in California, is now placed in the Amaryllidaceae, although formerly put into its own family.

Two other largely Southern Hemisphere families, the Haemadoraceae (two genera and eight species) and Colchicaceae (six genera and 38 species) are less important. The lily family is absent.

SOUTHWESTERN AUSTRALIA

The geophyte flora of Southwestern Australia is the most unusual of any of the five Mediterranean climate regions. While species with underground root tubers or stem tubers are common, both in monocots and herbaceous dicots, true bulbs and corms are extremely rare. Moreover, most of the petaloid monocots are evergreen, retaining their leaves through the dry summer season. The most familiar petaloid monocots from Australia to us in California are the kangaroo paws (*Anigozanthos*), members of the Haemodoraceae. However, these are technically not true geophytes as they are evergreen and lack a fleshy storage organ.

The largest diversity of monocot

geophytes are members of the Asparagaceae, all with root tubers. One of the most beautiful of these is the fringe lily (*Thysanotus*), with 45 species in Southwest Australia. The iris family is represented by just two genera, *Patersonia* (14 species) and *Orthrosanthus* (four species), both largely evergreen and rhizomatous, and relatively primitive lineages in their family. The Colchicaceae is represented by three genera, with *Wurmbea* and *Burchardia* the most widespread and notable. Outside of the kangaroo paws, none of these species are common in cultivation. There are no native species of the lily or amaryllid families present.

The almost total absence of geophytes with bulbs or corms in Southwestern Australia represents an evolutionary mystery. There appears to be an open niche for such species as South African geophytes have become seriously invasive. Of particular concern is the rapid spread of many Iridaceae, including species of *Babiana*, *Chasmanthe*, *Freesia*, *Gladiolus*, *Romulea*, *Sparaxis*, and *Watsonia*. It has been suggested that in the other Mediterranean climate regions there has been a diversification of geophytes with bulbs or corms in a co-evolutionary relationship with pocket mice, mole rats, or gophers. Australia lacks a marsupial equivalent of this type of mammalian life history, leaving this unfilled niche for colonization.

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TOP: *Thysanotus multiflorus* (Asparagaceae). Photograph by A. Chapman. BOTTOM: *Burchardia multiflora* (Colchicaceae). Photograph by N. Tapson.

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TAXONOMIC CLASSIFICATION OF PETALOID MONOCOTS IN THE NATIVE CALIFORNIA FLORA, EXCLUDING ORCHIDACEAE

The petaloid monocots of California are placed into genera with minimal controversy, but systematic botanists have held diverse opinions on the most appropriate distribution of the genera into families. This appendix provides a comparison of the family treatments for these genera in the Munz and Keck Manual of 1959, *The Jepson Manual* of 1993 (TJM 1), the new *Jepson Manual* of 2012 (TJM 2), and finally the APG IV (2016) system of classification. The latter is a consensus arrangement of plant families and genera determined by an international group of experts. You will see a trend from a very broad concept of the Lilia-

ceae in the earlier floras to recognition of more families in TJM 2 and the APG IV system. Here, I am following TJM 2 as the standard field guide to the California flora. It differs from the APG IV classification in several respects. It recognizes the Agavaceae, Ruscaceae, and Themidaceae as separate families rather than merging these into a broad concept of the Asparagaceae. It also recognizes the Alliaceae as a family rather than including this in the Amaryllidaceae as in the APG IV system. The Hyacinthaceae, not native to California but common in our gardens, have been moved into the Asparagaceae in the APG IV system. Brackets indicate woody genera.

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MUNZ & KECK 1959	TJM 1 – 1993	TJM 2 – 2012	APG IV – 2016
		LILIALES	ASPARAGALES
Agavaceae	Iridaceae	Agavaceae	Amaryllidaceae
[Agave]	<i>Iris</i>	[Agave]	<i>Allium</i>
[<i>Nolina</i>]	<i>Sisyrinchium</i>	<i>Camassia</i>	Asparagaceae – Agavoideae
[<i>Yucca</i>]	Liliaceae	<i>Chlorogalum</i>	[Agave]
Amaryllidaceae	[Agave]	<i>Hastingsia</i>	<i>Camassia</i>
<i>Allium</i>	<i>Allium</i>	<i>Hesperocallis</i>	<i>Chlorogalum</i>
<i>Androstephium</i>	<i>Androstephium</i>	[<i>Hesperoyucca</i>]	<i>Hastingsia</i>
<i>Bloomeria</i>	<i>Bloomeria</i>	<i>Leucocrinum</i>	<i>Hesperocallis</i>
<i>Brodiaea</i>	<i>Brodiaea</i>	[<i>Yucca</i>]	[<i>Hesperoyucca</i>]
<i>Muilla</i>	<i>Calochortus</i>	Alliaceae	<i>Leucocrinum</i>
Iridaceae	<i>Camassia</i>	<i>Allium</i>	[<i>Yucca</i>]
<i>Iris</i>	<i>Chlorogalum</i>	Iridaceae	Asparagaceae – Brodiaeaoideae
<i>Sisyrinchium</i>	<i>Clintonia</i>	<i>Iris</i>	<i>Androstephium</i>
Liliaceae	<i>Dichelostemma</i>	<i>Olsynium</i>	<i>Bloomeria</i>
<i>Calochortus</i>	<i>Disporum</i>	<i>Sisyrinchium</i>	<i>Brodiaea</i>

MUNZ & KECK 1959	TJM 1 – 1993	TJM 2 – 2012	APG IV – 2016
<i>Camassia</i>	<i>Erythronium</i>	Liliaceae	<i>Dichelostemma</i>
<i>Chlorogalum</i>	<i>Fritillaria</i>	<i>Calochortus</i>	<i>Muilla</i>
<i>Clintonia</i>	<i>Hastingsia</i>	<i>Clintonia</i>	<i>Triteleia</i>
<i>Disporum</i>	<i>Hesperocallis</i>	<i>Erythronium</i>	Asparagagaceae – Nolinoideae
<i>Erythronium</i>	<i>Leucocrinum</i>	<i>Fritillaria</i>	<i>Maianthemum</i>
<i>Fritillaria</i>	<i>Lilium</i>	<i>Lilium</i>	[<i>Nolina</i>]
<i>Hesperocallis</i>	<i>Maianthemum</i>	<i>Prosartes</i>	Iridaceae
<i>Leucocrinum</i>	<i>Muilla</i>	<i>Scoliopus</i>	<i>Iris</i>
<i>Lilium</i>	<i>Nartheicum</i>	<i>Streptopus</i>	<i>Olsynium</i>
<i>Maianthemum</i>	[<i>Nolina</i>]	Melanthiaceae	<i>Sisyrinchium</i>
<i>Nartheicum</i>	<i>Odontostomum</i>	<i>Pseudotrillium</i>	Liliaceae
<i>Odontostomum</i>	<i>Schoenolirion</i>	<i>Stenanthium</i>	<i>Calochortus</i>
<i>Schoenolirion</i>	<i>Scoliopus</i>	<i>Toxicoscordium</i>	<i>Clintonia</i>
<i>Scoliopus</i>	<i>Smilacina</i>	<i>Trillium</i>	<i>Erythronium</i>
<i>Smilacina</i>	<i>Stenanthium</i>	<i>Veratrum</i>	<i>Fritillaria</i>
<i>Stenanthium</i>	<i>Streptopus</i>	<i>Xerophyllum</i>	<i>Lilium</i>
<i>Streptopus</i>	<i>Tofieldia</i>	Ruscaceae	<i>Prosartes</i>
<i>Tofieldia</i>	<i>Trillium</i>	<i>Maianthemum</i>	<i>Scoliopus</i>
<i>Trillium</i>	<i>Triteleia</i>	[<i>Nolina</i>]	<i>Streptotus</i>
<i>Veratrum</i>	<i>Veratrum</i>	Tecophilaeaceae	Melanthiaceae
<i>Xerophyllum</i>	<i>Xerophyllum</i>	<i>Odontostomum</i>	<i>Pseudotrillium</i>
<i>Zigadenus</i>	[<i>Yucca</i>]	Themidaceae	<i>Stenanthium</i>
	<i>Zigadenus</i>	<i>Androstephium</i>	<i>Toxicoscordium</i>
		<i>Bloomeria</i>	<i>Trillium</i>
		<i>Brodiaea</i>	<i>Veratrum</i>
		<i>Dichelostemma</i>	<i>Xerophyllum</i>
		<i>Muilla</i>	Tecophilaeaceae
		<i>Triteleia</i>	<i>Odontostomum</i>
		DIOSCORIALES	DIOSCORIALES
		Nartheiaceae	Nartheiaceae
		<i>Nartheicum</i>	<i>Nartheicum</i>
		ALISMATALES	ALISMATALES
		Tofieldiaceae	Tofieldiaceae
		<i>Triantha</i>	<i>Triantha</i>

OUT OF THE WILD AND INTO THE GARDEN: GEOPHYTES IN THE LIFE AND WORK OF CARL PURDY

by Dot Brovarney

He is a man of great nobility, a man of strong character and high purpose . . . a man clear-minded, far-seeing and gifted with a rare sagacity.

—Willis Jepson
on Carl Purdy, 1935

It is somewhat common knowledge amongst California Native Plant Society members that Carl Purdy was a bit of a raper-plunderer.

—Phil Van Soelen, 2011

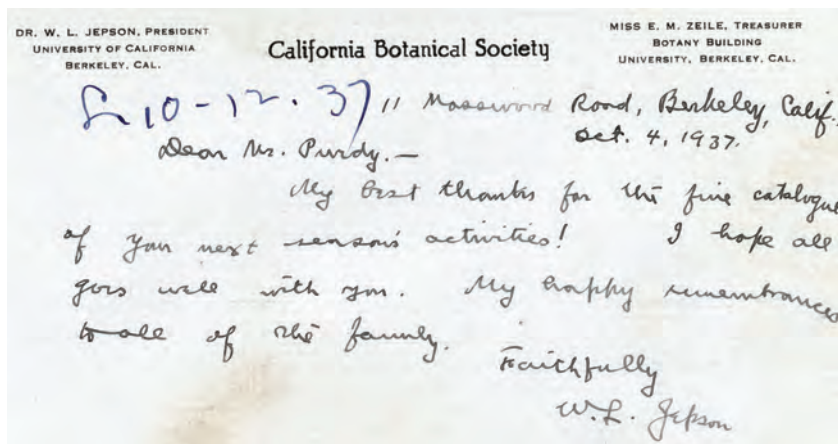
The disparity between these views of bulb collector and nurseryman Carl Purdy calls for research into the man's life, his work, his relationships, and the historical and botanical context in which he lived.

DISCOVERING CALIFORNIA WILDFLOWERS

By the turn of the 20th century, botanist and horticulturalist Carlton Elmer Purdy had become a leading expert on Western North American lilies, specifically *Calochortus*, *Erythronium*, and *Lilium*. He had arrived in Mendocino County as a nine-year-old in 1870. Inspired by his sister's love of flowers and fasci-



Golden globelily or Diogenes' lantern (*Calochortus amabilis*) was given its Latin name by Carl Purdy in 1901, years after he discovered it in Mendocino County in 1878. Photograph by Ree Slocum.



Willis Jepson remained a lifelong Purdy friend and correspondent, as did Cal Academy Curator Alice Eastwood, who named Purdy's iris (*Iris purdyi*) and Purdy's fritillary (*Fritillaria purdyi*) for him. Photograph courtesy of the Carl Purdy Family Collection.

nated by the natural world, young Carl spent hours hiking the countryside of rural Mendocino. In 1878 at the age of 17, he found a species of *Calochortus* that he would later learn had not been identified by botanists. Purdy followed a friend's advice and shipped the pressed flower of the bulbous plant to a New Jersey plant and bulb dealer who was seeking California wildflowers. This decision proved pivotal and was to set the course for the rest of Carl Purdy's life. The dealer, assuming it to be Mount Diablo globe lily (*C. pulchellus*), ordered 50 bulbs, paying 75 cents. For a young man facing limited job opportunities in a rural farming town, receiving payment for doing what he loved—exploring the natural world and learning about plants—was the catalyst for his career in horticulture. Growing and studying *Calochortus* over the next 20 years, Purdy determined that this flower he so admired was not *C. pulchellus*, but something different—a species unknown to science. Purdy named the new lily *C. amabi-*

lis, meaning “loved one,” commonly called golden globe lily or Diogenes' lantern.

A SELF-TAUGHT BOTANIST AND COLLEAGUE

An eager student of California botany, Purdy began learning about both wild and garden-raised geophytes—perennial plants propagated by underground storage organs, either bulbs, corms, rhizomes, or tubers. Purdy sent specimens and questions to California botanists, including Edward Lee Greene at UC Berkeley, John Gill Lemmon, and Mrs. Kate Brandegee. He developed lifelong friendships with Berkeley professor Willis Jepson; Alice Eastwood, Curator of Botany at the California Academy of Sciences; and Luther Burbank, who urged him to shift from a wholesale market to the retail trade in the early 1900s. Collecting natural specimens was a favored research method, so Purdy requested his colleagues collect and send specific bulbs from distant locations for him to study.

RESEARCHING AND WRITING ABOUT LILIES

Carl Purdy made a special study of lilies, especially the genera *Lilium*, *Erythronium*, and *Calochortus*, which he knew well from exploring north-west California. His two-decade study of *Calochortus* (Mariposa tulips, star tulips, and globe lilies) culminated in “A Revision of the Genus *Calochortus*” published by the California Academy of Sciences in 1901. Purdy based this monograph on extensive observation in the field, a study of herbarium specimens, and experiments in his garden where he tested different soils, elevations, light exposures, and moisture levels. This publication reveals that he was a disciplined researcher despite a lack of academic credentials.

During this period, Purdy applied what he learned from his experiments with geophytes and other plants to a growing horticultural business. English and European enthusiasm for gardening with West Coast native flowers had been kindled by Scottish botanist David Douglas who, in the 1830s, had sent Western North American native specimens back to England, including *Calochortus*. By the 1890s, Carl Purdy’s experience with East Coast sales and subsequent ones in Europe convinced him that a global market existed for West Coast native bulbs.

CHOOSING HOME AND GARDEN

Despite the lure of a lucrative landscaping career in the Bay Area following his role as garden manager for the 1915 Panama-Pacific International Exposition, Purdy returned to his home, “The Terraces,” in rural Mendocino County. Here, in the northern Mayacamas Mountains east of Ukiah, he had planted the spring-fed natural terraces with native and non-native bulbs. These gardens provided the grounds for

his experiments and horticulture business for over 60 years until his death in 1945 at age 84.

The earliest surviving catalog in the Purdy family collections is a simple one, printed for the wholesale market in 1891. Later retail catalogs, with detailed planting and growing descriptions, reflect Purdy’s knowledge from his experiments and customer reports about bulb growth in various locales. He marketed what he grew both from seed and bulb, as well as wild bulbs, which were collected primarily by trained employees and contractors in distant places.

COLLECTING

With landowners’ permission, Carl Purdy collected primarily in

California’s Coast Ranges, from the prairies bordering the Pacific to the interior valleys. He described his scope: “There are fifty-two counties in the state, and I get bulbs from only fourteen of them. . . . I draw from as little as a thirty-foot square in one case, and scattered over a few hundred acres where I get the most.”

Purdy’s assistants included trained local employees who traveled mainly in California and contractors in more distant West Coast locations. In 1912, Purdy told a *San Francisco Call* reporter, “My collectors are instructed to leave the bulbels [aka. bulbils, small secondary bulbs that grow between leaf and stem] and stalks, carefully covering them and in a few years they produce more than were dug out.”

This image of Carl Purdy in his gardens appeared in a 1940 issue of *Gentleman’s Quarterly*. Here he grew more than 3000 species and varieties of plants, including many California bulbs reproduced from both bulb and seed. Botanist Lois Weeth, who visited Purdy at the Terraces in 1936, recalls a variety of *Calochortus*, *Brodiaea*, *Camassia*, *Erythronium*, and *Trillium* species, as well as *Lilium pardalinum*, among other plantings. Photograph courtesy of the Carl Purdy Family Collection.



Documentation regarding Purdy's distant contractors is limited. Achieving complete control over their work habits would have been difficult, and in cases of their engagement to gather bulbs for other collectors, impossible. However, a newly discovered document indicates a vigilance regarding distant collectors and an insistence that they be of "the right fiber." In a 1903 letter, Southern California collector Robert Haley Asher, son of San Diego's first commercial nurseryman, described a Mr. Donaldson who had been sent to accompany him, as one who "was with Carl Purdy at Ukiah for several years."

HARVESTING FOR SUSTAINABILITY

Carl Purdy's collecting habits were informed by his experiences with Mendocino County's Native Pomo who relied on geophytes for starch in their diet. Purdy was familiar with their cultural traditions, having worked with the Pomo on his father's hop farm. His ventures into Mendocino's backcountry also provided a window into Native harvest practices.

The Pomo, like other California Indians, harvested edible bulbs, tubers, and corms, commonly known as "Indian potatoes." Using a digging stick, they removed large bulbs and dispersed the smaller ones, aerating the soil, accelerating plant growth for future consumption, in effect, cultivating and sustaining their food source.

QUESTIONS ABOUT OVERCOLLECTING

Concerns about Carl Purdy's work have been raised over the years, particularly in more recent times, as native plant rarity has increased and extirpation of some species has occurred. Besides misgivings about the practices of Purdy's distant collectors, other concerns are: the large

numbers of bulbs that Purdy claimed to have collected; his profiting from sales; and his marketing of some bulbs that he described as rare at the time.

"Rare" in the 19th century, when Purdy came of age and began his business, meant exotic and desirable, but not limited in abundance as it is considered today. (Think wild animal trophies, ladies' plumed hats, etc.) Some question whether his collection of then-rare plants contributed to their increasing rarity in the 20th century and, in some cases, current endangered status.

From the perspective of the present day, the volume of California native bulbs that Purdy collected seems shocking (e.g., 10 million between 1890 and 1920). The numbers of harvested bulbs, however, need to be considered in historical context. "Without historical perspective from which vegetative change can be reconstructed," cautions author Richard A. Minnich in *California's Fading Wildflowers*, "conclusions may be ad hoc stories."

Eighteenth and 19th century descriptions of California's native plant riches suggest that wildflowers generally grew in copious amounts, from the Pacific through the inland valleys and hills into the Sierra. The Coast appeared as a "Land of Fire" to the Spanish explorers for its profusion of flowers. To John Muir, the Sierra foothills were "living plant gold forming the most glowing landscape the eye of man can behold." Nine-year old Carl Purdy, en route to Ukiah from Petaluma in 1870, observed "masses of a single flower covering . . . hundreds of acres." Lacking quantitative data about existing geophyte populations in the American settlement period, it is difficult to conclude that Purdy's harvesting was excessive relative to plant abundance at the time.

Some critics point to Carl Purdy's business interest as a motivation for overharvesting. His lifelong career

of selling native and non-native bulbs and seeds was not a source of wealth. He engaged in other work to make ends meet—landscaping, article writing, and lecturing. Through these endeavors and his catalog, Purdy believed that his mission, in no small part, was to teach people about native plants, their culture, and adaptability to the garden.

ADDRESSING WILDFLOWER DISAPPEARANCE

During his lifetime, Carl Purdy himself addressed concerns about over-collecting and increasing wildflower disappearance. He noted the loss of wildflowers in great areas of California and the West, much of it beyond his collecting range. He considered the problem in the context of complex environmental changes that he had witnessed since the 1870s. This perspective, including decades of collecting along the same route from Mendocino County to Yosemite, gave him a unique opportunity to observe shifts in environmental patterns and their effects on native bulbs.

Purdy believed that the severe impacts that native plants had suffered resulted from several settlement activities: fire suppression leading to rampant growth of forest and brush crowding out native plants (contrary to the Native practice of selective burning, which opened up shaded areas, promoting plant growth); ever expanding clearance of land for agriculture; grazing, particularly sheep; and the introduction of invasive grasses supplanting both wildflowers and native grasses.

Carl Purdy demonstrated a passion for plants throughout his life. His love of the natural world is reflected in the tone and content of his published writing and handwritten lecture notes, as well as in his personal and business correspondence, particularly with his colleagues in California botany and horticulture. His greatest pleasure



Carl Purdy and crew sorting bulbs at the Terraces, his nursery and home, in the Mayacamas Range near Ukiah, California, c. 1914. Purdy marketed garden-grown bulbs along with wild-collected ones. Photograph by Charles Turrill, courtesy of the Carl Purdy Family Collection.

beyond the plants themselves was sharing his joy with the world's gardeners.

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RARITY, THREATS, AND THE CONSERVATION STATUS OF CALIFORNIA GEOPHYTES

by Dieter Wilken

The rich diversity, regional endemism, and rarity of many plants in the California Floristic Province are mirrored in the patterns exemplified by geophytes. Some geophytes are among California's most common and widespread species, and occupy many different habitats. For example, heartleaf bittercress (*Cardamine californica*), blue dicks (*Dichostemma capitatum*), species of manroot (*Marah*), and the aptly named skullcap (*Scutellaria tuberosa*) represent geophytes commonly found in oak woodland, chaparral, and grassland throughout California. In contrast, spring beauty (*Montia chamissoi*) and three-leaved lewisia (*Lewisia triphylla*) are adapted to moist soils and ephemeral wetlands of montane coniferous forests. A few geophytes, like Bermuda buttercup (*Oxalis pes-caprae*) and *Asparagus asparagoides*, are invasive non-natives but they generally occupy disturbed habitats and are considered threats only in agricultural fields and cultivated areas along the coast.

Unfortunately, local rarity and a limited geographic distribution, combined with declines in population size resulting from habitat degradation and loss, characterize a relatively large number of native geophytes. Geophytes might not appear to be especially vulnerable, given their adaptation to surviving periods of summer drought or cold winters in montane habitats. However, their conservation status is related almost entirely to anthropogenic factors. Many imperiled species have restricted distributions occurring naturally in or adjacent to areas now occupied by urban areas and agricultural lands, conditions that have contributed significantly to their his-

toric decline. The most frequently cited threats include urbanization and associated residential develop-

ment, road construction and maintenance, trampling along roads and trails, grazing, and competition from



TOP: Munz's onion (*Allium munzii*). Photograph by Roxanne Bittmann. • BOTTOM: Spanish Needle onion (*Allium shevockii*). Photograph by John Game.

non-native plants. In some species, logging, mining, and changes to the hydrological cycle represent significant threats. Historically, collecting for personal and commercial horticultural purposes certainly contributed to population declines. However, collecting is infrequently cited as a current threat.

The examples discussed here (Table 1) have been ranked by the California Native Plant Society and the California Department of Fish and Wildlife as CRPR 1B, plants considered rare, threatened, or seriously (1B.1) to moderately (1B.2) endangered in California and elsewhere (CNPS 2016; CDFW 2016). Many of them are found among the monocots. Most of them were once treated as members of the Liliaceae (Fiedler 1996), but they are now placed in seven different families, the Agavaceae, Alliaceae, Liliaceae, Melanthiaceae, Nartheciaceae, Ruscaceae, and Tecophilaeaceae (Baldwin et. al. 2012)). A few others briefly discussed are dicotyledonous geophytes in the Crassulaceae and Saxifragaceae.

Among the 60 kinds of onions (*Allium*, Alliaceae) in California, 12 are ranked as 1B. Munz's onion is known from fewer than 20 occurrences in the Perris Basin and Gavilan Hills of western Riverside County, an area currently experiencing considerable urbanization. Threats include residential development, mining, agriculture, grazing, vehicles, and non-native plants. A significant, historic decline in number of populations resulted in its designation as Endangered by the U.S. Fish and Wildlife Service. A few populations located within the Cleveland National Forest are monitored as part of a focused management plan. In contrast, Spanish Needle onion has one of the most narrowly restricted ranges of any California onion, with only two occurrences. The largest, with fewer than 1,000 plants, occurs on the slopes of Spanish Needle Peak in

Kern County. Here, the only perceived threat appears to be maintenance of the Pacific Crest Trail. Threats at the other occurrence, partly on land administered by the Bureau of Land Management, include the potential for off-road vehicles and effects of development on adjacent private lands. Nevertheless, the highly restricted distribution and small population size provide sufficient rationale to consider this species as endangered.

Seventeen of the 18 species comprising *Brodiaea* (Themidaceae) are endemic to the California Floristic Province, nine of which are endangered. Six of them are adjacent to areas that have experienced considerable urbanization or conversion to agriculture in the foothills north of San Francisco Bay, in the Sierra Nevada foothills, and in southern California. The newly described Sulphur Creek brodiaea consists of only a few hundred plants and is found at only one location in Shasta County (Preston 2010). Threats include the potential for horticultural exploitation, power line maintenance, and foot traffic. Chinese Camp brodiaea occurs at only two separate localities in Calaveras and Tuolumne counties, distributed along ephemeral stream courses on both serpentine and non-serpentine soils. The entire range of the species is on private land, threatened primarily by development, although efforts to protect plants at one locality have been pursued through efforts by the CNPS Sierra Foothills chapter (Anonymous 2007).

Almost half of the 52 different species and subspecies in *Calochortus* (Liliaceae) found in California are considered rare, including 20 ranked as 1B. The most commonly cited threats to endangered *Calochortus* include trampling and road construction, development through urbanization, grazing, and invasive plants. At least one species, single-flowered mariposa, is believed to be extinct. It has not been seen



TOP: Sulphur Creek brodiaea (*Brodiaea matsonii*). • BOTTOM: Chinese Camp brodiaea (*Brodiaea pallida*). Photographs by Robert Preston.

since 1876, when the only known specimen was collected by Edward Lee Greene in meadows on the banks of the Shasta River near Yreka, Siskiyou County. CNPS botanist Mark Skinner visited the site in 1990 and reported it to be heavily overgrazed and infested with many introduced weeds. Tiburon mariposa, a serpentine endemic occurring only in Marin County's Ring Mountain Open Space and Preserve, is the rarest extant *Calochortus* in California. Its existence continues to be threatened by invasive non-natives and recreational activities. Alkali mariposa is one of the few geophytes occurring in California's deserts, where it occupies a few seeps and wet meadows in the western Mojave Desert, but with a few outlying populations in the lower Owens



Floristic Province (Raven and Axelrod 1978). Most of the known occurrences of Red Hills soaproot, a gabbro and serpentine endemic, are on lands managed by the Bureau of Land Management, including the Pine Hill Ecological Reserve (El Dorado County) and the Red Hills Area of Critical Environmental Concern (Tuolumne County). However, threats to outlying populations on both private and public lands include development, mining, road construction, and vehicles. Purple amole is composed of two varieties, both listed as threatened by the U.S. Fish and Wildlife Service (Kofron et al. 2013). The typical variety is found almost exclusively on Fort Hunter Liggett (Monterey County) and Camp Roberts (San Luis Obispo County). Known from fewer than 20 occurrences, management plans have included cessation of grazing and either the curtailment or monitoring of military activities in the vicinity of known populations. Non-native plants and feral pigs remain the most significant threats. In contrast, the Camatta Canyon amole is represented by only two known occurrences, mostly on lands managed by the Los Padres National Forest and a highway right-of-way managed by the California Department of Transportation. Erection of fences to protect the site from off-road vehicles has significantly re-



River Valley and near Buena Vista Lake in the southern San Joaquin Valley. Although it shares many other threats in common with other endangered *Calochortus*, the loss of a mesic habitat resulting from lowered water tables represents its most critical, long-term threat.

The amole, *Chlorogalum* (Agavaceae), comprises five species worldwide and is notable as one of few genera endemic to the California

UPPER LEFT: Single-flowered mariposa (*Calochortus monanthus*), Type specimen. • LEFT: Tiburon mariposa (*Calochortus tiburonensis*). Photograph by Dieter Wilken. • UPPER RIGHT: Alkali mariposa (*Calochortus striatus*). Photograph by Roxanne Bittmann.



TOP: Purple amole (*Chlorogalum purpureum* var. *purpureum*). • BOTTOM: Camatta Canyon amole (*Chlorogalum purpureum* var. *reductum*) in fruit. Photographs by Dieter Wilken.

duced one threat, but invasive plants, pocket gopher activity, and uncontrolled cattle grazing remain as threats.

Six of the 20 species in *Erythronium* (Liliaceae) are considered endangered; another four are considered rare, threatened, or endangered in California but not elsewhere (CRPR 2). The rarest species, Pilot Ridge fawn lily is known from only one locality in the Stanislaus National Forest of Tuolumne County, with a population size estimated to be composed of no more than 1,000 plants. Potential loss from rock climbing activities and horticultural collecting are considered the two major threats to this narrow endemic. Another rare and endangered fawn lily is the recently described *Erythronium shastense* (York et al. 2015). Independently discovered by Dana York, Julie Kierstead Nelson, and Dean Taylor, this species is a limestone endemic known from only a handful of localities in the vicinity of Shasta Lake. Potential threats include road maintenance, mining, hydrological alterations arising from reservoir expansion, and invasive species (Himalayan blackberry, *Rubus armeniacus*). Shasta fawn lily exemplifies ongoing efforts to more fully document the California flora and identify species of special environmental concern.

Eleven of the 20 kinds



TOP: Pilot Ridge fawn lily (*Erythronium taylori*). Photograph by W. Dean Taylor. • BOTTOM: Shasta fawn lily (*Erythronium shastense*). Photograph by Julie Kierstead Nelson.

of *Fritillaria* (Liliaceae) in California are considered endangered; another five species are on the CNPS watch list (CRPR 4). Frequently cited threats to species in this genus include grazing, impacts of road maintenance and vehicles, and urbanization. California's rarest fritillary, Gentner's fritillary, is a recent addition to the flora and was first documented in 2003 from only two localities in northern Siskiyou County. First described in 1951 from a few scattered populations in Jackson and Josephine counties, Oregon, it was listed as endangered by the U.S. Fish and Wildlife Service in 1999, based on multiple threats. These include habitat loss and fragmentation, competition from non-native plants (e.g., star thistle, *Centaurea solstitialis*), fungal disease, fire



Gentner's fritillary (*Fritillaria gentneri*). Photograph by John Doyen.

suppression, wildlife grazing, small population size, and over-collection by bulb enthusiasts. The California populations occur on Bureau of Land Management lands, and their management has been incorporated into a recovery plan embracing the species in both states (Amsberry and Meinke 2009).

Among the 17 species of *Lilium* (Liliaceae) in California, four species are considered endangered, although another eight are on the CNPS Watch List (4). Listed as federally endangered by the U.S. Fish and Wildlife Service, the western lily (*Lilium occidentale*) occurs in both Oregon and California. It was once known from ca. 60 occurrences in wetland habitats, ranging from fens to coastal prairies and shrublands, and early successional beach pine forests, among others. Disturbance, resulting from natural or limited agricultural grazing and occasional fires, may have played an important role by limiting succession and providing opportunities for

natural colonization and establishment. By the time it was federally listed as endangered in 1994, the number had dwindled to about 25 occurrences, with fewer than eight in California. Threats on both public and private lands include development, herbivory, inappropriate grazing, fire suppression, vegetation succession, and horticultural collecting (Anonymous 2009). Implementation of a recovery plan through research at Humboldt State University and reintroduction efforts conducted by the Berry Botanic Garden (Portland, OR) and the U.S. Fish and Wildlife Service (Arcata, CA) provide an opportunity for measurable success in stabilizing the species. These efforts have been augmented through cooperation and voluntary protection by some but, unfortunately, not all private land owners. Full recovery, however, will depend on efforts that ensure periodic disturbance through carefully managed selective grazing and fire regimes (Anonymous 2009).

The five tuberous species comprising *Dudleya* subgenus *Hasseanthus* (Crassulaceae) in California are all considered endangered. Santa Cruz Island dudleya (*Dudleya nesiotica*), endemic to the Fraser Point peninsula on Santa Cruz Island, was originally threatened by preferential herbivory and habi-

tat degradation by feral pigs. In the late 1990s estimates of population size indicated the occurrence of 30,000 to 60,000 plants, restricted to an area of approximately 32 acres (13 hectares). Following eradication of pigs between 2005 and 2007, a slow but gradual recovery has been observed, including discovery of small outlying populations. These newly discovered populations have increased the known range to over 60 acres (24 hectares). The only major threat remaining to recruitment is from *Festuca perennis*, which forms a mosaic of dense stands on part of the peninsula. Although not listed as endangered, island jepsonia (*Jepsonia malvifolia*, Saxifragaceae), is another island endemic and geophyte, and has shown the same pattern of recovery in the absence of pig rooting on both Santa Cruz and Santa Rosa islands.

Among approximately 285 species of bulbiferous or cormaceous native monocots in California, 75 (26 percent) are ranked as 1B. The percentage of 1B plants in the California flora as a whole is approximately 1157 among 6502 or 18 percent (CNPS 2016). This suggests that, at least in monocotyledonous geophytes, there is a higher than expected proportion of endangered species. Most likely, such endangerment is a result of multiple factors,

Western lily (*Lilium occidentale*). Photograph by John Game.





Santa Cruz Island dudleya, *Dudleya nesiotica*. Photographs by Dieter Wilken.

as shown by examples above. However, in general, the natural distribution of many species in several genera coincides with areas of intense human activity, including agriculture development and urbanization along the margins of the Great Central Valley and on the coast. Some species are protected through land management and plan-

ning efforts, but only a few are found in preserves or in state and national parks. New approaches to conservation, including regional planning, exploration of novel recovery efforts, and more coordinated efforts by CNPS and land management agencies, may become necessary (Bartosh and André 2015). Ultimately, successful conservation will rely on a

deeper public awareness and a more widely accepted environmental ethic to guide effective efforts, especially on private lands.

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TABLE 1. EXAMPLES OF ENDANGERED GEOPHYTES IN THE CALIFORNIA FLORA.

COMMON NAME	SCIENTIFIC NAME	CALIFORNIA RARE PLANT RANK
Alkali mariposa	<i>Calochortus striatus</i>	1B.2
Camatta Canyon amole	<i>Chlorogalum purpureum</i> var. <i>reductum</i>	1B.1
Chinese Camp brodiaea	<i>Brodiaea pallida</i>	1B.2
Gentner's fritillary	<i>Fritillaria gentneri</i>	1B.1
Munz's onion	<i>Allium munzii</i>	1B.1
Single-flowered mariposa	<i>Calochortus monanthus</i>	1A (presumed extinct)
Pilot Ridge fawn lily	<i>Erythronium taylori</i>	1B.2
Purple amole	<i>Chlorogalum purpureum</i> var. <i>purpureum</i>	1B.1
Red Hills soaproot	<i>Chlorogalum grandiflorum</i>	1B.2
Santa Cruz Island dudleya	<i>Dudleya nesiotica</i>	1B.1
Shasta fawn lily	<i>Erythronium shastense</i>	1B.2
Spanish Needle onion	<i>Allium shevockii</i>	1B.1
Sulphur Creek brodiaea	<i>Brodiaea matsonii</i>	1B.1
Tiburon mariposa	<i>Calochortus tiburonensis</i>	1B.1
Western lily	<i>Lilium occidentale</i>	1B.1

SOURCE: California Department of Fish and Wildlife, Natural Diversity Database. January 2016.

and Wildlife, Natural Diversity Database. January 2016. *Special Vascular Plants, Bryophytes, and Lichens List*. Quarterly publication. 126 pp. CNPS, Rare Plant Program. 2016. Inventory of Rare and Endangered Plants (online edition, v8-02). California Native Plant Society, Sacramento, CA. Website www.rareplants.cnps.org [accessed 15 January 2016].

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DECLINING SPECIES DIVERSITY ON THE NORTH COAST: THE ROLE OF DISTURBANCE

By David Imper

In many ways this article is the story of my career, and lessons I learned working with endangered plants for the past 35 years. I believe we are experiencing a steep decline in a broad range of early successional habitats on the North Coast, threatening many rare species, geophytes, and biodiversity in general. In my view this threat stems in large part from changes in agricultural practices since World War II, altering disturbance patterns that previously maintained early successional habitats on a broad scale.

DISTURBANCE—AN ELUSIVE CONCEPT

Given the important role disturbance plays in determining the structure and composition of natural communities, the term is surprisingly hard to define, and frequently misused. A standard defini-

tion might read: any factor or process which produces a change in a biological community from some baseline condition. However, defining what baseline means can be messy. For example, does the act of removing grazing after a century constitute removal of disturbance, or is it a disturbance itself. Frequently cited disturbance factors include things like fire, grazing, direct human manipulations (for example, development and logging), wind, and disease.

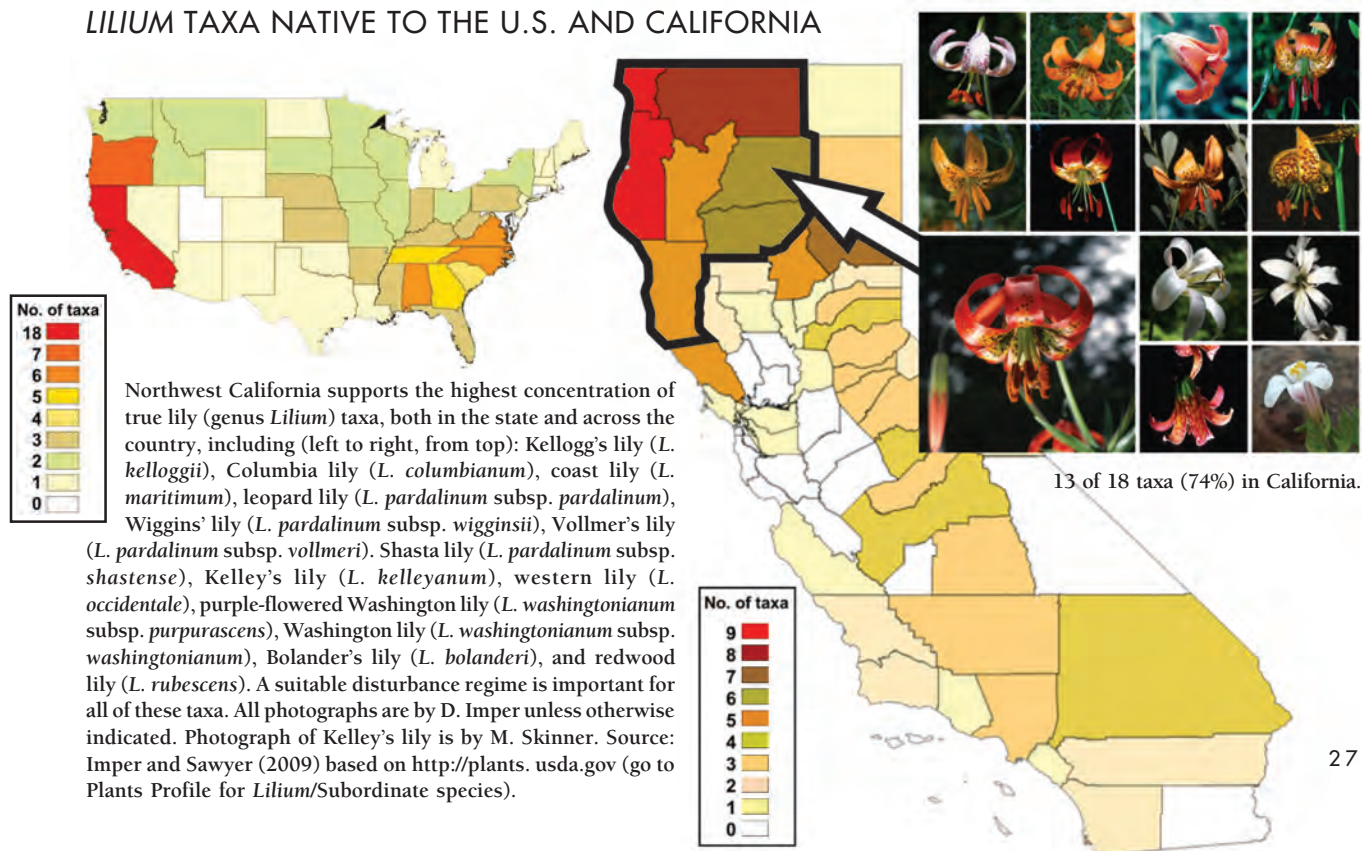
The effect of disturbance can vary dramatically, depending on the timing, duration, intensity, degree of impact on native soils, and many other variables. This relationship might seem obvious, but oddly, is often ignored in relation to domestic grazing. While un-grazed and over-grazed conditions are easily recognized endpoints, controlled grazing entails a broad continuum of effects,

with potential benefits for a great many natural communities.

LILIES AND DISTURBANCE

On my first day as a botanist at Six Rivers National Forest in 1981, I visited the only site then known for the State and Federally endangered western lily (*Lilium occidentale*) in California, which happened to be a pasture near Eureka. I soon discovered that northwest California is world-class in its diversity of true lilies (sidebar). Eventually, I also learned that disturbance is critical to maintaining healthy populations in this group. For years I led field trips to the Bluff Creek watershed, north of Orleans, to observe what I suspect may have been the highest concentration of true lilies in the country, and perhaps the world. Seven *Lilium* taxa and hybrids between most of those taxa occurred

LILIUM TAXA NATIVE TO THE U.S. AND CALIFORNIA



CRESCENT CITY MARSH—BOTANICAL PARADISE



TOP: The Crescent City Marsh encompasses approximately 300 acres on the south side of Crescent City, and supports many rare species and habitat types, and greater than 70 percent of the range-wide flowering population of western lily. Top: Typical, exceptionally diverse Bogbean (*Menyanthes trifoliata*) Marsh, and Western Labrador Tea (*Rhododendron columbianum*) Marsh communities near the northern boundary of the Crescent City Marsh. BOTTOM: Some geophyte species in the marsh (left to right): White-flowered bog-orchid (*Platanthera dilatata* var. *leucostachys*), bogbean (*Menyanthes trifoliata*), arctic starflower (*Trientalis europaea*) and king's scepter gentian (*Gentiana sceptrum*).



LEFT AND BELOW: Southern portion of Crescent City Marsh in 1972 and 2005. Grazing was removed in the 1980s, stimulating encroachment by woody species, and virtually eliminating the early successional habitat around the edge of the open water marsh, where the western lily and other rare plants had occurred.



Oblique aerials
©2002–2015
Kenneth & Gabrielle
Adelman, California
Coastal Records
Project.

within a few square miles. The diversity in soils and elevation, geographic location, and history of logging, road maintenance, and fire combined to create a virtual lily paradise. Timber harvest has declined dramatically in the watershed since the 1980s, and with it, the abundance of lilies.

Much of my career was subsequently devoted to conservation of the western lily and other rare species, largely focused near the coast

between Coos County, Oregon, and Mendocino County, California. That work included observing changes in literally hundreds of biologically rich, early to mid-successional habitats, over the course of decades. Among others, these included many of the best examples of coastal prairie and scrub, emergent wetlands, *Darlingtonia* fens, and vegetation associated with Blacklock series soils along coastal Oregon (Blacklock soils are poorly

drained, and support pygmy forest and its different successional stages in Mendocino County). As a result, I have watched the successional dynamics affecting much of the near-coast vegetation in this area.

THE RULE RATHER THAN EXCEPTION?

Besides true lilies, many of our rare species, and a great many geophytes are dependent on periodic disturbance. For example, of 114 California Rare Plant Rank 1 and 2 flowering species found in Del Norte and Humboldt counties, some 25 percent occupy emergent wetland, open scrub or prairie near the coast, habitats dependent on periodic disturbance. Thirty percent occupy wetlands further inland, typically dependent on fire or other disturbance, and another 25 percent occupy dry serpentine, chaparral or broadleaf woodland habitats, again predominantly dependent on fire.

EARLY SUCCESSIONAL HABITATS DISAPPEARING

The rapid industrialization of the U.S. after World War II may be thought of as synonymous with a general simplification of disturbance regimes. A couple of changes that particularly impacted biodiversity involved the many sprawling ranches that extended up and down the coast, which either were subdivided, or more intensively grazed after the war. Another change was the development of more efficient methods of fire suppression, which resulted in either no fire, or ultimately, more severe fires. In effect, what had been frequent, dispersed, often moderate disturbance events became essentially all or nothing.

California's north coast is characterized by relatively fertile soils and mild climate. If not checked, shrub and tree growth are rapid and relentless in most habitats. It is not unusual to see Sitka spruce (*Picea*

sitchensis) or shore pine (*Pinus contorta* ssp. *contorta*) grow six feet annually. Other species, notably slough sedge (*Carex obnupta*)—in absence of disturbance, such as grazing—tends to form monocultures displacing large swathes of species-rich wetlands in a matter of a few years. Salt marsh, coastal dunes, and exceedingly rocky sites are among the few kinds of habitats generally immune to replacement by a relatively few aggressive native species.

SPECIFIC EXAMPLES

The list of special habitats either lost, or in serious decline is long. I'll mention just a few. Point St. George and the Crescent City Marsh, in Del Norte County, together comprise 800 acres, but contain 25 percent of the rare and endangered species in the county. Both properties were grazed for a century or more, until the 1980s. Point St. George was acquired by the state in 1992. Since 1981, I estimate the cover by virtually pure stands of slough sedge has doubled, and together with advancing willow scrub and forest, has replaced more than half of the early successional, diverse wetlands and prairie.

Much of Crescent City Marsh (sidebar) was acquired by the California Department of Fish and Wildlife in 1980 and became a wildlife area. Although recent manual clearing has bought some time for one population of western lily there, four of the five populations that remained in 1992 are gone, along with much of the habitat for other rare plants.

Farther south in Humboldt County is Big Lagoon Bog (fen). Similar to Crescent City Marsh and Inglenook Fen, in Mendocino County, it is highly unique and botanically rich. In decline for decades, the North Coast chapter has developed a plan to restore the original open fen. I fear Inglenook Fen is suffering a similar fate.

With few exceptions, the *Sphagnum* and *Darlingtonia* fens up and

down the Oregon coast have vanished or are declining rapidly (Christy 2005), including many within Oregon state parks. In fact, my experience suggests species diversity formerly associated with a wide range of open habitats across most of the Oregon state parks between Coos Bay and Brookings, including Shore Acres, Sunset Bay, Floras Lake, Cape Blanco, and others, has declined dramatically. Included are thousands of acres of headlands historically burned by Native Americans, and then domestically grazed, prior to state acquisition.

These examples do not include the more than 60 percent of the historical sites for western lily in both states, which simply disappeared into forest, scrub, and slough sedge over the past century.

THE CASE FOR GRAZING

Steve Edwards (1992) provided *Fremontia* readers an excellent sum-

mary of both the prevalence and ecological benefits of mega-faunal grazing in late Pleistocene California. More recently, Anderson (2005) and others have documented the widespread and relatively sophisticated use of fire by Native Americans. Based on the dependence of so much of our native flora on moderate-level disturbance, there can be little question that Native American use of fire, as well as macro-ungulate grazing, notably elk, were critical factors in maintaining early successional habitats for centuries prior to the 1850s, when the influx of settlers on the west coast brought a new set of disturbance regimes, often including widespread clearing followed by domestic grazing. Though Roosevelt elk were nearly extirpated from the North Coast in the last century, the species is now prospering. Elk habitat in areas receiving high usage bears a remarkable resemblance to habitat passively-grazed by cattle.

Research documenting the ben-

A JEWEL NO MORE



Natural succession has progressed rapidly throughout the seasonally-dry portions of Crescent City Marsh since removal of passive domestic grazing in the mid-1980s. • The wet coastal prairie in 1992 (upper left), five years after removal of passive domestic grazing, supported a dense stand of great burnet (*Sanguisorba officinalis*) (upper right), and stream orchid (*Epipactis gigantea*) as well as the western lily and many other native wetland species. By 2008 (bottom) that community was entirely replaced by slough sedge (*Carex obnupta*), Douglas aster (*Symphotrichum subspicatum*), shrubs, and conifers.

30 YEARS OF MANAGING THE WESTERN LILY, TABLE BLUFF ECOLOGICAL RESERVE, HUMBOLDT COUNTY



The California Department of Fish and Wildlife acquired the former Ocean Ranch near Eureka in 1986 and designated it the Table Bluff Ecological Reserve, in part, to manage for the western lily. Removal of passive grazing by cattle in 1988 led to rapid encroachment, decline of the western lily, and a steep decline in species diversity. Seasonal grazing was resumed in 1997.

ABOVE LEFT: Coastal prairie before (top) and after (bottom) winter grazing, 2011. • ABOVE: Western lily in June following winter grazing.



LEFT TO RIGHT: Typical geophytes include Douglas iris (*Iris douglasiana*); coast sneezeweed (*Helenium bolanderi*); and coast clover (*Trifolium wormskioldii*), a common butterfly host plant.

efits of controlled grazing has exploded in the past two decades, not just for plants, but a wide range of species, including butterflies, fish, and kit fox, to name just a few. With respect to the western lily, just three sites across its range are considered to be stable, based on presence of a reasonably reliable disturbance re-

gime. Seasonal grazing is employed at two sites (sidebars), and a third site is maintained by routine vegetation clearing under a powerline.

Research conducted at the Table Bluff Ecological Reserve (sidebar) and elsewhere, has documented a variety of ways controlled grazing benefits the western lily besides habitat maintenance, such as improved hydrology and enhanced germination. Five years following treatment with goats at Floras Lake State Park, total western lily individuals had increased more than 400 percent, compared with 200

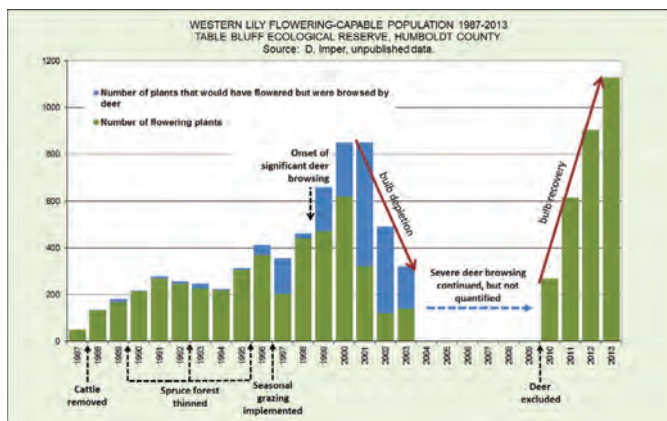
percent in the burned, and no change in the control treatments.

TIME IS RUNNING OUT

Protection of natural areas in this country—be it designation of wildlife areas, parks or wilderness—has long been equated with eliminating human disturbance. That effort ignores two important facts: 1) natural disturbance patterns have changed dramatically, even in the past 60 years, and 2) absence of historic disturbance will inevitably have a major influence on species composition and diversity.

As a rule, agencies entrusted with conserving our natural resources simply do not perceive managed disturbance to be a significant part of their mission. Many of the greatest losses I have observed have occurred following public acquisition of working landscapes, most often after domestic grazing was removed. Many times I faced vigorous opposition by the public, environmental community, and even agencies to resumed grazing, which based on the scientific merits, I can only explain as based on predetermined bias. Such bias is understandable given the history of domestic grazing abuse, but regrettable from the standpoint of its huge potential value to conservation. One example, perhaps unwitting, is contained in the online guidance for our own rare plant inventory; the glossary lists seven grazing-related threats, none of which identify specifically, the absence of grazing.

Certainly many agencies, including the U.S. Fish and Wildlife Service and National Park Service, apply disturbance (usually fire) for specific purposes, such as fuels reduction, maintenance of oak woodlands, or game management. In addition, the agencies responsible for resource extraction, such as the Forest Service and Bureau of Land Management, obviously administer routine disturbance as a part of their mission. These efforts, while often ben-



BLACKLOCK SOILS AND GEOPHYTES

efitting biodiversity, are rarely if ever aimed at maintaining plant diversity or rare plant species. The simple fact is the two principle public agencies in California entrusted to manage our botanical heritage, the Department of Fish and Wildlife and the U.S. Fish and Wildlife Service, dedicate almost no resources toward monitoring or recovery of rare plants, or plant-related biodiversity. Thus the agencies literally have no way of knowing the extent of the problem, nor impetus to deal with it.

I know some will question my assessment of this threat and the paucity of actions being taken to address it, which in part, is why I wrote this article. My response is that I have observed, firsthand, this growing threat for the past 35 years in a region of the two states I know well. I strongly suspect the problem is prevalent elsewhere, to varying degrees, especially in areas either subject to rapid natural succession (fertile soils and/or mild climate) or where extensive time has passed since a more natural disturbance regime existed (for example, designated wilderness areas too small to support a natural fire frequency). For those that doubt, however, I welcome the opportunity to provide further evidence, in the field or otherwise.

I spent 30 years coordinating efforts involving well over a thousand volunteers, manually treating as many sites as possible across the range of the western lily. In the end, these efforts were exceedingly short-lived, and affected only a fraction of its declining habitat, not to mention the tens of thousands of acres of high quality, early successional habitat slipping away nearby. Without question, this challenge is daunting—to respond at an appropriate scale will require a monumental change in attitudes across the public and regulatory spectrum, not to mention a great commitment of resources. But I have to believe that if we, as a professional society, fully understand all that is at stake,



Poorly drained Blacklock series soils are common to marine terraces along the coast in Coos and northern Curry Counties, Oregon, and Mendocino County, California. They support a wide array of plant communities and rare plant species. In absence of fire and grazing over the past 40 years or more, natural succession has eliminated vast areas of previously species-rich, early successional vegetation.

TOP: Mixed wet coastal prairie/scrub supporting the western lily and other rare species at Cape Blanco State Park, near Port Orford, Oregon, in 2010. A rare example of early successional vegetation on Blacklock soils, this five-acre remnant was then threatened by encroachment of Sitka spruce (*Picea sitchensis*), subsequently removed. The habitat is seasonally grazed. • BOTTOM, LEFT TO RIGHT: Some of the geophyte species associated with western lily on Blacklock soils: California pitcher-plant (*Darlingtonia californica*); bear-grass (*Xerophyllum tenax*); round-leaved sundew (*Drosera rotundifolia*); and western false-asphodel (*Triantha occidentalis* subsp. *occidentalis*).

we would collectively come up with a plan.

Ultimately, land managers and the regulatory community must come to embrace the inextricable links between managed disturbance, biodiversity and rare species, in the everyday management of our environment and infrastructure, and seek ways to both meld the two and streamline the process wherever possible. I emphasized grazing here, in part because it can provide an economic benefit, an important factor in designing a sustainable disturbance regime. In the same manner, appropriate vegetation management conducted as part of fire safety programs offers a great opportunity to integrate disturbance with conservation of rare species and diversity. Other significant opportunities lay in our management of utility corridors, roadsides, timberlands, exotic species, open space, and other areas.

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Calochortus amabilis on Walker Ridge (2009). Large photograph by Jeff Bisbee; inset by Richard Philip Bouchard.

GEOPHYTES RESPOND TO FIRE DISTURBANCE

Heightedened number and patch size of wildflowers benefit insects and seed-eating birds.





ABOVE: Fremont's star lily (*Toxicoscordion fremontii*) after the Morgan Fire (2013) on Mount Diablo. NOTE: Poisonous. Large photograph by Scott Hein (www.heinphoto.com); inset by Richard Philip Bouchard.



Vast swath of Ithuriel's spear (*Triteleia laxa*) blooming after the Walker Fire (2009) on Walker Ridge. Scenic photograph by Ames Gilbert; close-up by Richard Philip Bouchard.



Edible geophytes like blue dicks are phenomenally abundant on California's Channel Islands, as evidenced by the springtime bloom on Santa Cruz Island's West End. Blue dicks occur in various plant communities, but are especially prevalent in grassland/forb field communities, occurring throughout western North America and on all the islands off the California coast. Photograph by Eamon O'Byrne, TNC, Santa Cruz Island, spring 2014.

10,000 YEARS OF GEOPHYTE USE AMONG THE ISLAND CHUMASH OF THE NORTHERN CHANNEL ISLANDS

by Kristina M. Gill

Just off the southern California coast, the archipelago of the Santa Barbara Channel is comprised of four east-west trending islands, located between approximately 19 and 42 kilometers from the mainland today. When people first arrived during the last Ice Age, the islands of Anacapa (*Anyapakh* in

Chumash), Santa Cruz (*Limuw*), Santa Rosa (*Wi'ma*), and San Miguel (*Tuqan*) were connected as a single landmass commonly referred to by geologists and archaeologists as Santarosae (~10-12 km from the mainland). The Island Chumash and their ancestors thrived on these islands, adapting to sea level rise,

climate change, and population growth for at least 13,000 years, until Europeans drastically impacted their traditional way of life through disease, enslavement, and forced assimilation.

The Island Chumash are famous for their seafaring capabilities and strong maritime orientation, with a

long history of fishing, sea mammal hunting, and shellfishing. Plant foods were also important, supplying Islanders with carbohydrates needed to balance rich fats and proteins obtained from marine resources. Island archaeobotanical assemblages (the preserved remains of plants in archaeological sites) indicate that easily procurable plant foods high in carbohydrates were consistently the most important. These archaeobotanical remains are well preserved through carbonization and identifiable thousands of years after they were initially burned (often during cooking accidents) and deposited in habitation sites. Geophytes, small seeds (especially grasses and chenopods), and non-toxic pits like manzanita berries are frequently found in island sites, whereas toxic nuts such as acorns and cherry pits (*islay*) that require

extensive processing are much less common. Other plant foods were also used, but geophytes and small seeds appear to have been staple plant foods in Islander diets (Gill 2015; Gill and Hoppa 2016).

Geophytes are notably rich in carbohydrates and phenomenally abundant on the islands today, especially those in the *Brodiaea* complex (Themidaceae) (e.g., *Bloomeria* spp., *Brodiaea* spp., *Dichelostemma* spp., *Triteleia* spp.). The archaeobotanical corms could be any one of these four genera within the *Brodiaea* complex, but are morphologically indistinguishable when carbonized. Here, I refer to all ancient corms as blue dicks (*Dichelostemma capitatum*), which are the most likely candidate used extensively by the Island Chumash based on modern distributions and ethnographic information (Gill 2015). Blue dicks

are the most abundant geophyte on the islands today, especially in grasslands/forb fields, growing from sea level to the highest points, including Diablo Peak on Santa Cruz at 2,429 feet elevation.

Blue dicks reproduce both sexually (seed) and asexually (cormlets), with each mature corm capable of producing more than 15 cormlets annually that in turn produce their own cormlets the following year. Moreover, blue dicks corms on the islands are significantly larger than their mainland counterparts, measuring upwards of nearly 50 mm in diameter. Two possible explanations for the larger corms on the islands include a long history of Island Chumash harvest/selection for larger corms, and/or the lack of native burrowing or grazing herbivores present on the islands (e.g., gophers, deer, rabbits). Geophytes are espe-

Blue dicks field on southwest Santa Cruz Island near Pozo Canyon. Photograph by Kristina Gill, Santa Cruz Island, March 2014.





Hundreds of whole and nearly whole carbonized blue dicks corms were found associated with an earth oven at the Diablo Valdez site on Santa Cruz Island during excavation. Later detailed archaeobotanical analysis of soil samples revealed that blue dicks corms were used for nearly 6,000 years of occupation at this site, from ~5,800 years ago until around AD 1800. Blue dicks corms are the most frequently identified food plant on the northern islands, found in nearly all sites where archaeobotanical analysis has been done. K. Gill is pictured. Photograph by Terry Joslin, Santa Cruz Island, August 2011.

cially fecund on the islands today and the Island Chumash would have had no competition (aside from other Islanders) for this incredible food resource (Gill 2015).

Ethnographic use of edible geophytes, and blue dicks in particular, is extensively documented throughout much of California as well as in the Santa Barbara Channel region.



Modern blue dicks corms and underground storage organs of other geophytes on the Channel Islands are significantly larger than their mainland counterparts, measuring upwards of nearly 50 mm in diameter. The larger island corms may be the result of millennia of selection by Island Chumash and/or a lack of native burrowing and browsing herbivores (e.g., gophers, squirrels, deer, rabbits) that are common in mainland California, and that target blue dicks corms, shoots, and flowers as a food source. Photograph by Kristina Gill, Santa Cruz Island, July 2014.

Among the Chumash, the name *cacomite* (derived from the Nahuatl word *cacomitil* and introduced by the Spanish) was most commonly applied to blue dicks, as was the Chumash name *shiq'o'n* (Gill 2015; Timbrook 2007). *Shiq'o'n* was harvested using a digging stick, often weighted with a perforated stone (a.k.a “donut stone”). Fernando *Kitsepawit* Librado, an important Chumash consultant who worked with ethnographer John P. Harrington in the early 1900s, indicated that *shiq'o'n* was particularly important on the islands with several families involved in harvesting and cook-



Digging stick weights, also known as “donut stones,” are one of the most prevalent artifacts found on the Channel Islands, and have been identified in dateable contexts to at least the last 7,500 years. Donut stones have a single hole drilled through the middle and vary in size, shape, and extent of modification around the edges. These artifacts were typically affixed towards the base of digging sticks and used to provide more weight and leverage. The proportion of digging stick weights found on the islands (87%) compared with the adjacent mainland (13%) is quite high (Sutton 2014), further indicating that geophyte procurement was especially important on the islands. Photograph is by Kristina Gill, San Miguel Island, August 2012.

ing large quantities in earth ovens measuring over a meter across (Timbrook 2007).

Archaeobotanical data confirm ethnographic records that blue dicks corms were the most important Island Chumash plant food, with evidence of their use for nearly 10,000 years. Island sites generally have re-

markably well preserved stratigraphy (due to a lack of burrowing animals) that allows for plant remains within a given stratum to be radiocarbon dated directly and/or associated with a specific occupation layer. Aggregated extant archaeobotanical data from 26 sites on Santa Cruz and San Miguel Islands comparing densities and frequencies of carbonized blue dicks corms and corm fragments through time show no statistically significant change in their use over this 10,000-year span (Gill and Hoppa 2016). A similar pattern was also identified at a single site (Diablo Valdez) on Santa Cruz Island, where I documented no significant change in the use of blue dicks for nearly 6,000 years, using measures of density, frequency, and ratios to total plant weight (Gill 2015). A well-preserved earth oven associated with hundreds of carbonized blue dicks

corms was found during excavations at Diablo Valdez, confirming its primary function as a *shiq'o'n* cooking feature, the first of its kind to be identified archaeologically on the islands. While other plant remains from the Diablo Valdez site also show a similar pattern of consistent use through time, blue dicks corms were the most abundant and most frequently identified plant food.

Although most ethnographic literature in California indicate blue dicks corms were harvested in the spring after flowering, a second season of harvest has been documented on the islands during the fall. Blue dicks corms undergo seasonal morphological changes on an annual basis that can be identified on carbonized archaeobotanical speci-



Fernando Kitsepawit Librado, Chumash, demonstrates the use of a digging stick with no weight attached, near Ventura, CA, around 1912. Photograph courtesy of the Braun Research Library Collection, Autry Museum, Los Angeles; Plate 708.

mens (Gill 2014). The mature parent corms exhibit smooth sides in the late spring/summer, with adventitious root growth occurring around the base of the corm in the fall, as the corm emerges from summer dormancy in anticipation of fall and winter rains. The corm then appears to “divide” in the winter, where the old corm withers from its base, using its reserved starches to develop a new corm on top in preparation for flowering, again exhibiting smooth sides that remain through spring flowering and summer dormancy (Gill 2014). Cormlets (clones of the parent corm) follow a different morphological trajectory in their first year, and are sometimes found archaeologically as well, although much less frequently than mature

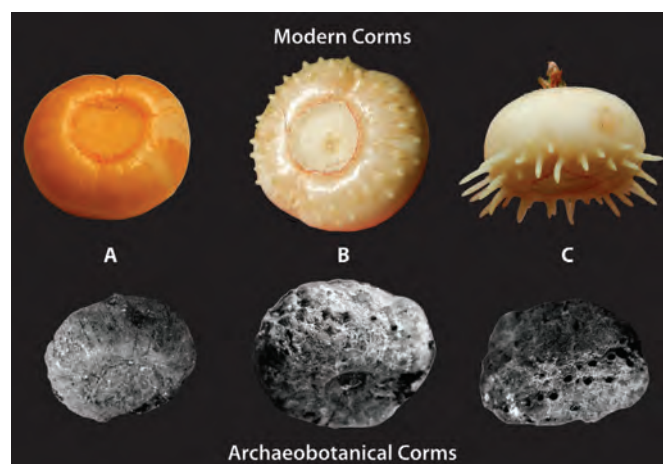
corms. Both the spring/summer (smooth) and fall (adventitious root growth) stages of seasonal morphological changes in the corms have been documented on archaeobotanical specimens from 6,000 years of occupation at Diablo Valdez (Gill 2014, 2015) and from a site on Santa Rosa Island (SRI-666) that dates to approximately 8,500 years ago. These specimens dating to multiple time periods indicate a long tradition of employing at least two seasons of harvest for blue dicks on the islands.

The remarkably long history of Island Chumash geophyte use employing two seasons of harvest, with no significant change seen over nearly 10,000 years attests to the importance of blue dicks as a food staple and overall geophyte-based subsistence regime. Furthermore, it appears that the Islanders were actively engaged in managing their

wild blue dicks fields, including “tilling” the soil during the repeated process of harvesting *shiq'o'n*, replanting cormlets and primarily harvesting mature corms, and possibly using other means such as seed dispersal during fall harvest and fire. These types of landscape management strategies would have promoted growth and increased the habitat of blue dicks and other important economic grassland taxa throughout prehistory. Current land management regimes (i.e., fire suppression, lack of new disturbance/regular “tillage”) are vastly different from those that the islands experienced over the previous 13,000 years, and it remains to be seen how well island geophytes will fare in the future.



TOP: Excavations at two loci of Diablo Valdez, an upland village site on the northern side of Santa Cruz Island, revealed deep and well-stratified deposits spanning nearly 6,000 years of occupation. Various features including two earth ovens, a house floor, and hearth cleaning pits, indicate that this was primarily a domestic site where daily activities such as cooking took place in and around living areas. K. Gill is pictured. Photograph by Amber Marie Madrid, Santa Cruz Island, August 2011. • BOTTOM: Earth ovens were used for cooking large quantities of geophytes at a time, and were most often built and used communally. Chumash consultant Fernando Kitsepawit Librado indicated that *shiq'o'n* was particularly important on the islands where several families collectively harvested and cooked them in earth ovens measuring more than a meter across. At the Diablo Valdez site, an upland village on the north side of Santa Cruz Island, a well-preserved earth oven dating to ~4500 years ago was identified during excavations. Hundreds of carbonized blue dicks corms were found associated with this feature, confirming its primary function as a means to cook geophytes, and representing the first such feature to be identified archaeologically on the islands. Composite photograph by Kristina Gill, Santa Cruz Island, August 2011.



Several different stages of annual corm morphology are shown here, with modern blue dicks corms on the top row (fibrous coats and basal caps removed), and carbonized archaeobotanical corms identified from the Diablo Valdez site on Santa Cruz Island on the bottom row (not to scale). From left to right, corms exhibit smooth sides (A) in late spring/summer; adventitious roots begin to emerge in early fall, as the corms emerge from summer dormancy (B); adventitious roots continue to grow from around the corm base through the fall months, with scars of fully emerged adventitious roots present on archaeobotanical specimens (C). On archaeobotanical specimens, smooth-sided corms are indicative of a late spring/summer harvest (A), while emerging adventitious roots or root scars are indicative of a fall harvest (B, C). Composite photograph by K. Gill, adapted from Gill 2014.

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GEOPHYTES AND HUMAN EVOLUTION

by M. Kat Anderson

Geophytes are both diverse and abundant in Mediterranean-type climates throughout the world but nowhere are they more diverse than on the continent of Africa, where our species began. Because of this association, geophytes may hold a very special place in our evolutionary history.

Modern DNA studies reveal a surprising fact: our species carries little genetic diversity relative to other species. Our limited genetic variability may be best explained by a “population bottleneck,” a population crash in early *Homo sapiens*. It seems that humans came perilously close to extinction, and that all the humans alive today de-

scended from several small refuge populations.

What was the phenomenon that pushed humans to the brink? Climate change. A short time after the human species arrived on the scene, some 195,000 years ago, the climate shifted, producing colder and more arid weather less conducive to the growth and survival of the edible plants and animals on which early humans depended. This ice age, which climatologists refer to as “Marine Isotope Stage 6,” lasted until roughly 123,000 years ago. Sometime during this long period came the population bottleneck, when several small groups of early humans survived in locales with food resources more varied and

abundant than those elsewhere. These refuges may have been in the Cape South Coast region of South Africa.

In a cave known as PP13B, archaeological excavations reveal a very long record of intermittent human occupation between 164,000 and 35,000 years ago, a period that spans both the bottleneck and the time thereafter when the human population recovered and grew. Based on this and other evidence, archaeologists hypothesize that shellfish, marine mammals, and geophytes together provided the essential proteins and carbohydrates that the human residents of this area needed to survive this most difficult of times.

All geophyte species pictured are found in the Cape Region of South Africa. Here is a population of *Chasmanthae aethiopica* growing in dune fynbos vegetation within view of the Indian Ocean. This geophyte has astringent corms that require processing to make them edible. Photograph by Richard M. Cowling.





LEFT: *Cyphia digitata* occurring in renosterveld. Photograph by Jan de Vynck.

• ABOVE: Edible tubers of *Cyphia digitata* which can be eaten raw. Photograph by Susan Botha.

Although geophytes have left little in the way of material remains because they lack bones or hard shells, archaeologists hypothesize an important role for them in the human food supply during the ice

A visualization of the Palaeo-Agulhas Plain off Mossel Bay some 60,000 years ago during a moderate cold phase (glacial). The mid-ground shows a group of modern humans at a campsite on a sandy, limestone ridge beneath a large white milkwood tree. On the left, children are collecting firewood from the dune thicket and protea veld, while two men return from a hunt with bluebuck (center), and two young women are offloading their harvest of intertidal shellfish. The women on the right are preparing to cook the corms of geophytes collected in the surrounding veld. This palaeoscape painting is by Maggie Newman, courtesy of the Centre for Coastal Palaeoscience at Nelson Mandela Metropolitan University.



age that ended 123,000 years ago. Geophytes, they point out, had diverse representation in the regional flora at the time, the ability to survive droughts, and high energy-yielding carbohydrate composition. Certain geophytes are also easy to gather and digest and there is plenty of ethnographic, historic, and later archaeological evidence that hunter-gatherer groups ate them. In the archaeologists' view, geophytes may have been one of the major foods that pulled us through the bottleneck.

This story also carries some lessons for the present day. As we enter another period of rapid climate change—this time of our own making—the human history of geophyte consumption reminds us of our reliance on the many non-human species that, like us, are products of the evolutionary process. In the coming decades and centuries, our continued existence as a species may, in part, hinge on the availabil-



ABOVE: Salvia infused *Ferraria crispa* tubers on a bed of wild cress. Photograph by Roushanna Gray. • RIGHT: *Ferraria crispa* growing in limestone fynbos. Photograph by Jan de Vynck.



ity of wild foods, and we are far more likely to avoid a second population bottleneck in humanity's future if we recognize and draw inspiration from the ancient relationship between people and the plants in our environment.

Pelargonium triste edible tubers. Photograph by Richard M. Cowling.



As edibles, geophytes in particular remind us of the importance of broadening the genetic and the ecological base of our food supply, and we can perhaps learn something from their amazing resilience in the face of aridity and drought. Furthermore, if geophytes helped us get through the hard times long ago, it seems only right for us to help them survive the coming climate disruptions through wise management and conservation. That principle of reciprocity—applied generally toward all species—

may end up being the key to our survival.

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THE CALIFORNIA ARCHAEOLOGICAL RECORD AND BRODIAEA COMPLEX CONSERVATION

by Eric Wohlgemuth

Paleoethnobotanists identify ancient macroscopic remains of plants from archaeological sites in California and around the world, recovered using fine-mesh water separation (flotation) of archaeological sediment. Charred plant remains of wood, nutshells, berry

pits, small seeds, and geophyte underground storage organs (bulbs, corms, and tubers) are most commonly found as residues of fuel and plant foods. These finds become charred in cooking or heating fires, and preserve because they are inedible to herbivores and microbes.

Plant remains help archaeologists reconstruct past diets, uses of plants and landscapes, practices that enhance particular plants, and impacts of human interactions with their environments.

The vast majority of the more than 250,000 paleoethnobotanical finds from California, mostly identified to the family or genus level, are dietary residues. Remains of at least four geophyte genera have been identified in more

than 75 archaeological sites. The most common are corms of the *Brodiaea* complex, which includes the closely related genera *Brodiaea*, *Dichelostemma*, and *Triteleia*.

Charred *Brodiaea* complex corms have been found in archaeological sites in grassland and savanna habitats over much of lowland California. Ancient finds of corms indicate they have been eaten for millennia: on the northern Channel Islands they date to about 10,000 years ago (Reddy and Erlandson 2012), while the oldest directly radiocarbon-dated corms, from near Fremont in the San Francisco Bay Area, are $9,365 \pm 30$ years old.

While archaeological finds of *Brodiaea* complex corms have been found throughout much of lowland California, they are most abundant by far in sites of the Channel Islands and the Sacramento Valley bottom (see Gill this issue; Gill 2015; Wohlgemuth et al. 2015). Intensive use of corms in these areas may be due in part to the lack of alternative dietary sources of carbohydrates, such as the diverse staple nut crops found in mainland foothill and coastal regions. Valley oak acorns, the only oak species along the lower Sacramento River, were not a preferred food and did not store well (McCarthy 1993). Geophyte corms may have become a mainstay food rivaling the staple food that acorns furnished in other parts of California. Very abundant archaeological corms also show that plants of the *Brodiaea* complex were an important component of local vegetation along, or within a short gathering distance of, the Sacramento River in the valley bottom, not gathered from distant stands and brought to the archaeological sites.

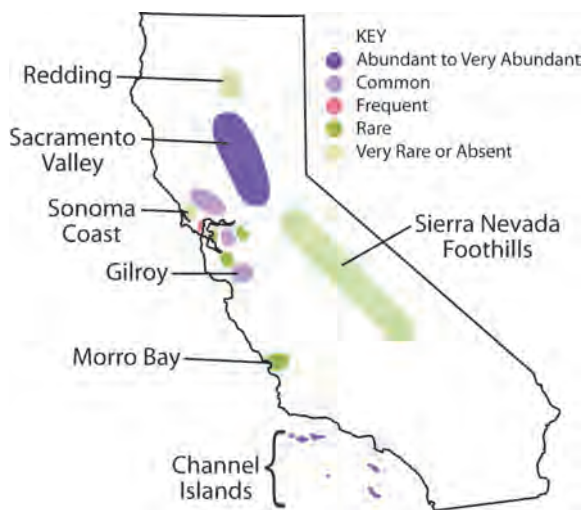
Archaeologist Bill Stillman processing a sediment sample using flotation. Sediment is immersed, and buoyant charred plant remains are recovered in 0.4-millimeter mesh. Photograph by Angela Arpaia, 2014.



5 mm



Ancient (>9,000 years old) charred *Brodiaea* complex corm, and modern *Triteleia laxa* corm. Photograph by Tammara Norton, 2016.



Map of *Brodiaea* complex corm abundance in California archaeological sites.

The paleoethnobotanical record can also assist archaeologists in detecting subtle shifts in harvest practices of plant foods, and resilience of plants to long-term gathering pressures. For example, hundreds of whole *Brodiaea* complex corms from two archaeological sites north of Sacramento were measured to track corm size from 2,500 to 260 years ago. During seasonally limited occupations of the sites, harvesters selected the largest corms without small cormlets, suggesting cormlets were replanted. However, when these sites were used as year-round village communities (from about 2,500 to 1,800 years ago, and again

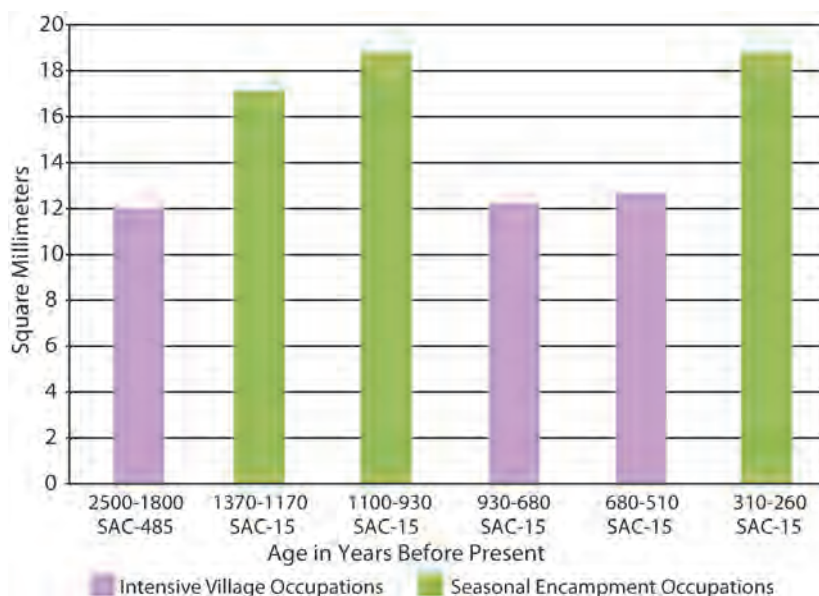
from around 930 to 500 years ago), charred corms are substantially smaller than when the sites were used as shorter-term seasonal encampments, and gathering pressure increased to the extent that some cormlets were collected along with mature corms. More intensive collecting and processing no doubt had an impact on local *Brodiaea* complex plant populations. Over these long time periods, however, it is clear that *Brodiaea* complex plant populations were not

completely extirpated, as corms continued to be gathered in quantity

ing with the interplay between plant harvest, restraint, and population maintenance as human interactions with landscapes are reestablished.

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Changes in corm size by settlement use at archaeological sites near Sacramento.



Modern *Brodiaea* complex cormlets, with example of a charred archaeological cormlet (inset) from a 600-year old village mound in the Sacramento Valley. Photograph by Tammara Norton, 2016.

after the sites were abandoned as village communities and used as seasonal camps after 500 years ago (Wohlgemuth et al. 2015).

Because populations of geophytes within the *Brodiaea* complex seem to withstand intensive harvest pressures over lengthy periods, common species could become candidates for plantings in ongoing restoration projects designed to restore ethnobotanical uses, and begin experiment-

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BEAUTY, BOUNTY, AND BIODIVERSITY: THE STORY OF CALIFORNIA INDIANS' RELATIONSHIP WITH EDIBLE NATIVE GEOPHYTES

by M. Kat Anderson and Frank K. Lake

California supported a great diversity of plants with edible underground storage organs available to Indian tribes. Together, plant foods, fish and meat made up an indigenous diet that was well-rounded, diverse, and relatively secure. The edible underground parts possessed by these plants are classified as bulbs, corms, taproots, tubers and rhizomes, and when conditions turn unfavorable (too cold or too dry), the above-ground stems die back and the underground organs remain alive. Botanists and ecologists call the plants that employ this strategy *geophytes*. Indians often call them Indian potatoes or “root foods” because they are hidden under the ground. Geophytes were an important source of food for indigenous people throughout California.

STAPLE FOOD CROP

In pre-contact California there were dozens of species of geophytes gathered for their edible underground storage organs in multiple plant communities from the salt marshes, to the deserts, to chaparral, to the open understories of coniferous forests and oak woodlands. For example: the Ohlone dug the bulbs of harebell (*Campanula prenanthoides*) in winter and early spring for food in the vicinity of tan oaks; the Wailaki and Pomo harvested the bulbs of the fawn lily (*Erythronium oregonum*) in the openings amongst interior live oaks; and the Kashaya Pomo unearthed the tubers of elegant piperia (*Piperia elegans*) in dry areas between California black oaks. Some of the most important genera gathered by many



TOP: Raw camas (*Camassia* sp.) bulbs and brodiaea (*Brodiaea* and *Triteleia* spp.) corms on a bed of Pacific big leaf maple leaves prior to baking them in an earth oven. Photograph by Frank K. Lake, 2005. • BOTTOM LEFT: A bounty of camas (*Camassia quamash* subsp. *breviflora*) for food. Photograph by Heron Brae, 2012. The camas bulb, found several inches below the earth's surface, is about the size of a large hazelnut, but can grow as large as a walnut. Camas (*C. leichtlinii* subsp. *suksdorfii* and *C. quamash* subsp. *breviflora*) produces few offsets, but Native people note that when dug repeatedly and encouraged, they tend to divide. • BOTTOM RIGHT: Cooked camas (*Camassia* sp.) bulbs and brodiaea (*Brodiaea* and *Triteleia* spp.) corms wrapped in a bed of Pacific big leaf maple leaves after baking them in an earth oven. Photograph by Frank K. Lake, 2005.

tribes include *Allium*, *Brodiaea*, *Camassia*, *Chlorogalum*, *Calochortus*, *Dichelostemma*, *Lilium*, *Lomatium*, *Perideridia*, *Sanicula*, and *Triteleia*.

Indian potatoes were not only diverse, but also provided a variety of tastes to please the palate from slightly bitter, to mildly nutty, to sweet. They were eaten raw, boiled, baked, or steamed and then mashed, made into cakes similar to a frittata, bread or biscuits. Many of these geophytes were stored in their raw state in great quantities for later cooking and consumption or stored after baking, roasting and/or drying them.

The use of geophytes as part of the regular human diet in California



ABOVE RIGHT: Alferetta and Grapevine Tom, Achomawi, digging the edible, medicinal, and ceremonial tubers of *būlidum'*, (*Lomatium californicum*). A hardwood digging stick was the most common digging implement used up and down California to pry millions of plump, juicy bulbs, corms and tubers from the earth. Photograph by J.P. Harrington, Catalog number JPH-CA-AC-18. Courtesy of the Santa Barbara Museum of Natural History, circa 1931-32. • ABOVE LEFT: A close-up of the tubers of *būlidum'* (*L. californicum*), one of eight *lomatiums* with edible tubers eaten by California Indian tribes. Others include Wasatch desertparsley (*L. bicolor* var. *leptocarpum*), Canby's *lomatium* (*L. canbyi*), Gray's *lomatium* (*L. grayi*), bigseed biscuitroot (*L. macrocarpum*), Nevada biscuitroot (*L. nevadense*), Indian biscuitroot (*L. piperi*), and nineleaf biscuitroot (*L. triternatum*). Photograph by J.P. Harrington, Catalog number JPH-CA-AC-19. Courtesy of the Santa Barbara Museum of Natural History, circa 1931-32. • RIGHT: Edible, dried, peeled taproots of bigseed biscuitroot (*L. macrocarpum*), some of which have been ground into flour. They will be combined with dried huckleberries and pine nut flour to make pinch cakes. Photograph by Heron Brae, 2013.





TOP: Columbia lily (*Lilium columbianum*) and other lilies have bulb scales which readily separate and scatter in the digging process. The bulbs of this species and at least three other lilies were eaten by California Indian tribes including leopard lily (*L. pardalinum*), alpine lily (*L. parvum*), and Washington lily (*L. washingtonianum*). • BOTTOM: The larger bulbs of checker lily (*Fritillaria affinis*) were roasted in ashes or baked in earth ovens, and mashed and made into cakes by various tribes. It has numerous rice-grain bulblets that scatter when dug. At least three other fritillarias were gathered for food: brown bells (*F. micrantha*), yellow fritillary (*F. pudica*), and scarlet fritillary (*F. recurva*). Photographs by Fred Sharpe, 2007.

is very old. The archeological record shows that geophyte harvesting is at least 10,000 years old on the Channel Islands and that bulbs, corms, and tubers were more or less harvested in most if not all regions of the state during the last several thousand years. This storage organ had its own month in many tribal calen-

dars, denoting a predictable, renewable food source. For example, one of the 12 moons of the Central Pomo year *Putitcda* (our May) meant “edible bulbs ripening.” These storage organs also have high nutritional value, containing significant amounts of fiber, and complex carbohydrates.

Before the substantial ecological changes brought by European settlement, many of the geophytes of California had all of the attributes of a staple food crop: they were abundant, widespread, storable, intensifiable, and nourishing. As little as 200 years ago, many areas in California were clothed in geophyte flowers during the spring and summer—purple patches of blue dicks, orange swaths of tiger lily, yellow carpets of common goldenstars, and

snowy areas of wild carrots. Early reports suggest that wildflowers with storage organs were much more prevalent historically and gathered in prodigious amounts. As will be discussed, the abundance of edible geophyte populations observed in certain areas around the time of contact (circa AD 1840–1850s) may

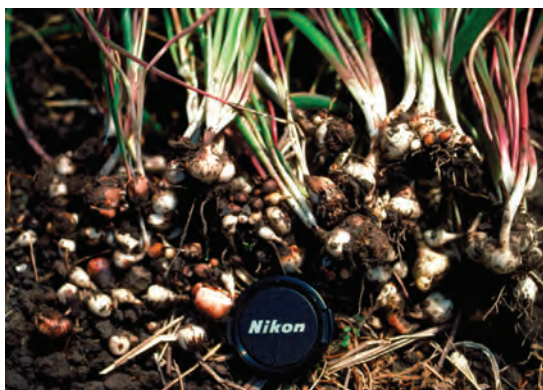
have been due, in part, to human management of the plants and their habitats.

THE HARVEST

Gathering the edible parts of geophytes, hidden below the surface of the soil, required extraction with a digging stick sharpened to a point. While digging time spanned the whole year, May to late October was the peak season. Harvesting different genera of geophytes differed by tribe and area. For example, among the Karuk, of northwestern California, *Brodiaea*, *Calochortus*, *Dichelostemma*, and *Triteleia* were dug in the spring to summer and *Lilium* species in the fall. Traditional gathering sites were visited annually, and areas were specifically owned and maintained by particular families and passed down intergenerationally.

Despite relatively intensive, annual gathering, populations of geophytes remained robust. This was due in part to the gatherers’ awareness of harvesting methods and how they affected the plant’s regeneration and the overall health of the habitat. Always thinking about the harvest into the future, tribes made sure that the harvest would help increase future yields.

When indigenous people harvested geophytes, they did more than just retrieve the largest storage organs for consumption. They replanted the smaller bulblets, cormlets, tuber fragments, and bulb scales; they tilled the soil to facilitate the growth of the new plants; weeded non-desired plants; and they scattered the seeds contained within the dried seed pods to enhance reproduction. A grassland or coastal prairie subject to this kind of management might not show overt signs of human manipulation, but the valued foods would likely have broader distributions and higher population numbers than would be the case in the absence of any tribal manage-



UPPER LEFT: Blue dicks has dozens of different names in Indian languages and was probably the most widely eaten geophyte in California. The corms are eaten raw, boiled, or roasted in ashes. Photograph by M. Kat Anderson, 1988. • LOWER LEFT: A single blue dicks plant can produce a large number of both corms and cormlets. This and other underground swollen stems were eaten in great quantity and gathered at the same sites year after year by employing harvesting and management strategies designed to benefit populations and ensure their continuation. One of these techniques was to replant the cormlets after digging, while another is described by Mono elder Melba Beecher to ensure re-seeding: “The bulb [*Dichelostemma capitatum*] is harvested in late summer or early fall when the blooms are gone.” Photograph by Kat Anderson, 1992. • RIGHT: Ross Stone, Big Pine Paiute, gathering *nahavita*, also known as blue dicks (*D. capitatum*) corms, a favorite traditional Paiute food on the east side of the Sierra Nevada. Photograph by Bill Helmer, 2005. All of the four other *Dichelostemma* spp. were also dug and eaten by California Indian tribes including fork-toothed ookow (*D. congestum*), firecracker flower (*D. ida-maia*), wild hyacinth (*D. multiflorum*), and twining brodiaea (*D. volubile*).

ment. Many tribal harvesters learned from, or emulated the digging-related disturbances of wildlife, such as gophers or bears.

The harvest of geophytes could be coupled closely with propagation because of the nature of their repro-

ductive adaptations. Evolving in environments in which drought, fire, and herbivory were common, geophytes all developed clonal structures—offsets or propagules in the form of scales, bulbils, bulblets, or cormlets—which if severed or oth-

erwise separated from the parent structure could grow into genetically identical plants. With these adaptations, disturbances, especially herbivory, that might threaten the existence of the parent plant were also likely to separate and disperse

the propagules—thus ensuring the continuation of the genome. In feasting upon these highly nutritious foods, gophers, voles, moles, bears, deer, or elk would simultaneously be acting as predators and dispersers. Native people who exploited geophytes as food were taking advantage of the pre-existing adaptations that made most geophytes ex-

cellent subjects for food intensification strategies.

Aerated and loosened with digging sticks, the soil had a higher moisture-holding capacity and became a better environment for seed germination and propagule growth. Native people also managed plant density, preferentially harvesting the densest patches to keep the plants

from getting too clumped and thus maximizing production. Perhaps, most importantly, indigenous people made conscious decisions about what to harvest and what to leave behind, based on accumulated knowledge about the plants' reproduction and adaptive traits. In the case of blue dicks, for example, Leah Harper, Nor-Rel-Muk (pers. comm. 2003) explained how she harvested the largest organs and left in the soil the immature ones: "Grandma told us how to take the big bulb and leave the babies. And put them back in."

Human geophyte harvesters could also benefit the plants' sexual reproduction by properly timing the harvest. When dug after seeds had matured, this process could facilitate dispersal of the seeds, which were more likely to find safe germination sites in tilled soil. It was a common practice to take this facilitation a step further by placing broken stems with seed pods into the holes before covering them. Undesirable plants were also weeded out to favor geophytes at many gathering sites—thus reducing competition and increasing site productivity.

Through observation and experimentation, Native Americans in California learned a great deal about the ecological requirements of the edible geophytes. The most important conclusion they came to was that fire was good for many of the "root foods," which included checker lilies, leopard lilies, sanicles, and wild carrots, among others. By burning geophyte habitats, Indians could maintain the sunny environments that most required, eliminate competition, reduce accumulated leaf litter and duff, that could block or hinder their emergence each year, and thus enhance reproduction. The results were manifested at both the individual and population levels: individual plants grew more vigorously, producing larger or more numerous underground storage organs, and populations were enlarged rela-



Ruby Pomona, North Fork Mono, with the edible *tana* or turkey pea (*Sanicula tuberosa*) dug in open black oak and ponderosa pine stands in Sierra National Forest. According to Ruby (pers. comm. 1989), *tana*, as well as a brodiaea with a purple flower, and wild carrot (*Perideridia* spp.), "came up better after a burn." The small tuber was gathered widely by the Mono, Nisenan, Pomo, Salinan, Sierra Miwuk, and Wailaki and it is still relished today and generally eaten raw. Already by 1932, Salinan consultants, Maria and David Mora, relayed to interviewer John P. Harrington that *tr'ôtēmák* (*Sanicula tuberosa*) is "scarce now." Photograph by M. Kat Anderson, 2006. At least two other sanicles were dug for their edible tubers, sharptooth blacksnakeroot (*S. arguta*) and poison sanicle (*S. bipinnata*).



tive to what would have been the case without fire.

In the historical and ethnographic record there are accounts of Indians burning to enhance the geophyte harvest. For example, anthropolo-

gist J.W. Duncan equated the Maidu burning of oak areas with motive of fostering more bulbs and greens. Linguist Alice Shepherd (1989:411) recorded for the Wintu: "Where the ground has been burned, wild pota-

ABOVE: Lois Conner Bohna (North Fork Mono/Chukchansi) sustainably harvesting wavyleaf soap plant (*Chlorogalum pomeridianum*) bulbs, another traditional food, by breaking them off at the root crowns and leaving them behind to grow into new plants. This was also a common practice among various Sierra Miwuk and Yokuts cultural groups. Photograph by M. Kat Anderson, North Fork, 2008. At least three other soap plants were harvested for food including narrowleaf soap plant (*C. angustifolium*), smallflower soap plant (*C. parviflorum*), and Santa Lucia purple amole (*C. purpureum* var. *purpureum*). • RIGHT: Lois Conner Bohna (North Fork Mono/Chukchansi) taking two additional conservation-minded steps. She scattered the seeds into the hole and covered them and the remaining root crowns with additional soil. This North Fork site had been burned the year before. She remarked: "Where it has been burned I find plants that are doubles, triples, and bigger clusters, and the bulbs are huge." Photograph by M. Kat Anderson, 2008.

atoes grow in bunches and ripen big...They go to find things there." Today Native elders equate productive bulb collection areas with deliberate burning or wildfires.

Because of their underground storage organs, geophytes are well adapted to withstand the effects of fire. Growing deep in soil, the bulbs, corms, and rhizomes are protected and insulated from the heat. Fire benefits geophytes in a number of ways, and are actually dependent on its regular occurrence.

One hypothesis is that for some geophyte species, fire confers its beneficial effects directly to the plants through heat. Their underground storage organs have contractile roots, and thus can pull themselves down deeper in the soil when stimulated by the heat of a fire. When this happens, the scales, bulblets, or cormlets attached to the main "mother" organ are stripped off. While attached, the growth of these clones is suppressed; when separated, they grow into new plants. In this direct way, therefore, fire promotes asexual reproduction and enlargement of population sizes. Geophytes receive





Tanya Spoonhunter, Dorothy Stewart, Jannah Terrazas, and Margaret Romero of the Big Pine Paiute tribe, displaying *nahavita* (*Dichelostemma capitatum*) corms that they will plant on their reservation in a large community garden plot and for a conservation field trial, October 2005. This effort is an example of diverse tribes bringing back traditional stewardship practices in various parts of California. Photograph by M. Kat Anderson.

most of the benefits of fire indirectly, however, through fire's effects on the environment or habitat in which they live. Thick layers of leaf litter and duff can inhibit or even prevent geophyte growth. The bulbs remain alive in the soil, but the accumulated dead biomass blocks the heat and light that would stimulate growth, and may even act as a physical barrier for sprouting. In overgrown areas, bulbs can sit in the soil bank for decades without growing. After the leaf litter and other biomass covering the soil are eliminated by fire, however, the plants are able to push through the blackened earth.

When fire reduces duff and litter, the sun can warm the soil thoroughly where the warming effect may in-

crease by the light-absorbing black color of the carbon that results from burning. Such warming is necessary for both vegetative growth and flower bud differentiation, and it also provides the sequence of cold-warm-cold temperatures that most edible geophytes in California need for good bulb development. Warmer soil temperatures in the spring promote more flower buds, and this means more dry fruits with seeds that can grow into new plants. Fire's cleansing properties, are therefore, a mechanism which promotes larger and denser geophyte patches.

Fire also impacts geophytes through its effects on the soil. Burning releases a flush of nutrients, but Indian burning may also have

changed the soil's texture or physical properties in ways that benefited geophyte growth and/or facilitated harvest by humans. The bi-product of burning woody material results in the production of charcoal or "biochar" that serves to increase soil porosity, nutrient retention and moisture holding capacity in addition to increasing soil texture complexity. Today, the traditional beneficial uses of biochar are being investigated and technologically developed for modern garden and agricultural uses.

Probably the most important effect of fire on geophytes is to maintain (or increase) the size of the areas in which the environmental conditions are suitable for geophyte

growth. To a great extent, this means simply eliminating or suppressing the growth of plants that compete with geophytes for light. Most edible geophytes require full or partial exposure to the sun to grow and reproduce properly. The flowering and bulbing of wild onions (*Allium* spp.) and wild lilies (*Lilium* spp.), for example, are greatly affected by how much light they receive. In the lily family, low light intensities usually result in flower abortion. The high light requirements of most geophytes are a primary reason for their occurrence in open habitats. When trees or brush encroach on open lands and create unfavorable shaded conditions, camas (*Camassia* spp.), leopard lily (*Lilium pardalinum*), wild onions, and other geophytes remain as a corm and bulb bank in the soil, their growth suppressed. With fire, plants are released from the shaded environments, and grow and flower vigorously. Flowering greatly benefited insects and other pollinators. Botanist Mark Skinner (pers. comm. 2007) said: "Burning definitely encourages (the growth of) many North American *Lilium* taxa. Some are adapted to frequent fires (*L. pyrophilum*, *L. iridollae*, *L. catesbaei*), some proliferate after fires (*L. washingtonianum*). I'm sure it's nutrient availability to some degree, but mostly it's light availability that drives that phenomenon."

CONCLUSIONS

Tribal gathering secured huge quantities of subterranean plant parts by revisiting the same traditional gathering sites. Tribal harvesting and management strategies were designed to benefit populations and ensure their continuation with ecological consequences for species, populations, and plant communities. The Native gathering and management systems have been in place long enough to influence what constituted fitness for evolving geophyte species. Over the last two centuries,

there has been a general decline in geophyte populations, and today there are numerous rare and endangered geophyte taxa in California; this decline may be tied not only to habitat loss and fragmentation, but also to the termination of the former indigenous disturbance and management regimes under which the geophytes most recently evolved.

While few indigenous people gather or manage root foods today, this is changing. Tribes are renewing their gathering rights and practices, forming new collaborations with land management entities, setting up ethnobotanical gardens, creating their own land trusts, restoring digging, and returning fire to their reservations, rancherias, and other traditional lands. Many tribes are incorporating food security interests with landscape restoration strategies. An example is thinning of dense trees and shrubs and prescribed burning to meet the dual objectives of hazardous fuels reduction and the re-establishment of edible geophytes aligned with broader tribal resource objectives. These efforts are helping to restore the beauty, bounty, and biodiversity of California landscapes.

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ABOVE: Early fall bloom of a yampah (*Perideridia gairdneri* and *P. kelloggii*) dominated prairie at OAEC. With what began as a relatively small patch of yampah over 20 years ago, we have actively expanded its size and density through targeted mowing, weed whipping, hand removal of velvet grass (*Holcus lanatus*), seed collection, and seed sowing. We also distribute seeds to other favorable seasonally saturated wet prairies at OAEC, which previously lacked representation with either yampah species. Photograph by Brock Dolman. • BELOW: Gairdner's yampah (*Perideridia gairdneri*) has delectable seeds and tuberous roots, which were and still are highly coveted by indigenous peoples, and the land stewards at OAEC. The root when eaten raw is nutty, earthy and sweetens up when cooked. The delicious seeds have a spicy flavor reminiscent of coriander. Some of the seeds will be saved for hand dispersal later in the season. Photograph by Brock Dolman.

MENDING THE WILD AT THE OCCIDENTAL ARTS AND ECOLOGY CENTER

by Brock Dolman

For over 20 years, members of the residential community Sowing Circle LLC in collaboration with staff biologists of the non-profit Occidental Arts and Ecology Center (OAEC) have been restoring geophyte habitat on our 70-acre Wildlands Preserve in western Sonoma County using guidelines derived from both indigenous traditional practices and hor-

ticultural techniques. Through ecological and observational studies, we have concluded that the geophytes on our land, including yampah (*Perideridia* spp.), bluedicks (*Dichelostemma* spp.), *Triteleia* spp., *Brodiaea* spp., and yellow mariposa lily (*Calochortus luteus*) need management at different scales. First, management has to be



finely tuned to the ecological requirements of the species at the habitat level—the right moisture, light regime, plant associations, and other factors. The geophyte populations that occur on our land are found in coastal prairie. Second, at the scale of the individual—these plants have a reproductive biology that doesn't readily propagate through cloning or seed dispersal without assistance in the form of disturbance: such as small or large mammal digging, eating, and dispersal of cormlets or bulblets, and human dispersal of propagules and seeds.

Taking these requirements into consideration, OAEC designed an active management program through a combination of: collecting native wildflower and grass seeds; reintroducing traditional practices of burning the coastal prairie; active removal of encroaching Douglas fir, coyote brush, Scotch and French brooms; targeted mowing/weed whipping of invasive annual and perennial grasses; sowing the seeds into the burned and unburned areas; and finally monitoring the results. We call this “mending the wild” and it requires active human engagement with the landscape repeatedly with an astute focus on managing for stages of succession optimally conducive to the structure, function and composition of a healthy diverse coastal prairie. From the beginning of our project, we chose to honor and curate our onsite genetic lineage, thus focusing our restoration efforts on working with and expanding our localized native plant populations and the plant communities that house them.

THE HISTORIC LANDSCAPE AND RECENT DEGENERATIVE DISTURBANCE

To understand why we chose these practices, we need to step back and explore the historical

Before and after images of a coastal prairie restoration effort at OAEC which initially required a very labor intensive process of removing encroaching coyote brush, Douglas fir and exotic Scotch broom. As can be seen in the after image, the woody slash was burned onsite with the ashes later scattered. Afterwards previously collected native bunch grass and forb seeds were sown into the burn pile areas and places with bare mineral soil created from the removal of the various woody plants. Many of these sites have been restored to prairie, although the capacity of an older stand of Scotch broom, with a significant soil seed bank, should not be underestimated relative to the level of need for ongoing and multi-year follow up! Photographs by Brock Dolman.



ecology of the coastal prairies, recent changes, and the current condition on our land and in the surrounding region. Research in the past 25 years has found that California's coastal prairies are rich in biodiversity (Stromberg et al. 2001). Native perennial grasses often are the dominant form of plant life, with forbs (wildflowers) making up a significant proportion of the species richness of coastal prairies (Hayes and Holl 2003). On our preserve, we currently have roughly seven acres of remnant coastal prairie, and there are native perennial bunchgrasses like blue wildrye (*Elymus glaucus*), California oatgrass

(*Danthonia californica*), and purple needlegrass (*Stipa pulchra*), interspersed with the geophytes already mentioned.

In zones with very low frequency of lightning strikes, such as along California's coast, whole ecosystems exist that are clearly fire-dependent, including coastal prairies. Further, ecologists are recognizing that a general decline in biodiversity in coastal areas is likely linked to the absence of indigenous management using digging sticks and propagule replanting combined with the setting of frequent, low intensity fires, because lightning along the coast would have been insufficient (Stuart



and Stephens 2006). Originally these prairies were subjected to grazing pressures exerted over many millennia by Pleistocene megafauna, which are well documented in the regional fossil record (Parkman

of the unplowed area at the base of each grapevine. A closer inspection of these mounds show that some of the largest crowns of native bunchgrass we have onsite are often found on the tops of these historically



A restored coastal prairie in bloom at OAEC of California oatgrass (*Danthonia californica*) co-mingling with sanicle (*Sanicula* sp.)—several species of which provide important edible tubers to indigenous people, shooting star (*Dodecatheon hendersonii*), and sun cup (*Taraxia ovata*) to name a few. Photograph by Brock Dolman.

2006) and in later times the prairies supported herds of mule deer, pronghorn antelope, and tule elk, also developing under some grazing pressure (Schiffman 2007).

In the last 150 years, Euro-Americans heavily influenced OAEC's coastal prairie. In the early 1870s the first Italian homesteaders commenced logging of old growth redwood, and the targeted plowing of all our prairies to plant vineyards, which persisted until their removal during the era of prohibition in the 1920s. Vines were dry farmed on 10' x 10' centers and managed as headpruned shrubs, which were subsequently maintained with annual plowing between vine rows to a narrow perimeter around the base of each vine. This resulted in an easily observed pattern on the land of hundreds of 1m circular – 10 to 20cm tall mounds, which are the vestiges

of unplowed mounds. Grassland ecologists have documented the capacity for *Stipa pulchra* to live for several hundred years (Hamilton et al. 2002). Based on the large size of some bunchgrass crowns on the mounds, we have inferred that they represent the assumed vegetation community at time of the type conversion to vineyards, and thus offer us “reference” state or quasi-baseline window into the past that inspires our management goals and informs our “mending the wild” activities.

Nearly a century later in the 1960s/70s the land ownership went through several new changes, which came with a different degree of disturbance marked in this case by a significant decrease in active management of the land towards a passive untended approach, although regional fire suppression policies were enforced. We have roughly

another five acres of 30+-year-old dense Douglas fir stands, or coyote brush/broom patches along the edges of our existing prairies. Interestingly, when you look at the ground surface below these stands you will also find the telltale pattern of the plowed vineyard mounds. Thus, these areas have recently been encroached by coastal coniferous forest and coastal scrub, a successional pattern that provides evidence for an even greater loss in our overall extent of coastal prairie. Tree and shrub encroachment also appear to be accelerated by the removal of keystone processes, such as lack of frequent, low intensity fire, native herbivore grazing regimes and/or the cessation of wild-tending practices by traditional peoples.

We therefore have come to see some of these historic and modern Euro-American settlement activities as “degenerative disturbances,” leaving a legacy of ecological illiteracy expressed in the landscape. As a way forward, our management practices try to mimic the natural disturbances with which coastal prairies have evolved, striving to become agents of regenerative disturbance rather than degenerative disturbance.

REGENERATIVE DISTURBANCE: RESTORING GEOPHYTES AND COASTAL PRAIRIE

Based on the aforementioned impacts of European settlement, our work over the past 22 years has primarily focused on land management practices that favor and strengthen existing native biological assemblages. Recovery from such rapid and extensive changes requires patience and ample adaptive management to re-adjust the species composition, structure and function of ever evolving ecological states.

Our approach recognizes the critical importance of human communities reviving and re-“story”ing our relationship to, and acknowledging our dependency on thriving biologi-



TOP: Using prescribed fire on a cool windless early morning at the Occidental Arts and Ecology Center to restore geophyte habitat in coastal prairie, November 11, 2005. The timing of this fire was in the fall after initial rains had moistened the landscape for general safety concerns. Goals of the burn were to reduce the exotic grass seedlings, and remove extensive dense thatch so as to open up soil space between native bunch grass crowns for onsite collected native geophyte and grass seeds to be thrown and sown, or “shucked and hucked.” Photograph by Brock Dolman. • ABOVE LEFT: Yellow mariposa lily (*Calochortus luteus*) flower with red yarn tied on it, which significantly enhances the process of locating the dry pod for seed collection several months later when it blends into the dense standing stalks of various grasses. Photograph by Brock Dolman. • ABOVE RIGHT: Yellow mariposa lily (*C. luteus*) pods and seeds were hand collected, or “shucked” in September. The seeds were stored in paper bags in a cool dark location and subsequently sown several months later with the first rains, after the prescribed burn. Photograph by Jim Coleman.



After burning, native geophyte seeds, such as yellow mariposa lily (*Calochortus luteus*) and perennial native bunch grass seeds were sown into the exposed bare mineral soil, aiming for enhanced seed germination, with the influx of nutrients and reduced competition. Photograph by Jim Coleman.

cally and culturally diverse watershed communities. The results of our work over two decades are markedly heightened patches of diverse native perennial bunchgrasses and wildflowers in our coastal prairie.

As a case study, yellow mariposa lily is one species that receives special attention. It is simply a spectacular flower and has ethnobotanical value in the edible landscape of the indigenous peoples being an important food of tribes as diverse as the Coast Miwok, Pomo, Southern Paiute, and Southern Sierra Mi-Wuk. In 1994, there were only seven individual plants found in one remnant patch on an east-facing slope. Making early note of this, we began a concerted effort to locate the pods each season for seed harvest to be sown later that year. Finding the beautiful yellow flowers in full bloom is not a challenge in late

spring, but by late summer, close searching for seedpods amidst a sea of dried brown annual exotic grasses requires one to develop a skilled search image. After several seasons we learned to optimize our chances of re-locating the dried seedpods by tying short lengths of bright red yarn on the blooming flower stalk.

The process of visiting each individual flower in the spring and tying the red yarn on was quite fulfilling knowing that in a few months, we would more easily relocate the mature pod for seed harvest. In late summer/early fall, we collected the seedpods and shucked them by hand to access the small disc-like seeds. Next, we stored the seeds in paper bags in a cool dry indoor location. Prior to the first fall rains we then went out in the field and hucked the *Calochortus luteus* seeds. We call this our “shuck-n-huck” method. Over the years, in order to assure seed contact with bare soil, we either, scattered the seeds in recently burned areas of coastal prairie, or opportunistically flattened the soil mounds of the gophers with our boots, then sprinkled some seeds on the new mineral seedbed—roughing up the surface lightly with our hands to cover the seeds. To optimize our “assisted migration” efforts, we diversified the distribution of seeds on the property by targeted shucking and hucking in all other suitable prairie patches on the property. We are elated to say that after 22 years, in the spring of 2016 we stopped counting flowers/plants at 1,000 individuals in the original source prairie site alone!

The over-arching goals of the OAEC Wildlands Program are to demonstrate, educate, and train communities about the various practices and experiments we use to re-establish a more regenerative relationship with our wildlands and watersheds. Special emphasis is placed upon Traditional Ecological Knowledge (TEK) collaborative trainings with Coast Miwok/Southern Pomo

tribal citizens of the Federated Indians of Graton Rancheria. In 2016, OAEC completed a comprehensive Stewardship Plan that details the land history and management goals of our Wildlands Preserve. This 200-page plan and much more information can be found at oaec.org/wildlands.

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CALIFORNIA BULBS' LOVE AFFAIR WITH NATIVE POLLINATORS

by Nancy Gilbert

Many insect pollinators, especially domesticated honeybees, wild native bees and numerous butterfly species, are declining world-wide, including within California. Public and private gardens designed specifically to attract and sustain our insect pollinators are popping up all across the country. Many excellent books and articles continue to be published to assist those of us drawn to pollinator gardening, and organizations, such as the Xerces Society, the UC Berkeley Urban Bee Lab and the California Native Plant Society, are actively promoting and supporting this trend. Lists of plants that attract pollinators are being published in books, magazines and online. As I have read through these lists I have noticed that our native California bulbs are often not as well represented as the pollinator all-stars, such as plants in the Buckwheat and Aster families. This is unfortunate, as the flowers of California's native bulbs are incredible magnets for a wide array of pollinators and the two have evolved together over many tens of thousands of years.

As I delve deeper into the complex relationships between pollinators and flowering plants, I have become captivated by this dynamic micro-world. My husband, Ames, and I became charmed long ago by our

native bulbs and this led to our eventually establishing a small native bulb business, Far West Bulb Farm, which we fondly describe as a hobby gone berserk. These two interests, along with Ames' and my shared interest in wildlife and native plant photography, have all converged to our present focus on studying and photographing the love affair between native bulb flowers and their pollinators. In this article I wish to share a bit of what I have learned over the years about our native bulbs and their pollinator partnerships.

As early in the spring as late February and continuing through March and early April, the fritillarias emerge

and open their bell-like flowers. Their blooming period is synchronized with the early spring emergence of the mining bees, whose small size and adaptation to cool weather suit them perfectly for pollinating these early bloomers. Like most native bees, they are soil nesters and when the queens emerge, they immediately begin foraging for nectar, their primary source of energy. Mining bees' adult lives are short and busy and they mate almost immediately. The females then excavate their nests and collect pollen, which they transport on the stiff hairs (called scopae) of their hind legs. This pollen is the food that will feed their larvae in the

underground nests. As you observe *Fritillaria* flowers, watch for these small bees, with their heavy loads of pollen, flying from flower to flower and then disappearing inside a nodding blossom.

The *Erythronium* spp. (fawn lilies) begin blooming just as the fritillarias are finishing up, usually in late March and ending by May, with higher elevation species flowering concurrent with snow-melt. Now other native bee species are emerging from nests in the ground or within chambers located in the hollow stems and cavities of plants or tree stumps. As with the mining bees, they have evolved to pollinate the flowers that are flowering at the time the adults are flying. Native bees such as sweat bees, digger bees, leafcutter bees, mason

Butte County fritillary (*Fritillaria eastwoodiae*) with mining bee (*Andrena* sp.). All photographs by Nancy Gilbert, taken near Grass Valley.





LEFT, TOP TO BOTTOM: California fawn lily (*Erythronium californicum*) and long-horned bee (*Eucera* sp.). • Papery onion (*Allium membranaceum*) and bee fly (*Merodon equestris*) and Nelson's juniper hairstreak butterfly (*Callophrys gryneus nelsoni*). • Fork-toothed ookow (*Dichelostemma congestum*) and snowberry clearwing moth (*Hemaris diffinis*). • ABOVE: Humboldt's lily (*Lilium humboldtii*) and tiger swallowtail (*Pterourus rutulus rutulus*).

bees, polyester bees, long-horned bees, carpenter bees and bumblebees are beginning to appear during this time. Honeybees are also now actively foraging. These many types of bees can be found flying throughout California from mid-spring well into summer, and the carpenter bees and bumblebees can be seen foraging into the cool autumn months. Each bee genus has a variety of adaptations for taking in nectar and for collecting and transporting pollen to their nests. Observing, classifying and understanding the many bee species, as well as the butterflies, moths, flower flies and beetles can easily become a life-long pursuit.

A frequently overlooked family of spring-flowering native bulbs is the alliums, or onions. It is in a very large family with species in nearly every habitat. I have never seen a patch of alliums that is not mobbed with honeybees and native bees, small butterflies such as hairstreaks and coppers, as well as a variety of bee flies and flower flies. For your garden, select *Allium* and other bulb species that are adapted to your local area and plant the bulbs in fairly large groups for maximum pollinator visits, as it is much more efficient for pollinators if there are large patches of each plant species rather than a one-here, one-there approach.

As spring progresses, the camasias, dichelostemmas, and triteleias begin blooming and many continue flowering well into May or early June, depending on the species and location. They flower just in time for the arrival of the later emerging native bee species, as well as myriad beetles, butterflies, wasps, moths, and bee and flower flies, not to mention an occasional hummingbird. Swallowtail butterflies are particularly fond of both fork-toothed (*Dichelostemma congestum*) and round-toothed ookow (*D. multiflorum*), as are bumblebees, sweat bees, digger bees, and snowberry clearwing moths.

As spring merges into the warm months of summer, the true lilies open their gorgeous and sometimes fragrant blooms to be pollinated by bees, butterflies, hummingbirds, and moths. Species such as Humboldt lily (*Lilium humboldtii*) and leopard lily (*L. pardalinum*), are enticements for hummingbirds, many types of bees and pale and tiger swallowtail butterflies, which offer the photographer some great opportunities. The fragrant lilies, such as Washington lily (*L. washingtonianum*) and redwood lily (*L. rubescens*), attract not only numerous day-time pollinators, but also the moths that fly from dusk to dawn; they locate the flowers mostly by their sweet fragrance.



Redwood lily (*Lilium rubescens*) and leaf-cutter bee (*Megachile* sp.).

Soap plant (*Chlorogalum* spp.) is another summer-blooming native bulb species that is primarily pollinated during the early evening by a variety of bees and an occasional hungry butterfly, while moths frequent the white flowers after dark. Each blossom of a soap plant literally pops open as dusk approaches and has closed by sunrise. The many species of *Brodiaea* are also now blooming and they provide a rich source of nectar and pollen for our pollinators through the month of June.

The dates for bloom times and pollinators that I have given are largely based on my observations here in the Northern Sierra foothills, and timing for the flowering of

our native bulbs and their pollinating partners varies throughout our diverse and large state. In the higher elevations of the Coast Range and the Sierra Nevada, the blooming dates and emergence of native bees, butterflies and other pollinators is considerably later. In the warmer and drier habitats of Southern California, as well as the more moderate coastal zones, these dates will likely need to be adjusted to an earlier time frame.

As citizen scientists, we can all join in the fun and challenge of learning more about the amazing and complex relationships between our native geophytes and their numerous and diverse pollinators. We can also work to preserve their wild habitats, reduce destructive pesticide and herbicide use throughout our state, and restore native plant and pollinator habitats one garden at a time in our communities and home landscapes. I hope this article will help inspire you to take a closer look at who is visiting the blooms of our native bulbs, to preserve wild bulb populations and to incorporate some of our beautiful geophytes into your landscape.

Visit cnps.org/fremontia/geophytes for more resources on native pollinators and native geophytes.

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LEFT: Crinkled onion (*Allium crispum*) and black-rumped bumblebee (*Bombus melanopygus*). • RIGHT: Bridge's triteleia (*Triteleia bridgesii*) and a visiting male California bumblebee (*Bombus californicus*).



LEMON LILY FESTIVAL OF IDYLLWILD: HOW A LOCAL LILY BECAME A CAUSE TO CELEBRATE

by Kathryn A. Kramer

The lemon lily (*Lilium parryi*) of the Southern California Mountains may be the only native geophyte with its own festival. This is the tale of how an entire town came together to celebrate and conserve this species.

THE LILY

Lilium parryi is one of 11 species of the genus *Lilium* native to California. It occurs in scattered populations in the transverse and penin-

The lemon lily (*Lilium parryi*) found in the southern California mountains and the Sky Islands of southern Arizona. One population has been reported from Mexico. Photograph by Jordan Zylstra and courtesy of the U.S. Forest Service.



sular ranges of southern California and in the Sky Island Region of southeastern Arizona and Sonora, Mexico. Although neither Federally or State-Listed, *L. parryi* is rare enough to warrant 1B.2 status by CNPS and is a Forest Service Sensitive Species. This perennial herb grows from a bulb-like scaly rhizome along mountain streams and meadows above 4,000 feet; it is restricted to riparian habitats. A single plant may grow to four to six feet with multiple, large, fragrant yellow flowers. Local botanists found one plant with 40 buds and flowers in a single year! This stunning plant is an excellent excuse for a hike to cooler mountain meadows in early July.

Unfortunately, most lemon lilies are now *only* found in high elevations above 7,000 feet; there are few to enjoy in easily accessible areas. There are many reasons that lemon lilies have disappeared from the most visible public creeks and streams: the striking flowers are tempting to pick and tuck on the outside of a daypack, lemon lilies are eaten by local herbivores: deer crop off flower buds and gophers consume the rhizomes, and lower snowpack in recent years has resulted in less prime habitat. However, the

most horrifying reason may have to do with bulb fanciers at the turn of the last century. In 1902, Harvey Monroe Hall noted the activity of bulb collectors in the San Jacintos: "... one party took out over 5000 [lemon lily] bulbs in a single season" (p. 68, Hall, 1902). While lemon lily habitat quality has declined, this may be the case of a plant becoming rare due to being over-loved.

CONCERN IN THE COMMUNITY

Our story takes place in Idyllwild, a small community in the San Jacinto Mountains above Palm Springs. Local botanists Dave Stith and Tom Chester have studied the local flora as an avocation for several years. Dave, in particular, is a longtime admirer of lemon lilies. After finding the quote in Hall's monograph on the flora of the San Jacinto Mountains several of us wondered if something couldn't be done: public awareness was key. Holding a festival devoted to the lemon lily was one way of getting the word out to a large number of people. Idyllwild has a history of festivals; one celebrating such a beautiful plant would help ensure that both locals and visitors are aware and care about the fate of this stunning plant.

The mountain environment of Idyllwild is a getaway place for people of San Diego, Los Angeles and the desert cities to escape the summer heat. It is a tourist town with repeat visitors, some whose families have been coming to Idyllwild for generations. It also attracts artists, musicians, and hikers and is a stop for Pacific Crest Trail through-hikers. In short, Idyllwild



ABOVE: Spectacular *Lilium parryi* in its native habitat. The flowers are large, 4–6" in diameter.
 • RIGHT: Lemon lily close-up. Photographs by Jordan Zylstra and courtesy of the U.S. Forest Service.

attracts enough interested people for a festival celebrating a beautiful plant to be successful.

STARTING THE FIRST FESTIVAL—JULY 2010

Dave Stith started working on the Lemon Lily Festival in 2009 by garnering support from the local merchants, Riverside County's Idyllwild Nature Center and various interested groups and individuals. His efforts and commitment to include the town have paid off in spades. He has said that whenever he mentioned Hall's report of 5,000 lily bulbs being dug up in a single year to the various groups, there would be "an audible

gasp in the room." It was easy to convince people that this was a good cause. Several committees were formed and met for months before the first festival in 2010 at the Nature Center. The Nature Center director at the time, Shelly Kibbey, was extremely supportive of the festival. The festival committee became part of the non-profit Friends of the Idyllwild Nature Center, an organization that facilitated much of the preparation. Another talented leader from the business community, Doug Yagaloff, stepped up, and the merchants were very active in the first year's festival. Doug also contacted the local county supervisor and a group of lemon lily sup-



porters convinced the county supervisors to proclaim July as Lemon Lily Month in Riverside County.

"Education, celebration, and restoration of the lemon lily" was Dave's festival mantra. This was a very relevant theme as few people at that time had actually seen a lemon



lily. With photographs of lemon lilies and a few purchased bulbs, community creativity was set loose! Over the years of the festival, various lemon lily-themed activities have occurred: gift baskets of donated items were offered in a raffle in which money had to be spent in local stores to obtain the raffle tickets in the first year. Many merchants offered lemon lily-themed products during the Festival weekend. The local quilting guild designed and donated an original lemon lily quilt to be raffled off with the proceeds benefiting the Lemon Lily Festival restoration

work; later, original artwork including a stained-glass piece and a ceramic lemon lily platter were raffled off. A lemon lily banner competition was held and the banners

were also auctioned off. Prior to the festival, the banners were displayed in town to encourage people to come to the event. Festival organizers have offered t-shirts and pins for visitors.

The theme for the festival was celebrating the time in Idyllwild when lemon lilies would have been abundant, before the turn of the last century. Music and activities were organized with this in mind. A lemon lily song was written and performed by a group of local singers and people dressed in turn-of-the-last-century inspired clothing. Education talks were offered several times each day

ABOVE: Each year an original piece of art is made especially for the festival. In the early years, the local quilt guild donated a handmade quilt for this purpose. Photograph by Avianna Jones; courtesy of the Idyllwild Town Crier. • FACING PAGE: *Lilium parryi* in the San Jacinto Wilderness in typical habitat. Photograph by Jordan Zylstra; courtesy of the U.S. Forest Service.



TOP: Information table at the first Lemon Lily Festival in Idyllwild. Photograph courtesy of the Idyllwild Town Crier. • BOTTOM: For several years, the Lemon Lily Festival held a banner competition for the local artists. The banners were displayed in downtown Idyllwild before the Festival and auctioned off afterwards. Photograph by Barbara Rees and courtesy of the Idyllwild Town Crier.

and naturalists led hikes to observe lemon lilies in nature. Fortunately, there were a few, accessible lilies left in Lily Creek on Idyllwild Nature Center land for festival visitors to see. We talked about what had happened to the lemon lily and how its numbers could be increased through both preservation and restoration at every opportunity.

Los Angeles public television station KCET even did an entire epi-

sode of California's Gold devoted to the first festival—which the station graciously continues to replay each year before festival time.

RESTORATION EFFORTS—INCREASING THE LEMON LILY

Having actual lemon lilies in bloom in nature for people to see was important for festival credibil-



TOP: Education talks are given each year at the festival about lemon lily natural history, restoration efforts and the fate of lilies after the Mountain Fire in 2013. Photograph by J.P. Crumrine and courtesy of the Idyllwild Town Crier. • BOTTOM: Lemon lily with bulb scales. This plant is three years old. Photograph by Kathryn Kramer.

ity. In addition to the few plants growing naturally at the nature center, bulbs were also purchased from

a nursery in Oregon whose original stock had come from this area in the 1970s. The first bulbs were planted

in hopes that they would be in bloom in time for the festival; it is always difficult to plan an event based on flowering in nature in advance! Over the years, this has supplied many “teachable moments” at the festival on how springtime temperatures affect the bloom time of most plants. Bulbs have been planted in appropriate habitat around the community on private property and at the Nature Center—in Lily Creek—to augment the population.

We continue to perfect propagation techniques for increasing lemon lilies. We’ve tried tissue culture techniques but have found that local seed is relatively easy to germinate after being stratified for a few months in a refrigerator. We are learning how to “overwinter” the seedlings in order to grow bulbs large enough to survive once planted. The goal is to re-establish colonies in the Idyllwild area in lily habitat.

As of this writing, the Lemon Lily Festival continues on. The Idyllwild Nature Center has taken the lead and held the festival for the last few years. Festival status can be found at lemonlilyfestival.com.

The festival has changed the public’s attitude towards lemon lilies—from being unaware of this gorgeous native plant to becoming fiercely protective of it! Lemon lilies are celebrated every July in Riverside County and there is now a continuing community effort among botanists and gardeners to “bring them back” to local habitats.

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TIPS ON GROWING GEOPHYTES IN THE GARDEN

by Judith Larner Lowry

You may be a devoted native plant gardener, enjoying the benefits of a yard replete with California native species. The bulbs, corms, tubers, and

with many geophytes are neither mysterious nor complicated. Appropriate for beginners are many members of the family Themidaceae, or Brodiaeae, which includes the *Brodiaea*, *Triteleia*, *Bloomeria*, and *Dichelostemma* genera, with many species both widespread and adaptable. They are the focus of this article.

Even they may be difficult to find in native plant nurseries and are relatively expensive. Supplies can fluctuate from year to year. Bulb suppliers with high standards, who grow bulbs from seed of wild stock, who



TOP: Prettyface or golden star (*Triteleia ixioides*) can be found from central California north to Oregon in a variety of situations. There are five subspecies. • BOTTOM: Ithuriel's spear (*T. laxa*) is one of the most showy and frequently grown native geophytes. All photographs by Peter G. Smith unless otherwise noted.

taproots that are a compelling and threatened part of the California landscape are not often found in our gardens. Growing geophytes is a Californian form of gardening practice, an opportunity to deepen familiarity with our state's indigenous flora and ecology.

The requirements for success



TOP: One-leaf onion (*Allium falcifolium*) close-up. *A. falcifolium* is considered difficult to grow but does well in containers. • BOTTOM: *A. falcifolium* in a container.

do not wild-collect bulbs, and who keep track of sources, often sell out early in the fall. Buying enough bulbs

to paint your grassland with color may be costly and possibly anxiety-producing. The seasonal above-



TOP: Ithuriel's spear (*Triteleia laxa*) in a container. • BOTTOM: Ithuriel's spear corms. The results of a two-year long grow-out in a container, which began with six large corms.

ground disappearance of geophytes when they die back and go dormant in the fall, may create more suspense than some gardeners will tolerate. The bulb-hungry gopher population that provides a healthy disturbance for a large stand of flourishing wild geophytes can be devastating to a garden planting of a dozen expensive bulbs.

The beginner can gain confidence, practice techniques, and readily propagate planting stock by starting with growing bulbs in the almost foolproof situations provided

by ornamental containers. Lessons learned will serve the gardener well when planting in the ground.

For example, in three years, six corms of California brodiaea (*Brodiaea californica*) planted in one large ceramic container produced 24 good-sized parent corms, as well as approximately 100 robust offsets attached to their sides. The offsets, when separated from the parent corms and replanted in the ground, produced blooming plants the following year, enough to create a notable garden feature at the front of a perennial border.

CONTAINER-GROWING

To augment planting stock through container-growing, select a large ceramic or wooden container at least 18" deep and 2' wide.

Square to rectangular boxes of different sizes can be easily built to house bulbs.

Smaller containers may produce fewer or scrawnier offsets. The top of a corm from which the sprout emerges comes to a more or less obvious somewhat pointed tip, while the roots emerge later from the base, the flattened side, where a plate or callus from a previous withered corm is often visible. Plant corms root side down, 2" to 6" deep and 1" to 4" apart, depending on the ultimate size of the plant. Some corms will have sprouted already, even when stored in a cold dry place. Plant these immediately, sprout facing upwards and almost covered by the soil.

When selecting which corms or bulbs to plant, don't begin with montane species when you live in the lowlands, or coastal species when you live in the desert. Choose those species known to be local to your area. They will be useful for local insect populations, including native and honey bees, bee-flies, flower beetles, butterflies, and hummingbirds.

Move offsets to new pots or to

the ground and top-dress annually, during the early growth period, with more potting soil or compost. Light bulb fertilizer is sometimes used. Allen Chickering (1938) observed greatly expanded *Calochortus* blooms following fires. He regularly applied an annual wood ash top-dressing with good results. Crushed oyster shells will also supply needed potassium.

Many different soil combinations are suitable for container-growing bulbs. Light, organic, manure-free potting soil, available from garden centers, works well. Vermiculite, perlite, peat, or sand can help maintain good drainage and avoid root rot. Woodland species like additional humus. Desert species prefer a higher percentage of sand.

Bulb bloom in containers and in the ground begins from March through July. For containers planted with summer-dry species, stop watering after bloom and seedset. Separate these containers from those planted with species that prefer some summer moisture, such as white brodiaea (*Triteleia hyacin-*



Blue dicks (*Dichelostemma capitatum*) in bloom in a bulb box.



TOP: White brodiaea (*Triteleia hyacinthina*) in bloom in a bulb box. Photograph by Peter G. Smith. •
BOTTOM: A close-up of white brodiaea blossoms in April 2016.

thina), crown brodiaea (*Brodiaea coronaria*), and seep brodiaea (*Triteleia peduncularis*). Others can handle drought once the buds appear. Information on habitat of origin in the wild will influence your watering strategy.

To make use of your abundance of bulbs and corms, whether in the ground or in a container, many variations of the basic strategy work. Large, healthy bulbs with well-developed and numerous offsets, optimal density, and the well-churned soil once found in managed indigenous bulb gardens are the goal. From the ground or from a container, bulbs and their offsets can be either dug, separated, and immediately replanted in the same spot or

in a new place, dug and stored in a cool, dry place for later replanting October–December, or left in place. After seedset is generally a good bulb-digging time. Use a hori-hori, trowel, digging stick, or iron pry-bar to dig bulbs and corms. A continuously worked soil makes it easier to avoid inadvertently jabbing the bulbs. In clay soil, it may be preferable to dig bulbs before the soil bakes hard in summer.

GROWING FROM SEED

Growing geophytes from seed, another inexpensive way to gain access to sufficient quantities for satisfactory garden effects, has a few pitfalls and requires a bit more patience. According to Diana Chapman, owner of Telos Rare Bulbs, access to native bulb seed is a limiting factor in bulb production (The Bulb Maven blog). To achieve bloom from seed ranges from two to five years.

The first two years, when new seedlings go dormant without much root to sustain them, is tricky. Sow seeds in flats 8" deep, to avoid having to move them until three or four years have passed.

During this critical time in the seedling's lifecycle, they are puny and hard to spot. They may be overcome by weedy species or even inadvertently pulled out. Once the sprouts have broken through the soil, supplement rainfall if grown outdoors with enough moisture to keep them growing.

Coir is a good, fungus-resistant medium for starting bulbs from seed when mixed with other supplements. Some growers recommend soaking both the seed and the planting medium in water before sowing, to ensure consistent moisture for germination. The Pacific Bulb Society provides invaluable member experiences for growing many species from seed.



Geophyte seeds in a plastic bag after cold-stratification (sealed in bag with moist medium, placed in refrigerator for two to three months), at Telos Rare Bulb Nursery in Ferndale. Photograph by Diane Chapman.

USES IN THE GARDEN

Once you have enlarged your supply of corms and bulbs, they can be used in dry borders as accent plants, grouping them with perennials requiring a similar watering regime, such as "summer-dry" or "summer-moisture-tolerant." Bulbs are also set off by driftwood or rocks, or grown in solid masses of one species, as seen in the wild. In this case, dig the soil out to a depth of two feet and line the bottom and sides of this hole with rust-resistant 1/2" screen. Reinforce the corners. Urban gardeners, whose cement driveways and sidewalks can inadvertently create a relatively bulb-predator-free "planter box," can sometimes plant in the ground without protection.

CREATING A NATIVE GRASSLAND

Native bulbs are an important addition to existing native grasslands or used as part of the creation of backyard "mini-prairies." For a grassland planting that includes geophytes, establish the native grasses first, spacing them based on their mature width, so that the spaces in-between the bunchgrasses can be planted with groupings of geophytes

and other perennials. We make small protective screen “cups” for groups of four to ten bulbs, or use store-bought gopher baskets for protection from gophers, ground squirrels, rabbits, mice, rats, and other bulb predators.

You may want to follow the bulb planting by sowing a wildflower bulb-cover.

Good possibilities abound, such as baby blue eyes (*Nemophila menziesii*), tidy tips (*Layia platyglossa*), or any of a number of late winter and early spring blooming annuals, including goldfields, gillias, lupines,

and Chinese houses. Douglas meadowfoam (*Limnanthes douglasii*) has been successful as an early-blooming bulb cover. This lover of vernal pools, seeps, and other seasonally moist areas is adaptable to drier situ-



Ithuriel's spear (*Triteleia laxa*) growing in the garden as part of an early spring flowering combination with alum root (*Heuchera* sp.), Pacific bleeding heart (*Dicentra formosa*) and driftwood. Photographer unknown.

ations and reseeds well. Blooming in February and March, it goes to seed in April and May. Blue dicks (*Dichelostemma capitatum*), possibly the most reliable and widespread native corm in the West, blooms next. It goes dormant in May-June, to be followed by white brodiaea and Ithuriel's spear.

A large planting of bulbs that are dormant for a good part of the year creates a challenging but interesting garden feature. Areas of bare, weed-free soil are increasingly rare in California. Such seasonally unvegetated



Douglas meadowfoam (*Limnanthes douglasii*) in bare soil area. These vigorous wildflowers favor seasonal wetlands. With the first drop of water, they germinate, blooming in February-March. The plants disappear by the end of March, making way for the first bulb shoots. Photograph by Peter G. Smith.



Diogenes' lantern (*Calochortus amabilis*) growing on dappled hillside in eastern Mendocino County on Rte. 162. Note nodding seed capsules forming. Photograph by Judith Lowry.

areas can become a place for ground-nesting native bees to make nests, for quail to enjoy dust baths, for other species that dislike competition to grow, for a safe firepit, and for summer play in an otherwise lawnless garden.

Success may turn your thoughts to growing members of the entranc-



LEFT TO RIGHT: Kellogg's yampah (*Perideridia kelloggii*) blossoms up-close. Photograph by ©Neal Kramer. • Kellogg's yampah (*Perideridia kelloggii*) tubers which are edible with a sweet, nutty flavor. Young sprouts and leaves are edible as well. It is a host plant for the anise swallowtail. Photograph by Peter G. Smith. • Gairdner's yampah (*Perideridia gairdneri*) edible tubers are grown out in containers before being divided and planted in the ground. The native yampah species are still common in some areas, such as the Sierra, while in other areas such as the Coast Ranges, they may be in decline. Their lacy white flowers are rarely seen in gardens. Photograph by Peter G. Smith.



ing genus *Calochortus*, which contains many spectacular species. It is divided into three sections and numerous subsections (Gerritsen and Parsons, 2007). Globe lilies, also called fairy lanterns, in the section *Calochortus* and in the subsection *Pulchelli* are among the easiest to grow. *C. albus*, *C. amoenus*, *C. pul-*



chellus, and *C. amabilis*, all with glossy, intricately folded pendant flowers, are enchanting in partly shaded to sunny gardens.

One difficulty in their management is that *Calochortus* bulbs sometimes make their way to the bottoms of containers, where they can assume dormancy for years, with no indication of life. Good drainage is essential in preventing the rotting of these obstreperous bulbs. They prefer no summer water.

Interest in geophytes as food can deepen and enrich your garden with rarely grown species, like Kellogg's yampah (*Perideridia kelloggii*) or the

highly nutritious Gairdner's yampah (*Perideridia gairdneri* subsp. *gairdneri*), which is considered threatened. *Perideridia* species still thrive in some places and were once gathered by Native Americans by the basketful.

The genus *Allium* has many attractive and easy-to-grow species with a familiar oniony taste and odor. They are used like any domestic onion.

The corms in Themidaceae can be boiled for 20 minutes and then roasted or sautéed till they are soft and golden, producing a delicately flavored potato-like appetizer.

Camas (*Camassia* spp.) contains substantial levels of inulin. It was cooked by indigenous peoples in earth ovens for up to 36 hours to make it digestible. (Some research indicates that a certain amount of inulin in the diet is beneficial). Bake them in the oven, in a closed casserole with water reaching halfway up the bulbs, for five hours at 300 degrees. Water is added as needed. As they caramelize, the oven temperature is lowered. Sprinkle on balsamic cream and salt and pepper. Or boil in sweetened, rosewater-flavored milk for a pudding.

Beautiful and delicious, your garden geophytes can offer garden time spent reveling in their abundance, giving back to them some part of the territory they have lost. You may wonder why you waited so long.

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TOP: One-leaf onion (*Allium unifolium*) close-up. It is a widespread and easy to grow native onion. • BOTTOM: Camas (*Camassia leichtlini* subsp. *suksdorfii*) growing at the head-waters of Cherry Creek in Mendocino County. Photographs by Peter G. Smith.

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TOP TO BOTTOM: California fawn lily (*Erythronium californicum*). Digital painting by Ames Gilbert based on photograph by Nancy Gilbert. • Redwood lily (*Lilium rubescens*) and leafcutter bee (*Megachile* sp.). Digital painting by Ames Gilbert based on photograph by Nancy Gilbert. • Yellow mariposa (*Calochortus superbis*). Digital painting and original photograph by Ames Gilbert.



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SUBMISSION INSTRUCTIONS

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

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FROM THE EDITOR

As is typical for an organization with so many passionate supporters, having volunteers step forward to help in times of transition eases the experience for all. My transition into the job has been made easier by the efforts of volunteers as guest editors. Last issue we have Phyllis M. Faber to thank for her efforts, and this issue Kat Anderson stepped in to guide the process.

While this is the first *Fremontia* issue I have been a part of since being named editor, Kat Anderson deserves full editorial credit for this stunning issue. Kat has a true passion for excellence, easily seen through the captivating progression of storytelling in this special double issue. I first discovered Kat's work when a friend suggested I read *Tending the Wild* to explore her references to traditional uses for conifers. Reading the book changed the way I viewed and understood the California landscape. Since that time, I have continued to learn from Kat's work, and the work of others, who interpret land use and historic ecologies as they relate to the modern day. That is what this issue does for our current understanding of geophytes; perspective has grown in depth and breadth.

I am excited to begin my post as editor of *Fremontia* and will move forward, thanks in part to Kat's guidance, to produce future issues as important as this one. California Geophytes will have a special place on my bookshelf as both a reference guide and as a celebration of the unique botanical landscape we call home.

—Michael Kauffmann

(continued on inside back cover)