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DUDLEYAS

BURNED LANDSCAPES IN THE SIERRA NEVADA

FOREST RESILIENCE FOLLOWING WILDFIRE

CARE OF NATIVE OAKS

FREMONTIA

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California Native Plant Society

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the California Native Flora*

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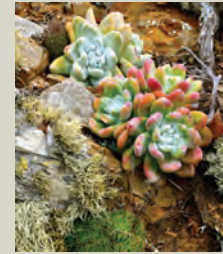
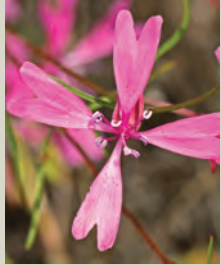
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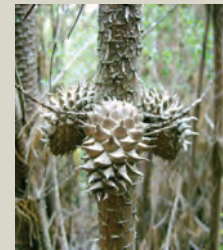


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THE COVER: San Gabriel Mountains dudleya (*Dudleya densiflora*), currently only documented in two canyons of this mountain range. Photograph by Jeremy Spath.



Perhaps the most sought after species in the genus is the incredibly colorful Cedros Island dudleya (*Dudleya pachyphytum*), which grows off the coast of central Baja California. A portion of another dudleya can also be seen at the bottom of the photo. There is some contention as to whether it is *Dudleya* sp. aff. *albiflora*, a form of *D. linearis*, or something else entirely.

THE RAPIDLY EVOLVING WORLD OF DUDLEYAS

by Jeremy Spath

Dudleya, a charismatic genus of succulents, includes some of the most fascinating native California plants. Yet despite their charms they are somewhat overlooked by native plant enthusiasts and horticulturists. However, the genus contains many taxa that are considered gems in the succulent world and are highly sought after by collectors for their beauty and rarity.

The diversity of this relatively small group of plants is astounding, ranging from single rosettes the size of dinner plates such as Britton's dudleya (*Dudleya brittonii*), to minuscule vernal plants like short-leaf dudleya (*Dudleya brevifolia*), a state-listed endangered species. The lat-

ter must be one of the smaller succulents in the world. This genus can be highly variable and the plants hybridize quite freely, suggesting that perhaps the group is evolving rapidly. This makes their taxonomic classification very difficult, with the biggest issue being the intergrading of species or gradual merging of physical characteristics through a series of intermediate stages (Thiede 2004).

When doing fieldwork with dudleyas, I am constantly reminded that what I am viewing is a snapshot in evolution. Being a student of these intriguing plants can be confounding, and when discussing them I often fall back on the caveat, "This is what I know about dudleyas today."

HISTORY

Before the genus *Dudleya* was created, the plants we now group under that name were included in other genera. The first three to be described scientifically were *Cotyledon caespitosa*, *Sedum cotyledon*, and *Echeveria pulverulenta*, all from coastal California. The first and last of these have retained their species names in *Dudleya*, while the middle one is now considered a synonym of *Dudleya caespitosa*. The genus *Dudleya* was established by botanists Nathaniel Lord Britton and Joseph Nelson Rose in 1903 when they reclassified the North American Crassulaceae. (Britton was an eminent US botanist who was the



Identifying dudleyas can be quite challenging due to their tendency to interbreed and produce hybrids. CLOCKWISE FROM TOP LEFT: Chalk dudleya (*Dudleya pulverulenta*) has a very widespread distribution. • *Dudleya arizonica* near Anza-Borrego Desert State Park in San Diego County. • Sticky dudleya (*Dudleya viscida*), top, is the parent plant of a hybrid offspring, bottom, a cross with chalk dudleya.

first director of the New York Botanical Garden, and promulgated a set of rules of botanical nomenclature. Rose was a curator at the Smithsonian.) *Dudleya* was named for William Russell Dudley (1849–1911), a professor of botany at Stanford and Cornell Universities.

The two botanists recognized 60 *Dudleya* species, along with 12 species in *Stylophyllum* and 4 in *Hasseanthus*. The species of *Stylophyllum* resemble those in *Dudleya*, but in general have narrower leaves and a more spreading corolla. Those in *Hasseanthus* have sedum-like flowers and deciduous leaves which die to the ground after the plants flower (Uhl 2004). In October 1942 Moran included *Stylophyllum* as a subgenus of *Dudleya*, and in time *Hasseanthus* was included as well (Moran 1953).

Today there are approximately 46 species of *Dudleya* (McCabe 2012), with 28 subspecies. More than half of these are native to California. However, these numbers are by no means definitive since many taxonomic problems in the genus remain unsolved.

DISTRIBUTION

The majority of the species in *Dudleya*, including the island species, grow on bluffs along or near the Pacific Ocean, ranging from southwestern Oregon to the south-

ern tip of Baja California in Mexico. Seed germination on coastal rocks is aided by moss and lichens, which retain soil and moisture, and coastal fog helps in reducing moisture loss (Thiede 2004). The northernmost species, bluff lettuce (*Dudleya farinosa*), extends from Northern California into southwestern Oregon. A few species can be found inland in California's Coast Ranges and in the Sierra Nevada. Arizona chalk dudleya (*Dudleya arizonica*) has a range extending from northern Baja California into northwestern Sonora and across the border into California, Nevada, western Arizona, and southwestern Utah. One species, *Dudleya saxosa* subsp. *collomiae*, is endemic to central Arizona.

No species occur in California's Central Valley due to the plants' preference for rocky habitats. Most of the genus is found in winter rainfall regions, and there is almost no overlap with the similar-looking genus *Echeveria*, which mainly inhabits the summer rainfall regions of Mexico (Uhl 2004; Thiede 2004).

SPECIES IN FOCUS

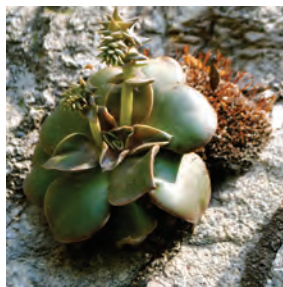
Bluff lettuce (*Dudleya farinosa*). This species has a range extending from southwest Oregon to the Big Sur region. Like many species it is variable, with each locality being unique. Both powdery-white (farinose) and green plants can be found



growing side-by-side at many locations. Some of the nicest populations I have seen were in Patrick's Point State Park in Humboldt County, California. There I found large clumps of beautiful chunky plants growing on small rock islands a few feet off the coast that were frequently splashed with sea spray.

Coast dudleya or sand lettuce (*Dudleya caespitosa*). Driving through Big Sur along Highway 1, if you manage to turn your head east, opposite the famous coastline, you will see exquisite clumps of *D. caespitosa*. Plants may be farinose or green, with large clumps of star-shaped rosettes often with fire-engine-red leaf tips. This species shows great variability and has a wide range that includes the Channel Islands.

Chalk dudleya (*Dudleya pulverulenta*). I never tire of finding



CLOCKWISE FROM TOP LEFT: One of the many forms of *Dudleya cymosa*, this particular plant was found in Big Sur. • San Gabriel River dudleya (*Dudleya cymosa* subsp. *crebrifolia*) is a striking tiny species that was photographed in the San Gabriel Mountains outside of Los Angeles. • *Dudleya cymosa*, photographed at 5,000 feet. *Dudleya cymosa* along with *D. caespitosa* are two species that are amongst the most difficult plants in the genus to key out due to their high variability and tendency to hybridize.

colonies of the snow-white *D. pulverulenta*, which is often found growing along road cuts. Especially in late winter and spring, when the plants are large and chubby, it is hard not to consider this opportunistic plant one of the most beautiful of the genus.

San Gabriel Mountains dudleya (*Dudleya densiflora*). This species has been found growing in two canyons outside of Los Angeles in the San Gabriel Mountains. It often grows alongside outstanding specimens of San Gabriel River dudleya (*Dudleya cymosa* subsp. *crebrifolia*) and lance-leaved dudleya (*Dudleya lanceolata*), the latter two hybridizing quite freely, making the plants

at this locality very difficult to key out. San Gabriel Mountains dudleya is somewhat reminiscent of the common landscape plant narrow-leaf chalksticks (*Senecio cylindricus*), although the leaves are whiter, and true to its name it is covered in compact clusters of white flowers in mid- to late spring.

Short-leaved dudleya (*Dudleya brevifolia*). It is difficult to resist the charm of this extremely diminutive plant. Hidden from view and essentially in hibernation most of the year, this vernal dwarf emerges from the soil once the winter rains begin to saturate the earth. Like many *Dudleya* species, it was likely far more abundant prior to the urbanization and rapid growth that ate up most of coastal southern California's real estate. However, it can still be found in numerous areas if you know where to look. Even knowing the right spot, it is very hard to find it except in spring when its sedum-like flowers, practically dwarfing the stems and leaves, are a dead giveaway.

Coronados Island dudleya (*Dudleya candida*), and **Britton's dudleya** (*Dudleya brittonii*). These are two spectacular species that grow so close to the California border that they can practically be called California natives. As the name suggests, Coronados Island dudleya occurs on the Coronados Islands, approximately eight miles off the coast of extreme northern Baja California, and the islands are visible from downtown San Diego. It forms both multiheaded farinose and green clumps, each stunning in its own way. When in flower it puts out red inflorescences with yellow flowers that contrast splendidly with the color of the plant's rosettes.

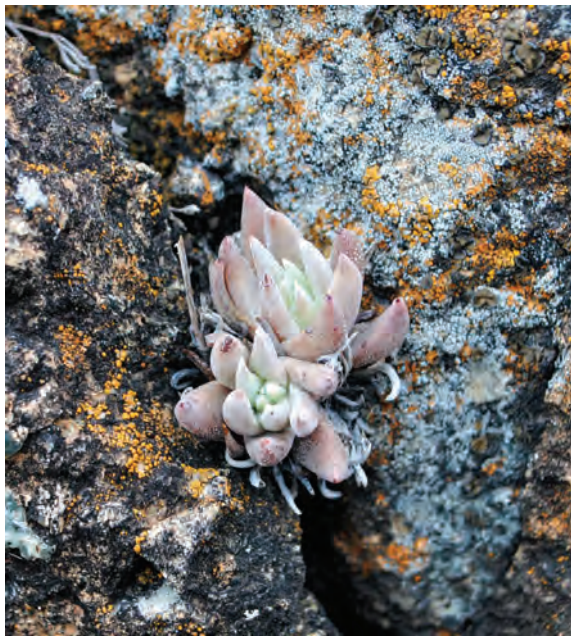
Almost directly across the channel on the mainland of Baja California, just north of La Misión, Britton's dudleya habitat begins along the cliffs, and plants can be seen growing in great numbers. The multitudes of large white rosettes are

reminiscent of a star-filled sky on a clear night. The flower of the two species is identical, but the leaves differ: Coronados Island dudleya forms smaller multi-headed rosettes while Britton's dudleya forms one large rosette. Very rarely, though, a multi-headed white Britton's dudleya has been found on the mainland. This all leads some to speculate that perhaps we're looking at the same species, one an island form and the other a mainland form.

GROWING DUDLEYAS

Most *Dudleya* species grow in winter and spring and are prone to rot when watered in the summer. Think of the Wicked Witch of the West's response to water: "I'm melting!!!" Also, keep in mind the climate these plants grow in and that summer rainfall in California is rare. Understanding the basics will help greatly in growing these plants, which are often said not to be difficult to grow, but difficult to grow well.

Being a landscape designer and a proponent and avid fan of native plant gardens, I am often surprised to come across beautifully designed ones that are lacking one obvious component—*Dudleyas*. Gardeners who live near the coast will likely find it easiest to grow them outdoors. However, some thought about placement can help greatly. Planting them among rocks and on a slope is culturally and ornamentally appealing, as well as preferable to flat ground. Assuming they are planted among other natives, any supplemental irrigation shouldn't be an issue. A few of the plants in my coastal Southern California garden that I have found easiest to grow, as well as more available in the trade, have been: Britton's dudleya, Coronados Island dudleya, bluff lettuce, and Cedros Island dudleya (*D. pachyphytum*). Additionally, these are considered to be some of the most ornamental plants of the ge-



LEFT: Mouse-gray dudleya (*Dudleya abramsii* subsp. *murina*), near San Luis Obispo. • ABOVE: Short-leaved dudleya (*Dudleya brevifolia*). This vernal species' stem and leaves are dwarfed by its blooms, making it relatively easy to find.

nus and have been able to handle some summer watering, which may be due to the fact that each of them is accustomed to year-round fog.

CONSERVATION

Many species of *Dudleya* are rare in the wild and are confined to small ranges with scattered populations. For this reason they should never be removed from nature without legal permission. The California Native Plant Society lists 26 species of *Dudleya* on their list of most endangered plants (the *CNPS Inventory of Rare and Endangered Plants*), with nine being considered federally endangered or threatened (rareplants.cnps.org/result.html?fulldata=dudleya). It is difficult to know the

status of many species, as numerous populations are found in extremely inaccessible areas.

The UC Santa Cruz Arboretum propagates plants in an effort to curb wild collecting. Some of the plants were collected as long ago as the 1940s, and enough plants are grown that some may be used for research while others are occasionally sold to the public (McCabe 2004). Growing *Dudleya* plants from seed and making them more available to the public theoretically would curb wild collecting. More often than not, wild-collected plants do not transplant well to a garden and soon die, whereas seed-grown plants adapt better and are easier to grow. Nurseries are supposed to label their plants as threatened or endangered species,

and mention that the plants have been propagated from those already in cultivation. Also, nursery-grown plants can cause genetic contamination if planted within the native range of the species but not in the area from which the propagules were collected.

Finding sound literature on the entire genus of *Dudleya* can be difficult. Reid Moran's 1951 thesis is the basis for most botanical understanding today, but it is difficult to obtain and lacks photos. In 2004 the Cactus and Succulent Society of America devoted an entire issue to *Dudleya*, and it is a wonderful reference available through the CSSA website's back issues section. Thomson's *Dudleya and Hasseanthus* (1993) is worth reviewing and is filled with color photographs, but also contains



A spectacular specimen of *Dudleya caespitosa* enjoying prime real estate in Big Sur.

questionable and flat-out wrong assertions. Kelly Griffin, Stephen McCabe, and I are currently working on an updated revision of the genus in book form that will give these plants the thorough treatment they deserve and make knowledge about them more accessible to the public.

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LEFT TO RIGHT: Greene's dudleya (*Dudleya greenii*), Santa Cruz Island. • Bluff lettuce (*Dudleya farinosa*) has a large range and is usually found only a few feet from the Pacific Ocean. • A particularly beautiful specimen of lance-leaved dudleya (*Dudleya lanceolata*) in the San Gabriel Mountains.



ABOVE: Coronados Island dudleya (*Dudleya candida*) grows only on the Coronados Islands off of extreme Northern Baja California. The Mexican government prohibits visiting the islands without legal permission.

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TOP: Two dudleyas found in Baja, California: Britton's dudleya (*Dudleya brittonii*) in full flower along the Pacific near El Mision, Mexico and (INSET) *Dudleya xantii*, the southernmost occurring dudleya species. • BOTTOM: This is a presumed hybrid of Greene's dudleya (*Dudleya greenii*) and candle-holder dudleya (*Dudleya candelabrum*), and is found on Santa Cruz Island. The plant exhibits characteristics of both species.

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Sun-loving pines germinate on the bare mineral soil left by a fire, eventually overtopping, shading and supplanting early seral shrubs such as ceanothus. Photograph by Scott Stephens.

MANAGING BURNED LANDSCAPES IN THE SIERRA NEVADA: BACK TO THE FUTURE (SLOWLY)

by Carolyn Longstreth

If you could time-travel back to the nineteenth century and wander the Sierra Nevada during John Muir's time, how would the landscape appear compared to today? A forest ecologist would tell you that, instead of the thick, uniform growth of medium-sized conifers that is common nowadays, you would see a patchier, more diverse mix of vegetation types. Chaparral would be more widespread; riparian corridors, hardwood groves, open meadows and conifer stands of many different types and variable age, including old-growth, would all contribute variety to the landscape. The forests would

look more open and spacious, with more shrubs, forbs, and grasses on the ground.

You would also be more likely to encounter a recent burn, perhaps from a fire a year or two earlier. Numerous snags—standing burned trees—would be under siege by wood-boring beetles; woodpeckers would be eagerly feeding on the larvae. Vigorously sprouting shrubs would intermingle with lush, new herbaceous growth giving rise to a surge of flowers, nectar, seeds and fruits, in turn drawing insects, owls, and other birds and mammals small and large.

ECOSYSTEM PROCESSES AND EARLY SUCCESSION VEGETATION

Such a landscape would have been created by fire, the West's ubiquitous agent of destruction and renewal. While humans regard fire with fear and dread, ecologically, it is an essential and highly positive force. It returns nutrients to the soil and regulates forest density. It creates conditions for plants to reproduce and influences species composition, favoring sun-loving pines over shade-tolerant firs and incense cedars. It affects forest diseases, re-



Black oak (*Quercus kelloggii*) readily sprouts from the root after even the most severe wildfires. Intolerant of shade, it frequently mixes with pines, ceanothus, and manzanita in the early succession plant community called complex early seral forest. Photograph by Peggy Moore.

news habitat for wildlife and fish, and increases the diversity of forest structure, species of plants, and age classes.

Over the millennia, highly variable fire regimes worked upon the Sierra Nevada's complex topography to create a spectacular landscape of globally significant biodiversity. Dry, south-facing slopes with forests of oak, ponderosa, and Jeffrey pine naturally tended to burn frequently—every ten years or less—usually at low severity, consuming the fine fuels, grasses, and litter on the ground. Where the terrain was especially dry and steep, chaparral could

persist indefinitely under the influence of recurring fires. North-facing and otherwise moister locations, supporting a thicker growth of Douglas fir, white fir, and other conifers, also burned regularly in the past but at variable or mixed severity. This type of regime would include areas of severe fire that replaced entire stands; these patches tended to be smaller in pine forests and chaparral than in the shade-tolerant fir-dominated forests (Collins and Stephens 2010).

Such pyrodiversity created the conditions for an exceedingly rich flora that includes as many as 405 endemic vascular plants, plus 25 conifer, 23 hardwood/woodland, 34 shrub/chaparral, and 5 herbaceous plant alliances.

One unique assemblage of plants is adapted to form quickly after a stand-replacing fire or lower intensity disturbance. Known scientifically as complex early seral forest, this early succession plant commu-



Seeds of many woody and herbaceous plants adapted to the fire-prone landscape germinate only when exposed to ash, smoke, or chemicals released by charred wood. CLOCKWISE FROM BOTTOM RIGHT: Full form and close-up of golden eardrops (*Ehrendorferia chrysantha*). • Whispering bells (*Emmenanthe penduliflora*). • Bush anemone (*Carpenteria californica*). All photographs by Bill Follette.

nity grows between the time of a stand-replacing fire and the reestablishment of woodlands and the closed-canopy forest (DellaSalla et al. 2014). This process can occur over a long period of time, ranging from 20 to 50 years or even longer, depending on site conditions.

This type of early seral forest is considered complex because of the abundant organic material that persists on the site despite a fire or other disturbance, and which may include standing burned trees (snags), shrubs, understory vegetation, seeds, spores, fungi, live or partially burned trees, and downed logs. Dormant for decades or even longer, the seed bank and other reproductive material spring to life, serving as “lifeboats” to carry early succession vegetation from one fire episode to the next.

Early succession vegetation, whether in the mountains or lowlands in California, is adapted to postpone reproduction until a stand-replacing disturbance—usually fire—releases resources of light, moisture, and nutrients that had previously been scarce. In addition, several adaptations that are specifically fire-dependent also play critical roles in the development of early seral forests.

For example, many kinds of shrubs, including yerba santa (*Eriodictyon californicum*), manzanita (*Arctostaphylos* spp.), and chamise (*Adenostoma fasciculatum*), resprout from burls or lignotubers—vegetative buds on deep underground stumps—sometimes as soon as two weeks post-fire. Other plants, both woody and herbaceous, reproduce from seed but only after exposure to heat in the range of 100° C to 130° C. These seeds are equipped with a waterproof barrier that keeps them viable for long periods; the barrier loosens when fire brings sufficient heat, allowing moisture to enter and germination to occur. Ceanothus seed, for instance, can survive for over 200 years. Knobcone pine (*Pinus attenuata*), Sierra coffeeberry



Sierra lupine (*Lupinus grayi*) put on a robust display during the summer following the 2009 Big Meadow Fire in Yosemite National Park. Photograph by Lynn Robertson.

(*Rhamnus rubra*), flannel bush (*Fremontodendron californicum*), and Fremont's bush mallow (*Malacothamnus fremontii*) also require heat from fire to reproduce from seeds. Occasionally a severe fire will burn even hotter than the seeds can tolerate, killing the entire seed bank.

In another adaptation, plants such as bush anemone (*Carpenteria californica*), chamise, golden ear-drops (*Ehrenborferia chrysantha*), and Baker's globe mallow (*Iliamna bakeri*) require exposure to chemicals leached from charred wood to trigger germination, normally within two years of a fire. Germination of green-leaf manzanita (*Arctostaphylos patula*) seed can be triggered by either heat or exposure to charred wood. Fire indirectly facilitates germination of whitebark pine (*Pinus albicaulis*) and other conifers: the bare mineral soil left by a burn reduces pathogens and seed predation.

Perhaps in a class by themselves are the “fire-followers,” annual wildflowers that germinate, bloom, and set seed only in the first one or two years after a fire. These unique plants—including whispering bells (*Emmenanthe penduliflora*), hillside monkeyflower (*Mimulus brevipes*), spurred snapdragon (*Antirrhinum cornutum*), wooly-seeded ground-

smoke flower (*Gayophytum eriospermum*), and various species of lupine, lotus, and snapdragon—also depend on ash, smoke, or chemical leachate to germinate and reproduce. Each has its own requirements for slope, aspect, soil, elevation, and distance from the coast.

Accompanying the bountiful display of annual wildflowers during the first spring is a vigorous flush of growth of herbaceous perennials with bulbs, corms, and rhizomes. Calochortus (*Calochortus* spp.), blue dicks (*Dicheletemma capitatum*), Ithuriel spear (*Triteleia laxa*), iris, white brodiaea (*Triteleia hyacinthina*), pretty face (*Triteleia ixioides*), and others bloom profusely and set seed which then germinates and grows to maturity. These plants peak two to four years post-fire. Still other early seral plants—certain monkeyflowers and clarkias, for example—are opportunistic annuals and perennials that are capable of germinating without the heat or chemical stimulation from a fire but nevertheless increase in vigor and abundance on the sunny, nutrient-rich burned landscape.

Nitrogen in the soil, which may have been vaporized by the fire, is replaced by the action of lupine and other leguminous plants, alder, and



Drifts of Mariposa clarkia (*Clarkia biloba*), a California Rare Plant Rank (CRPR) 1-B species, are encountered less frequently under a regime of fire suppression. Photograph by Lynn Robertson.

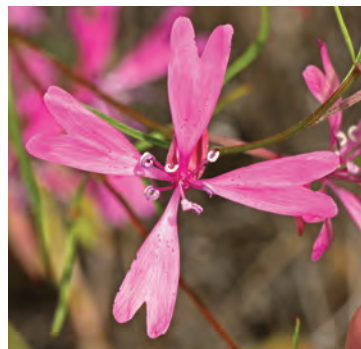
ceanothus. Litter from herbaceous and deciduous shrubs hastens decomposition, feeding the fungal and microbial communities and stimulating mycorrhizal fungi, such as morels, to produce an abundant crop of fruiting bodies.

The exuberant burst of angiosperm growth provides seeds, nectar, and foliage to attract insects, moths, birds, and small mammals. Reptiles are drawn by the heat and light. Wood-boring beetles, exquisitely sensitive to smoke, invade the

snags and attract opportunistic, insectivorous birds such as White-headed, Hairy and Lewis's Woodpeckers, and Red-Breasted and Williamson's Sapsuckers, as well as the post-fire obligate Black-Backed Woodpecker.

Cavities excavated by the woodpeckers are later used by Western Bluebirds and Mountain Bluebirds, swallows, wrens, Vaux's Swift, and pallid bats. Larger cavities in snags and logs are used by black bears, fishers (an uncommon forest-dwelling weasel), and pine martens. New evidence shows that Spotted and Great Gray Owls leave the old growth to forage on recent burns, drawn by the abundant rodents. Flycatchers and seed-eating birds abound on the burned landscape.

Indeed, early seral forest has been shown to be one of the most ecologically important and biodiverse habitat types in western conifer forests, yet it is ephemeral. Even as the shrub layer grows vigorously for 10 to 20 years before attaining maximum height, conifer seeds germinate and grow slowly underneath, shaded by the bushes and snags and protected from drying. Eventually, the small trees overtop the shrubs, reaching full sunlight. The young conifers then increase rapidly in height and girth, little by little shading the shrubs and causing them to lose vigor and disappear. With the gradual conversion of early seral forest to conifer forest, the animals move on, seeking the unique and diverse early succession plant community elsewhere.



These four rare annuals benefit from increased nutrients, light, and moisture after a stand-replacing fire removes the competing shrubs and conifers. All are CRPR 1B species. CLOCKWISE FROM TOP LEFT: Pansy monkeyflower (*Mimulus pulchellus*). Photograph by Peggy Moore. • Slender-stemmed monkeyflower (*Mimulus filicaulis*). Photograph by Keir Morse. • Small's clarkia (*Clarkia australis*). Photograph by Lynn Robertson. • Mariposa clarkia (*C. biloba*). Photograph by Lynn Robertson.

THREATS TO COMPLEX EARLY SERAL FORESTS

These forests are increasingly difficult to find, however. Although Sierra Nevada biodiversity depends on regularly occurring fires and the ecological processes that follow, fire suppression has been the rule for over a century. Much early succession vegetation that existed in the

past has been replaced by conifers, and without fire, new early seral forests have not developed. As might be expected, some of the annual species that benefit from fire are now rare enough to warrant the California Rare Plant Ranking of 1B-2: slender-stemmed and pansy monkeyflowers (*Mimulus filicaulis* and *M. pulchellus*, respectively), and mariposa and Small's clarkias (*Clarkia australis* and *C. biloba*, respectively).

For many decades, the practices of post-fire logging and replanting of conifers have also contributed to the loss of early seral forests. These practices became common decades ago. After some tree plantations failed to grow, forest managers became convinced that without these measures, conifers would not regenerate and grow sufficiently and that, instead, the resurgent chaparral would become permanent. It became the standard practice to log and then plant commercially stocked conifer varieties in rows. Broad-leaf herbicides were applied to suppress the emerging shrubs.

Timber managers also believed that standing snags increased the risk of another fire. This matter was complicated by the policy of fire suppression, which prevented the natural forest thinning that used to result from regular burning. As a result, forests became unnaturally thick and full of fuels that connected understory vegetation to the canopy. Over time, enormous or "uncharacteris-

tic" wildfires became more prevalent, threatening forest health, public safety, and timber stands alike.

Economic considerations have also shaped logging policy and continue to do so. Timber companies are, naturally, eager to recoup the value of burned trees before beetles and fungi render them commercially worthless within a year or two. Given the exigency, state authorities routinely issue exemptions from permitting requirements for private land and, in the National Forests, environmental review is expedited. And limits on the size of green trees that may be taken out of National Forests do not apply in the burned sites, making larger timber available after a burn (personal communication, M. Benech). Nowadays, with green forest logging in decline and reduced appropriations from Congress, the Forest Service depends on revenue from the sale of salvage logging contracts.

But logging followed by replanting also carries economic risks. Post-fire reforestation is very expensive and there is still considerable risk of failure. Despite (or even because of) thorough site preparation, conifer plantations have been known to quickly die from hot soil temperatures. Tree seedlings are often overstocked, leading to high fuel loads, dense canopies, insect damage, and stress from competition. Because thinning is also costly, land managers may wait until the trees are big

enough for a commercial harvest. Meantime, the risk of fire increases every year.

DEVELOPING BETTER MANAGEMENT PRACTICES

The 2002 Biscuit Fire, said to be the largest wildfire in Oregon history, prompted closer scientific scrutiny of post-fire logging and replanting practices. A surge of papers provided evidence for a range of detrimental effects. It was shown that, by removing dead trees and destroying seeds and other organic material, post-fire logging disrupts succession and natural ecological processes, creating a shortage of snags and cavities and rendering the burned sites unattractive to the many species that rely on early seral forests.

The heavy-duty equipment used to haul cut lumber from a burned site directly damages early succession vegetation and compacts the soil. The application of herbicide further harms the native plants that do manage to sprout and grow. Suppressing early succession plants like ceanothus, alder, and root-sprouting shrubs also inhibits nitrogen-fixing, nutrient cycling, and site stabilization. Erosion and sedimentation silt up streams and wetlands. Instead of an understory of native shrubs, forbs, and grasses, invasive non-native plants increase. The trees themselves, grown of nursery stock, can be less genetically diverse, rendering the forest more susceptible to disease outbreaks and climate change.

In addition, the research challenged the widespread notion that logged sites are less fire-prone than unlogged ones. Experiments showed that, where branches and other slash are left on the ground after logging, fire hazard increases in the short term (Donato et al. 2006). Another study found that logged and unlogged sites in the Sierra Nevada were equally prone to fire (McGinnis et al. 2010).

Eight months after the 2013 Rim Fire, slender-stemmed monkeyflower (*Mimulus filicaulis*) flourished on a rocky seep in Yosemite National Park. Photograph by John Longstreth.



Seeking to build on the new findings, scientists and conservationists began to advocate for affirmative stewardship of early seral forests and greater reliance on natural regeneration as a means to foster forest biodiversity and structural heterogeneity. A study conducted in the Klamath-Siskiyou region showed that in most forest types, natural conifer reseedling on burned sites was abundant underneath the canopy of broad-leaved shrubs. The rate of regeneration, however, var-



Many species of birds forage and nest on recent burns. TOP: In early seral forests with high snag densities, the Black-Backed Woodpecker feeds on beetle larvae and excavates nest holes that are later used by bluebirds, swallows and other species. Photograph by Stephen Shunk, paradisebirding.com. • BOTTOM: The abundance of seed attracts rodents, and in turn, predators such as the Spotted Owl. Photograph by John Longstreth.

ied considerably and in some cases was very slow. On the other hand, the conifers that naturally regenerated benefitted from increased nutrients and less erosion while the shrubs and hardwoods attracted animals to disperse conifer seeds (Shatford et al. 2007).

An analysis of chaparral plots west of Lake Tahoe yielded further evidence that, with sufficient time, conifers will gradually replace shrub cover, except on steep slopes with a southerly aspect (Nagel and Taylor 2005). Natural regeneration, researchers have pointed out, can be expected to result in a patchy, diverse landscape of variable aged stands able to support abundant wildlife.

Advocates are also developing management standards for burned landscapes. These would exclude post-fire logging from nature reserves, sites with fragile, steep or erodible soils, and roadless areas. While replanting would be deemed appropriate on uncharacteristically large, severely burned landscapes where conifer seeds are lacking, natural regeneration would be encouraged where feasible. As many as 80 to 120 snags per hectare would be retained instead of the 4 to 10 typically required by the Forest Service today (Sierra Forest Legacy 2012). Restoration projects would strive for structural complexity of the resulting forest; felled trees and other organic material would be retained. As the ultimate goal, ecologists envisioned large landscapes in which natural fire would maintain the ecological balance indefinitely.

DEVELOPMENTS IN FOREST MANAGEMENT

How best to manage our national forests has been a controversial subject ever since, at the urging of President Theodore Roosevelt, Congress established the US Forest Service in 1905. While fire suppression and logging held sway for

much of the twentieth century, starting in the 1990s the Forest Service committed itself to a new emphasis on sustainability, forest health, wildlife habitat, recreation, and restoration. With the promulgation of new Planning Rules in 2000 and 2012, sustainability became the foundation of planning and management decisions, with policies to be based on Best Available Scientific Information.

In the Pacific Southwest Region of the Forest Service, which includes the Sierra Nevada, a 2011 Statement of Leadership Intent affirmed the Region's commitment to ecological restoration and sustainable practices. Yet, after the 2013 Rim Fire—a large, mixed-severity conflagration within the Stanislaus National Forest and Yosemite National Park—the Forest Service issued a proposed Recovery and Rehabilitation Plan that appeared to signal a rejection of both the recent developments in forest planning and the criticisms of post-fire logging practices.

The Plan depicted salvage logging as “the first step in the process of long-term forest recovery.” In the Draft Environmental Impact Report (DEIR), the alternative preferred by the agency slated 30,000 acres of former conifer forest for harvest, significantly reducing the potential for growth of complex early seral forest. Stating that the forest had been unnaturally thick before burning, the Plan called for the retention of only 4 to 6 conifer snags per hectare, well below a natural baseline in the hundreds. Because no logging would occur on the 70,000 acres that burned in adjoining Yosemite National Park, the Stanislaus planners considered it unnecessary to protect additional early seral forests in the National Forests. And the revenue to be gained from the salvage operation could be used for fuels management and a wide variety of restoration projects (Personal Communication, M. Benech).



Seven years after a fire and subsequent logging in the Eldorado National Forest, negative ecological effects are still apparent. LEFT: Nitrogen-fixing shrubs such as ceanothus are absent. RIGHT: Klamath weed (*Hypericum perforatum*) and non-native annual grasses have invaded. Both photographs by Dennis Odion.

Nevertheless, there are indications that the concerns of conservationists are being heard. According to Maria Benech, Rim Recovery Interdisciplinary Team Leader, all living and partially green trees within the burn area will be left to serve as seed sources, replanted conifers will be grouped for structural diversity, and judicious use of prescribed fire will be favored over herbicide. Where the four rare annual monkeyflowers and clarkias occur, logging will be prohibited until after seed is set and the plants have withered. And the amount of slash to be left on the ground will be closely regulated so that enough is left to protect the soil without increasing the risk of fire.

Moreover, an additional alternative analyzed in the DEIR specifically sets aside 2,571 acres for the Black-Backed Woodpecker, with no logging to occur there. In other portions of the burn, experiments would be conducted to see how the Spotted Owl responds to different snag densities.

It thus remains to be seen how the final restoration plans for the Rim Fire will develop. But whether or not the Forest Service gradually alters its approach to the post-fire landscape, there is clearly a shift toward the increased use of prescribed and natural fire as management tools. If the substantial con-

cerns for public safety and air quality can be addressed, the reintroduction of fire may prove to be the easiest, least expensive, and most effective way to increase early seral forests and return the Sierran forests to the patchy, biodiverse mosaic of vegetation types they once were.

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Canopy of the closed-cone pine forest dominated by mature bishop pine (*Pinus muricata*), just outside the perimeter of the 1995 Vision Fire on the north side of Inverness Ridge, Point Reyes National Seashore. All photographs by Brian J. Harvey.

FOREST RESILIENCE FOLLOWING SEVERE WILDFIRE IN A SEMI-URBAN NATIONAL PARK

by Brian J. Harvey, Barbara A. Holzman, and Alison B. Forrestel

When most of us think of forest fires, we likely invoke images of the 1988 fires in Yellowstone or the 2013 Rim Fire in Yosemite—wildfires in national parks or national forests far away from urban areas. Over the last half century, we’ve learned volumes about the importance of wildfires in these large, relatively remote expanses of forest. But what about forests that exist within a morning commute from places like San Francisco or Los Angeles? What role does fire play in the coastal conifer forests that neighbor some of the major cities in California?

CALIFORNIA CLOSED- CONE PINE FOREST

One such ecosystem is the closed-cone pine forest, which exists in a narrow band of disconnected populations along the Pacific Coast of California and Baja California. Many of these forests are dominated by bishop pine (*Pinus muricata*), a medium sized tree that typically lives to be 80–100 years old before succumbing to disease or pests. Bishop pines bear serotinous cones that remain sealed with resin until the heat of a fire breaks the cone scales open and releases seeds; therefore reproduction in the ab-

sence of fire is rare. Mature bishop pine trees are easily killed by fire, but the synchronous release of most seeds immediately following a fire allows for abundant post-fire seedling establishment. As such, most bishop pine forests are even-aged stands that originated after fire (Sugnet 1985).

One of the largest native bishop pine forests in the world exists in and around Point Reyes National Seashore, approximately 30 miles north of San Francisco. Until 1995, most forest stands in Point Reyes had not experienced fire in 60–80 years. Many mature bishop pine trees were approaching the end of their

lifespan and very few seedlings existed in the forest understory. This all changed abruptly in early October 1995 when a wildfire ignited just outside the eastern park boundary on Mount Vision. Over the course of several days, the 5,000 hectare (ha) Vision Fire burned through Point Reyes Peninsula during a period of steady warm, dry winds blowing from the east, eventually reaching the Pacific Ocean just days later. In the bishop pine forest, the fire severity was so high that nearly all pre-fire vegetation was killed.

The Vision Fire was an important ecological disturbance in one of the most prized natural areas in the San Francisco Bay Area, and provided a unique opportunity to study the role of fire in coastal California ecosystems. Concern over how the ecosystems at Point Reyes would respond to a severe fire was high, although observations suggested that the bishop pine forest was teeming with plant life within months following the fire (Ornduff and Norris 1997; Ornduff 1998). Here, we synthesize the scientific findings from longer-term post-fire research, focusing on vegetation changes in the bishop pine forest that have occurred over nearly two decades since the fire. We highlight insights gained from several studies and identify key unknowns and priorities for future research. Much of the research we describe was supported by a Doc Burr Educational Grant from the California Native Plant Society and a small grant from the US National Park Service.

THE END AND BEGINNING OF A FOREST

The severity of the Vision Fire transformed mature forest stands (approximately 750 trees/ha) into a charred landscape with few traces of living vegetation within days after the fire, but bishop pine population dynamics after the fire demon-

strated enormous post-fire resiliency (the capacity to recover following fire). Once the pre-fire trees were killed, post-fire bishop pine seedling germination and establishment became critical for forest persistence. Released from cones on burned mature trees, bishop pine seeds covered the blackened soil within weeks of the fire, and seedlings sprouted

within months (Ornduff and Norris 1997). Shortly thereafter, anyone would be hard pressed to say that the forest stands were not on their way back. One year post-fire, Holzman and Folger (2005) recorded an average of 250,000 bishop pine seedlings/ha—greater than a 300-fold increase from the pre-fire tree density! As seedlings grew into larger saplings and then young trees, intense competition for resources resulted in post-fire tree density decreasing to an average of approximately 15,000 live bishop pine trees/ha by 14 years after the fire (Harvey and Holzman 2014). This process is referred to as “self-thinning,” and is expected to continue as surviving individuals grow larger at the expense of neighboring plants.

POST-FIRE SUCCESSION AND FOREST STAND DEVELOPMENT

Plant community dynamics after the Vision Fire demonstrated a pattern common to many fire-prone Mediterranean ecosystems; that is, plant species diversity was highest in the first years following fire. Two years after the fire, 34 different plant species were present (Holzman and Folger 2005), but by 14 years post-fire this number had decreased to 21 species (Harvey and Holzman 2014). The peak in plant diversity immedi-



Burned and weathered bishop pine cones from a mature tree killed by the 1995 Vision Fire remain attached to a fallen branch in a canopy gap filled by sticky monkeyflower (*Mimulus aurantiacus*) in 2009.

ately following fire results from the myriad fire adaptations exhibited by the native plants in this forest. While bishop pines store their seeds high in the forest canopy, blue blossom ceanothus (*Ceanothus thyrsiflorus*) and several manzanita species (*Manzanita* spp.) store theirs in a soil seedbank where they are stimulated to germinate after fire. Less dominant tree species such as coast live oak (*Quercus agrifolia*) and California bay/California laurel (*Umbellularia californica*) can resprout from their root crowns or their stems after fire. Small statured plants such as yellow bush lupine (*Lupinus arboreus*) and annual herbs in the *Lotus* genus specialize in colonizing recently burned areas, where they gain an early competitive advantage by fixing nitrogen through a symbiotic relationship with bacteria in their roots.

The fact that species diversity is at its highest immediately following fire illustrates the importance of fire in maintaining plant community structure in bishop pine forests. All species that were recorded at any point during the first 14 years following the fire were present in the first two years, after which some early post-fire specialists were outcompeted and later disappeared. It is likely that some of these may re-emerge when the next fire comes through. Some non-native species were also recorded in the early post-



Severe fire renews the bishop pine forest. ABOVE: Bishop pine forest stand that did *not* burn in the 1995 Vision Fire. Trees are approximately 80 years old and illustrate moderately sparse stand density representative of the pre-fire forest. No tree seedlings are present in the forest understory, indicative of a long interval since the last fire. OPPOSITE TOP: Post-fire bishop pine forest stand in 2009 in an area where *all* pre-fire trees were killed in the 1995 Vision Fire. Abundant seedlings established immediately following the fire, leading to high, but variable post-fire stand density.

fire years. Australian fireweed (*Erechtites minima*) was of particular concern, as this species can rapidly colonize burned areas and form a long-lived soil seedbank. Park managers and volunteers removed Australian fireweed in 1996 and very few plants were observed up to six years after the fire. It is not clear if there are any long-term effects from Australian fireweed on post-fire forest dynamics; however, seedbanks of this species may be present in the forest soils now, and long-term effects may not be evident until another fire occurs.

The Vision Fire also promoted diversity in forest structure (tree density, shrub cover, and plant species composition) across the burned

landscape (Harvey and Holzman 2014). Pre-fire forest density (approximately 750 stems/ha) was fairly uniform across space, but different pathways of post-fire forest stand development were evident immediately after the fire and have persisted nearly two decades later. Some stands that had the highest initial post-fire bishop pine seedlings (in a few cases over 1,000,000 seedlings/ha) have since proceeded along a densely-forested “closed-canopy pathway” with low shrub cover and plant species diversity. Other stands with initially lower bishop pine seedling establishment (approximately 40,000 seedlings/ha) have since proceeded along an “open-canopy pathway” with sparse

canopy trees, high shrub cover (mostly blue blossom ceanothus), and high plant species diversity. This diversity in vegetation structure generated by fire is important for wildlife habitat diversity for many animals.

FIRE AND FOREST EXPANSION

In addition to the abundant tree regeneration within the footprint of pre-fire bishop pine stands, fire served as a catalyst for forest expansion into new areas. The forest nearly doubled its extent after the fire, encroaching into pre-fire coastal grassland and coastal scrub. Before the fire, bishop pine stands were



restricted primarily to the high-elevation portions of Inverness Ridge; after the fire, they expanded all the way from the ridge top to the Pacific Ocean (Forrestel et al. 2011). Forest expansion occurred close to both pre-fire stands and around solitary pre-fire bishop pine trees that were at times over 500 meters from the edge of a pre-fire contiguous forest stand (Harvey et al. 2011). These solitary trees were killed by the fire, but the seeds released from their serotinous cones resulted in dense post-fire stands that are now greater than 1,000 stems/ha. Similar to the regenerating stands in areas that were forest prior to the fire, many of these expanded forest stands are interspersed with thickets of blue blossom ceanothus, which increased in extent by more than 4,000% across the burned landscape. Findings from Forrestel et al. (2011) and Harvey et al. (2011) il-

lustrate the importance of pre-fire legacies—the location of pre-fire individual trees, forest stands, and soil seedbanks—in shaping post-fire vegetation patterns that may last decades or more.

KEY UNKNOWNNS AND FUTURE RESEARCH PRIORITIES

While the research following the 1995 Vision Fire provides insights into the disturbance ecology of coastal California pine forests, several key unknowns remain. First, mechanisms underpinning the patterns we observed over 14 post-fire years could be explored through careful experiments. Such designs could help determine the relative importance of initial seed influx (through soil or canopy seedbanks) compared to post-fire competitive interactions in determining the

eventual landscape patterns of forest versus coastal scrub. Second, whether the evidence of forest resiliency and expansion following the Vision Fire is broadly representative of other populations of California closed-cone pines is unknown. Tracking post-fire trajectories or



Mature bishop pine cones on a 14-year-old tree that established after the 1995 Vision Fire. Bishop pine cones are strongly serotinous (they only open and release their seeds after being exposed to the heat of a fire), and are guarded from seed predators with spines on the tips of cone scales.

examining fire histories in other closed-cone pine forests could fill this knowledge gap. Third, with climate change likely to increase fire frequency, understanding the consequences of short-interval fires on the bishop pine forest is needed. If fires were to occur before the trees accumulate a sufficient aerial seed-bank and shrubs and herbs accumulate a sufficient soil seedbank, post-fire resilience may be compromised. Finally, young post-fire bishop pine stands in Point Reyes have been recently impacted by pine pitch canker disease, leading to pockets of locally high tree mortal-

ity. Understanding the potential interactions between introduced disease and subsequent wildfire is another priority for future research.

The vegetation response following the Vision Fire illustrates the importance of wildfire in shaping one of the emblematic forest ecosystems in coastal California. Post-fire research spanning two decades at Point Reyes has demonstrated high natural resilience following severe wildfire in closed-cone pine forests—information that is critical to the conservation of this ecosystem. National Parks serve as vital scientific laboratories that provide insight

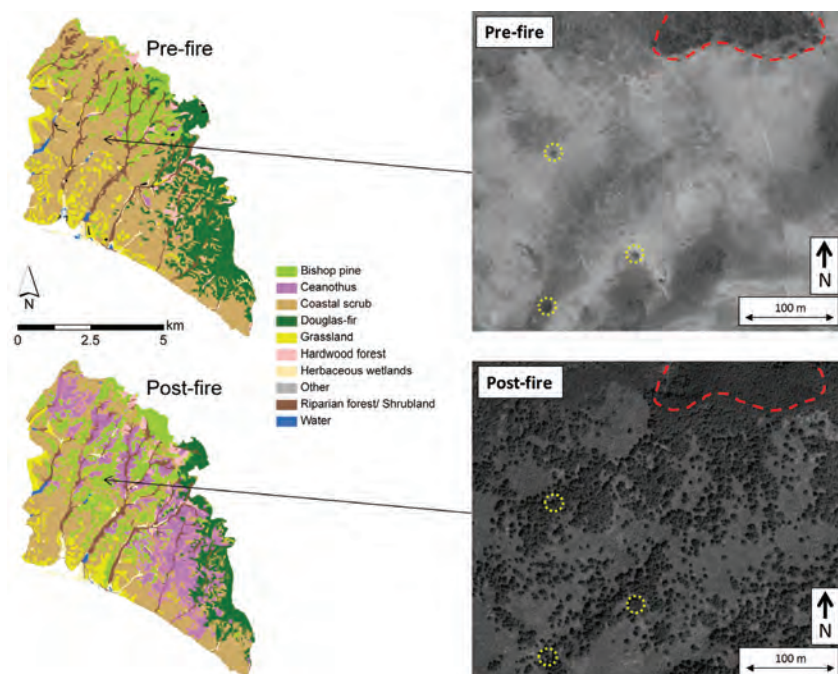
into systems that extend beyond their borders. Parks such as Point Reyes National Seashore, which are within or close to urban areas, are especially unique as they offer an opportunity for visitors to understand the important processes that shape their local ecosystems.

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FIGURE 1. BISHOP PINE FOREST EXPANSION CATALYZED BY FIRE.



LEFT: Map of pre-fire (above) and post-fire (below) vegetation within the perimeter of the 1995 Vision Fire, illustrating the substantial change in spatial distribution of plant communities. In particular, the bishop pine forest (light green) expanded to the southwest.

RIGHT: Aerial photos taken in July 1993, two years before the Vision Fire (above), and August 2012, 17 years after the Vision Fire (below). Photos illustrate the dual modes of post-fire bishop pine forest expansion from pre-fire contiguous stands (dashed red line) and isolated pioneers (dotted yellow line). In both photos the lighter/non shadow-casting vegetation is grasses or shrubs whereas the darker/shadow-casting vegetation is bishop pine tree crowns.

NOTE: Black arrows connect the aerial photos to their corresponding location on the pre- and post-fire vegetation maps.

SOURCE: Maps are modified from Forrestel et al. (2011). Aerial photo data: Google, US Geological Survey, and DigitalGlobe.



ABOVE: A thriving 40-year-old coast live oak in Laguna Beach, California. The homeowners' garden is on a timer system, but they make sure no summer watering occurs under the oak tree's canopy, which contains only California natives adapted to dry summers. Two additional photos (BELOW) show what the landscaping looks like from other angles. Photographs by Allan Schoenherr.

CARE OF NATIVE OAKS IN THE HOME LANDSCAPE

by Barrie D. Coate

The questions I'm asked most often concerning the care of native oaks relate to mature specimens in a home landscape. These trees have usually lived much of their lives without the im-

pact of humans. Although they may have had turf beneath their canopies for 20 or 30 years, this is probably a small proportion of their lives. I'll address some of those questions here, but I'll also address the care of

native oaks that are newly planted in landscapes, since the procedures required for their successful management are different from those for existing mature specimens.

We'll begin by restating a well-



known fact: California's native oaks—and that includes most of the species that we are likely to encounter in the home landscape—do not like water during hot weather. Our native plants, including the oaks, evolved in a Mediterranean climate characterized by natural precipitation (rain or snow) falling only during cool weather. Numerous diseases that can plague our native plants operate most effectively during warm weather when soil moisture is high; the same diseases are dormant or benign when soil moisture is high but soil temperatures are cool.

WE ARE THE CULPRITS

It is our gardening practices that are primarily responsible for killing native oaks. When we water plants during the hot season, certain dis-

eases, especially those caused by soil-borne water molds, have the opportunity to proliferate. For example, oak root tips can die from *Phytophthora cinnamomi*, and the root collar (the area where roots join the main stem or trunk) can die from *Phytophthora cactorum*. Summer irrigation also allows other pathogens to infect oaks, such as oak root fungus (*Armillaria mellea*) and other mushroom-producing fungi.

The more we modify an oak tree's natural environment as we create a new home landscape around it, the more likely it is that the tree will decline and eventually die. This is the conflict that so often occurs between landscape designs and the needs of mature native oaks. When the design calls for turf (grass and its layer of matted roots), as well as other heavily irrigated garden plantings, the soil is usually rototilled to a depth of eight inches. This is precisely where the critical water- and nutrient-absorbing roots of the established oaks are found. Turf, in particular, usually requires frequent shallow irrigation after installation (from three times per week to every day), which is the most frequent cause of oak root death.

layer of organic mulch (wood chips, bark, or compost), and then ceasing the irrigation in the covered area. You can also remove the turf and the top inch of soil with a turf stripper machine and immediately cover the soil with a four-inch layer of mulch. This latter procedure could be followed by the planting of drought- and shade-tolerant herbaceous perennials or shrubs (see sidebar, page 23) to complete the landscape.

BENEFITS OF A MULCH COVER

The single most important thing we can do for our native oaks is to maintain a thick mulch of oak leaves or other organic material under their canopies, to provide the insulating blanket that is so important to their health. A natural coast live oak woodland contains a distinctive set of characteristics that we can emulate in the home landscape when native oaks are present. The ground in those natural woodlands is usually covered with a layer of oak leaves to a depth of six to eight inches, accumulated over several years. The leaves in contact with the soil are continually decomposing, in the process releasing nutrients into the soil and encouraging the growth of all the microorganisms that are part of a healthy, living soil. The trees usually have broad-domed canopies. If they are single specimens, 30 to 40 feet apart, or in a grove, their canopies break the rainfall well above the ground and protect the soil from direct exposure to the sun. The insulating layer of leafy compost provides a "blanket" that helps maintain an even temperature conducive to root health.

Homeowners often view this leafy mulch as untidy and ask their hired gardeners to remove it with a blower (or they do so themselves). This removal of leaf litter is one of the most destructive things that humans do around trees. The practice



Native oaks in the home landscape are most often killed when well-intentioned home gardeners create landscapes incompatible with the needs of these majestic trees. The regular shallow irrigation needed to maintain lawns is the number one cause of oak mortality. All photos by the author unless otherwise noted.

REMEDIATING EXISTING TURF

What should you do if your old oak already has turf beneath its canopy? The important thing is to get rid of the turf. You can eliminate the turf by first covering it with cardboard or newspaper, covering that with a four-inch



Though shapely, this coast live oak has been overly thinned, leaving most of the foliage at the outer reaches of the limbs.

leaves the soil exposed to heat, which will often rise to more than 65°, and dries out the soil where the critical absorbing roots exist. It also eliminates the natural fertilizing of the trees through decomposition of the mulch. Such bare soil is the antithesis of the condition seen in the natural forest.

Soil that is covered with mulch retains moisture much longer than soil that has lost its layer of protective leaf litter. Mulched soil may still hold moisture in the top several inches in July and August, several months after the last rainfall. This moist but not saturated condition is precisely what trees need in spring for healthy new root growth. If hired gardeners simply cannot be stopped from blowing the soil clean of its nurturing mulch, there are a couple of solutions. The most obvious is to

find a different landscape maintenance company. The second is to use a mulch of $\frac{3}{8}$ -inch quarry rock or coarser gravel that cannot be blown away without great effort. Also, do not install landscape fabric or plastic under this gravel cover.

TO PRUNE OR NOT TO PRUNE

The International Society of Arboriculture (ISA) recommends pruning trees only when necessary (usually to remove dead, diseased, or damaged branches), but certainly not on an annual or semi-annual basis simply out of habit. For mature, well-established oaks, it is generally best to consult with a qualified arborist before making any pruning cuts.

Of critical importance in protect-

ing our native oaks is to avoid the over-thinning of the canopy that is such a common practice with many pruning companies. The ISA warns against over-thinning, particularly avoiding the extreme situation called “lion’s tailing.” This practice usually involves removing all of the interior branches of a tree and leaving foliage only at the ends of branches. It has been shown that interior branches act as a counterweight to prevent the excessive movement of limb ends. The removal of interior branches not only does not improve a tree’s structure or its resistance to limb breakage but actually exacerbates it. When hiring an arborist, ask specific questions to be sure that he or she understands proper procedures and is not merely selling an unnecessary and potentially hazardous pruning procedure.



This coast live oak (14" trunk diameter, 20' tall, 25' branch spread) was growing within the footprint of a proposed new medical center on the Stanford University campus. Prior to construction the oak was dug and boxed, and will be replanted once the building is complete.

If you have an old oak that has been over-thinned for many years and is now composed of long, twisted branches with foliage only at the limb ends, there are a few things that you can do. First, avoid any further interior thinning. Be sure the trees are as healthy as possible by mulching, by restricting irrigation beneath their canopies, and by fertilizing—the last only when deemed necessary to compensate for a proven soil nutrient deficiency. Finally, allow the growth of water sprouts at two- to three-foot centers throughout the canopy to begin building a new interior canopy of foliage.

PROBLEMS CAUSED BY GRADE CHANGES

It was not uncommon in the 1920s, 1930s, and 1940s to bring in large quantities of soil to raise the

grade of an entire landscape site, burying the absorbing roots of any existing trees. In addition, the clay soil often used as the fill resulted in poor drainage around the trees. In such situations, roots are cut off from the oxygen that they need to take in, and root collars may suffer from excessive moisture in the soil around them.

If any of the oak trees on your property have been buried under fill soil, begin by carefully removing the soil around the trunk down to the root collar, so that air can reach the trunk to keep it dry. To increase the amount of air that is accessible to the tree's roots, use a trenching machine to dig radial trenches that begin several feet out from the trunk and continue to a point beyond the drip line. Be careful not to grade within the inner-half of the canopy radius.

These trenches should be dug at

least to the depth of the fill soil and preferably several inches below. They can then be filled with $\frac{3}{8}$ -inch quarry rock, which does not decompose but creates a porous environment attractive to roots. The tree's roots will eventually fill the trenches due to the improved oxygen/water environment. This procedure can also be used when heavily compacted soil is found beneath the canopy of a mature oak that was not properly protected during any demolition or construction project, as noted below. To protect tree roots, these steps should only be undertaken by an experienced contractor.

CONSTRUCTION OR DEMOLITION: PREVENTATIVE MEASURES

During construction, contractors often become careless about protect-

ing both the trunks and the root systems of established trees. Demolition contractors are often extremely rough and can cause severe damage to trees during the demolition phase of a project. Before any work commences, hire an ISA-certified arborist to examine any trees on site, evaluate the impact that planned construction will have on them, and offer instructions for their preservation. There are several preventative measures the homeowner can take in the event that construction, demolition, or renovation will occur around existing native oaks. Be certain to allow sufficient time to implement them.

During the planning of a new building or addition, make sure that no soil cuts or grading occur within a distance equal to at least five times the trunk diameter away from the trunk in any direction. If grading may occur in more than one quadrant of the root zone, increase that distance to at least seven to ten times the trunk diameter. If the architectural plans call for grading or trenching closer than these distances, an ISA-certified arborist should be consulted to provide alternative tree protection procedures.

A temporary fence is the single most important tree protection device. Protective fences should be erected before any demolition or construction begins and should have signs warning contractors to avoid damaging or removing the fence without agreement from the site arborist. These fences are critical to preserving the oak tree's root system; the contractor must not store any tools or equipment within the fenced area. No other activity should be allowed within the area enclosed by the protective fences.

Install six-foot high chain link fences mounted on two-inch diameter galvanized iron pipe posts. These fences should enclose as much of the root zone between the building and the tree and be as far away from the tree trunk as possible.

When a building to be demolished is situated close to an existing tree you wish to preserve, wrap the trunk with a protective material such as straw and plastic net rolls.

The fences should remain in place until all contractors and subcontractors have finished their work and left the site. Painters dumping paint thinner or carpenters moving lumber around the trees, even near the end of a job, can result in significant damage to the trees.

NEW OAKS IN THE LANDSCAPE

Native oaks can be planted in sizes from one gallon cans all the way up to wooden boxes as much as 120" in width (and sometimes larger). Specimens raised in a nursery from acorns are usually available in 48" boxes or smaller. Boxes larger than 48" usually contain trees

that have been field grown (in the ground), dug up, and planted in the box.

The benefit of buying a nursery-grown tree is that you are purchasing all of the tree's roots; in contrast, 80% of the roots are left in the ground when a tree is dug from the field. On the other hand, field-grown trees are likely to have the character of a naturally grown tree, while container-grown trees are likely to have been pruned and shaped to fit the space available in the nursery.

It's quite possible to transplant large coast live oaks (such as the coast live oak at Stanford University shown on page 22). However, the cost of digging a tree of this size and weight, the potential for its survival over a long period, and the difficulties of moving it on public highways and installing it in a new landscape setting all discourage many poten-

NATIVES FOR PLANTING UNDER OAKS

Howard McMinn manzanita (*Arctostaphylos densiflora* 'Howard McMinn')
 Monterey Carpet manzanita (*A. hookeri* 'Monterey Carpet')
 Wayside manzanita (*A. hookeri* 'Wayside')
 Oregon grape (*Berberis aquifolium*, syn. *Mahonia aquifolium*)
 creeping Oregon grape (*B. aquifolium* var. *repens*, syn. *Mahonia aquifolium* var. *repens*)
Dudleya species
 Island snapdragon (*Galvesia speciosa*)
 toyon (*Heteromeles arbutifolia*)
 alum root, coral bells (*Heuchera* species and hybrids)
 Douglas iris (*Iris douglasiana* and hybrids)
 sticky monkeyflower (*Mimulus aurantiacus*)
 western sword fern (*Polystichum munitum*)
 coffeeberry (*Rhamnus californica*)
 lemonade berry (*Rhus integrifolia*)
 red-flowering currant (*Ribes sanguineum*)
 evergreen currant (*R. viburnifolium*)
 wood rose (*Rosa gymnocarpa*)
 blue-eyed grass (*Sisyrinchium bellum*)
 snowberry (*Symphoricarpos albus* var. *laevigatus*)
Vancouveria species
 California fescue (*Festuca californica*)

Note: A good reference is the California Oaks Foundation publication, "Compatible Plants Under and Around Oaks" (1991), available for free at californiaoaks.org.

tial users from purchasing trees that large.

Remember that nature plants new oaks from acorns. In general, the smaller the oak at planting time, the faster it will become established in its new setting. Smaller size, nursery-grown oaks will, with proper care, surpass the size of larger boxed trees in only a few years.

PLANTING NURSERY-GROWN OAKS

Trees acquired as nursery-grown container stock can be planted at any time of the year, although autumn is usually the best time of year for planting. Each planting hole should be the depth of the root ball minus 10% to assure that the root collar remains above the surrounding grade after the tree is planted. Use only the native soil as backfill, provided that it allows an acceptable percolation; if the native soil is heavy clay, consider amending it to improve the drainage and aeration.

The most common reason that newly planted trees die is inadequate irrigation of their root ball. Place an irrigation system directly on top of the root ball to be sure that water travels down into it and not merely into the surrounding soil. Without this critical step, the root ball can easily remain dry even when there is plenty of water in the surrounding soil.

Newly planted trees will need to have their root balls irrigated for varying periods of time, depending upon the size of the root ball and the length of time the tree had been growing in its nursery container. For example, a 24" boxed tree will need irrigation for at least two years, and a 48" boxed tree for at least three to four years after planting.

PLANTING FIELD-DUG OAKS

Large trees that have been dug from a field, installed in a box, and

later planted in the ground require special treatment. The process of digging and boxing a large tree puts it under severe stress for some time and makes it attractive to oak bark beetles (*Pseudopityophthorus agrifoliae*). A heavy infestation of the beetles can quickly kill a boxed tree. To prevent such an infestation, spray the trunk and all branches with a systemic insecticide prior to the appearance of any beetles. Check with a qualified arborist for specific products.

A tree dug from the field and installed in a box should not be planted in its new location before it has grown a strong, fully developed root system that extends to the walls of the box. If replanted too soon after being dug, any newly formed roots will be weak and easily broken in the planting process. As an example, a 60" boxed oak will need one to two years for the roots to fill its box, while a 120" boxed tree should remain in the box for two to four years. The exact timing will depend upon the vigor of the individual tree. When the time comes to plant a field-dug, boxed tree into its final location, inspect the tree to be sure that roots have grown to the walls of the box and that the tree is vigorous enough to tolerate the planting.

The newly installed tree must receive irrigation on top of the root ball frequently enough to keep the entire root ball moist but not saturated for one to several years. A soil moisture inspection procedure is the best way to determine this, since it is not possible to evaluate soil moisture by merely looking at the soil surface. A soil probe that registers moisture levels to a depth of 24" can be a potential savior for an expensive tree, which could easily have moist soil at a depth of 8" yet be bone dry at 24".

The notion that rainfall will supply sufficient water during the winter for a large transplanted tree is naïve, since a totally inadequate

amount of rain falls directly onto the root ball surface. It will be necessary to continue irrigating newly planted trees, albeit at a reduced frequency, even through the winter.

It is essential to continue to apply water directly on top of the root ball as long as it takes for the tree to develop sufficient new roots in the surrounding soil to provide support for the foliage canopy. The larger the tree, the more critical this is. A typical 120" boxed oak tree is 25' in height and 35' in spread. It will require many years for the tree to develop sufficient new roots to provide anchorage and a complete water and nutrient supply for that canopy. In the interim, the tree is entirely dependent on the water supplied through irrigation of the root ball and the surrounding soil.

Native oaks have been transplanted at every month of the year at the Stanford Medical Center Project, which I have overseen for the past three years. We have been successful because the post installation irrigation has been adequate. The majority of large tree failures occur by failing to irrigate the root ball along with the surrounding soil.

The presence of a healthy, mature native oak in the home garden adds value to the property by enhancing the aesthetics, modifying the climate, and increasing the habitat for birds and other wildlife. When their relatively simple needs are met, oaks can be among the most care-free of trees in the landscape.

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NEW CNPS FELLOW: DAVID MAGNEY

by Patt McDaniel

David first joined CNPS as a member of the Channel Islands Chapter back in the late-1970s. He brought to CNPS a passion for the native flora supported by his academic training. He earned a BA in geography and environmental studies (with an emphasis in botany) in 1985 from the University of California, Santa Barbara. He also holds an associate's degree in landscape horticulture and a Certificate of Completion in Natural Resources (1975) from Ventura College, is a certified arborist, and is considered an expert in many fields. He has taught courses and given presentations on wetland impacts and mitigation, CEQA, permitting under the Clean Water Act, water quality, wetland delineation methodology, and wetland plant identification.

His contributions to the Channel Islands Chapter are many. He served as conservation chair from 1987–1989 and again from 1999–2003, and has continually been active in conservation activities. He has not been afraid to mount legal challenges after all other options were exhausted, and has taken on many large-scale projects such as Newhall Ranch. In doing so he has worked in conjunction with neighboring chapters and the state conservation program, and has established good and lasting relationships with other groups such as the Environmental Defense Center of Santa Barbara. He played a major role in the protection of the Ventura marsh milkvetch, and has filed several legal challenges against government agencies in defense of native plants.

David has served as Channel Islands Chapter president since 2004, and was interim editor of the chapter newsletter, *Matilija Copy*, for five years (2003–2008). David has served on the chapter board as legislation chair (1995–2003), vegetation mapping and monitoring chair (2003–2005), and served on the Invasive Exotics Committee (2005). He is currently serving as the chapter rare plants coordinator

and webmaster (2005–2014), and is also currently the chair of the conservation committee for the Redbud Chapter.

David is widely known for his contributions to the organization as a whole, which began when he joined the CNPS Board of Directors as Director-at-Large in 1989. He took on the weighty role of CNPS President from 1991 to 1995, stepped over to Vice-President for Legislation in 1995, Vice-President for Conservation in 1996, and then served as a member of the Board of Directors (under the new state organization) from 2002 through 2007. He was elected Chairman of the Chapter Council for 2011, and has continued in that position ever since.

David has made major contributions to our knowledge of the Southern California flora. He created the very first complete checklist of vascular plants of Ventura County in 2011 (based on voucher specimens), and has worked for 30 years on completing a full county flora. He has compiled numerous local plant checklists based on voucher collections and personal observations (mostly for places in Ventura County, 29 of which are



published on a public website), the checklist of Ventura County rare plants, and maps pertaining to biogeography of the county. His extensive data on the flora has provided David with sufficient authority that he has been able to make the County of Ventura aware of the concept of “locally rare plants” as being worthy of protection under law. He continues to promote this as a strategy for CNPS as a whole through his work with the



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CNPS Rare Plant Program and Local Flora Committee.

His interests extend well beyond vascular plants, as he has created and published online checklists of snails, bryophytes, and lichens known to occur in Ventura County. He created and published the first list (preliminary) of rare lichens of California through the California Lichen Society in 1999.



David teaching about riparian plants on a Channel Islands Chapter hike up Lions Canyon in October 2005.

He also has a life outside of CNPS, of course, but that too is all about plants. He formed his own company, David Magney Environmental Consulting (DMEC) in 1997 after working for other natural

resource consulting firms for nine years. DMEC's mission is to provide quality consulting services that are conducted with integrity and a high level of scientific accuracy. He has also taught science and photography at two private schools, worked for the US Forest Service on the Los Padres National Forest performing rare plant surveys, and at the Herbarium at the University of California, Santa Barbara.

David and his lovely and accomplished wife, Jamie Lynne, are excellent dancers, and as avid contra dancers can be seen at dances throughout the state. David has also been developing his cycling skills and on August 17, 2013, rode in his first Century Ride (100 miles) from Ventura to Goleta and back.



On his bike nearing the end of his first Century Ride in August 2013. Photograph by Ron Parker.

David is a very passionate, patient, and dedicated person, and those positive and influential traits surface in everything he does. He truly cares about people and truly cares about the environment, characteristics that have won him the friendship and respect of many. David's contributions to the persistence and preservation of the California flora are extraordinary and are so deserving of this recognition.

BOOK REVIEW

A Naturalist's Guide to the Santa Barbara Region by Joan Easton Lentz. 2013. Heyday Books, Berkeley, CA, in cooperation with the Santa Barbara Museum of Natural History. 485 pages. \$35 paperback. ISBN #978-1-59714-241-0.

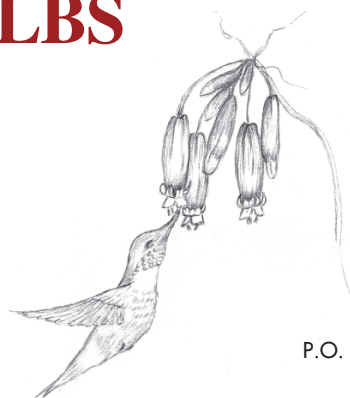
Joan Easton Lentz is an accomplished author who has written three birdwatching books: *Birdwatching: A Guide for Beginners* (1985), *Great Birding Trips of the West* (1989), and *Introduction to Birds of the Southern California Coast* (2006). This fourth book by Lentz is a well-researched and very readable overview of the natural history of a complex portion of California. The book is extensively illustrated with color photographs, color drawings, and maps. The majority of the photographs, which are found on nearly every page of the book, were contributed by nature photographer Stuart Wilson and are of outstanding quality. The numerous drawings and maps were produced by talented and meticulous illustrator Peter Gaede.

The book is divided into eleven chapters. The first two chapters introduce the reader to the physical geography, vegetation, climate, and geologic history of the Santa Barbara re-

gion. The remaining chapters describe the diverse habitats of the region, including the ocean, offshore islands, shoreline, coastal wetlands, coastal plain and foothills, coastal and inte-

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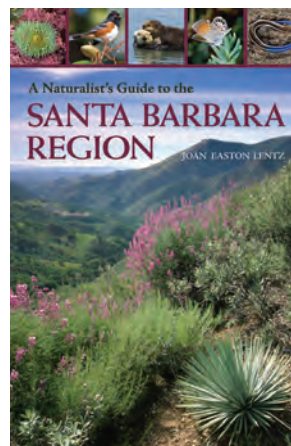
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rior valleys, mountainous areas, freshwater wetlands, and urban parks and backyards. Common organisms that one may expect to encounter in each portion of the study area are discussed, as well as a variety of ecological and distributional information about selected taxa and the habitats where they can be found. Interesting nature journal entries by Lentz, chronicling field trips that she has taken over the years, accompany each chapter.

For each organism mentioned, common and scientific names are given throughout the book and are also listed

in an appendix, where taxa that are not native to the Santa Barbara region are identified with an asterisk. Additional appendices list specific localities where the reader can visit the habitats described in the book, as well as a list of sample field trips organized by location. An extensive bibliography and an index to people, place names, general topics, and common names of taxa complete this fine publication.

This book will be a valuable addition to the library of any naturalist interested in the Central California region. Native plant lovers will also be interested in this volume, as it provides an abundance of interesting, well-organized, and well-researched background information about the



habitats where native plants occur in the Santa Barbara region. It also gives the reader an opportunity to learn more about the complex interactions between the physical environment, animals, and our native plants.

Although it is printed on heavy, high-quality stock, the book may not hold up

to extensive use in the field without the addition of a more durable glue to secure the cover to the book's spine. However, this does not detract from one's appreciation of all of the effort that has gone into the years of background research, writing, photography, drawing, editing, layout, and production of this very attractive and informative book.

—Steve Junak



A Special Offer for CNPS Members

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BERT WILSON: 1951–2014

by Greg Rubin

Native horticulture lost a true pioneer and giant in the industry on March 4, 2014, when Bert Wilson, the founder of Las Pilitas Nursery with locations in Santa Margarita and Escondido, California, passed away unexpectedly at his home. He was 63.

It all started in 1974 when Bert, a young chemistry student, decided he wanted to grow his own native plants. Obtaining his contractor's license in 1977, he began developing strategies to ensure the success of native plants in landscapes. Along the way, Bert introduced a number of popular cultivars, such as *Penstemon* 'Margarita BOP', *Salvia* 'Pozo

Blue', four *Ceanothus* varieties including 'Remote Blue', 'L.T. Blue', 'Celestial Blue', and 'Tassajara Blue', manzanitas including 'Mama Bear', 'Baby Bear', and 'Ian Bush'—the list is long. Beyond these wonderful plant introductions, the protocols Bert developed have had a major impact on native horticulture.

In front of the nursery office in Santa Margarita. CLOCKWISE FROM TOP LEFT: Bert, Virginia Yant, long-time nursery employee, Bert's daughter Penny Nyant, and her daughter Lily. Photograph by Celeste Wilson.



Some considered Bert's approach controversial. At times it contradicted accepted horticultural practice. Yet the underlying principle is straightforward: emulate native ecology as much as possible in the native landscape. It was a response to the frequent failures and negative perception of native plants prevalent in those early days. Bert's profound insight was to view native ecology



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as an impossibly complex, poorly understood, but completely interdependent web of variables, most of which may never be identified. His tactic was to avoid introducing anything that didn't exist naturally in the plant's native ecology. Subjecting such a complex system to non-native inputs might cause it to react in unpredictable ways, possibly leading to failure.

Many who had never met Bert personally certainly knew of him from his astounding website, laspilitas.com. His witty, profoundly insightful, ironic, and slightly dyslexic personality illuminated every word. Coming online very early in the history of the Internet in 1995, this groundbreaking tour de force of native horticulture expanded to well over 5,000 pages of hyperlinked wonder. Not only are 1,400 species and selections of native plants described in detail, but the site is full of useful information on native ecology, horticulture, wildlife, landscape construction projects, and much more.

It also contains a software program (mynativeplants.com) where you can enter your zip code, soil type, mulch,

watering schedule, and exposure, and it will generate a list of appropriate native plants for your site. The website is a work that represents 30 years of research and testing, all of which he offers up to the public for free in order to popularize native plants. It is a body of work that is breathtaking in its depth, yet delightfully quirky and playful. The website continues to grow under the extremely competent guidance of Bert's two children, Penny and Ian, and his wife, Celeste. His surviving family has vowed to continue Bert's important legacy of native plant horticultural research and propagation.

Landscape professionals and homeowners alike have reported unparalleled, repeatable success with Bert's recommendations for light overhead irrigation, unamended soils, appropriate mulches, and design based on native plant communities. Although Bert's untimely death has left a huge void in the native plant community, the strong foundation he created will help support the continued growth of successful native plant landscaping. He will be sorely missed.

SUBMISSION INSTRUCTIONS

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

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FROM THE EDITOR

We are experiencing a convergence of three milestone anniversaries over the next 12 months, all of which are intrinsically connected to the work that CNPS does.

First, 2014 marks the 50th anniversary of the Wilderness Act. This historic bill was signed into law by President Lyndon B. Johnson on September 3, 1964. It created the legal definition for wilderness in the US, and established the National Wilderness Preservation System (NWPS) that set aside an initial 9.1 million acres of wildlands. Today it protects nearly 110 million acres.

In part, the Act defined wilderness in the following manner: "A wilderness . . . [is] an area where the earth and its community of life are untrammelled by man, where man himself is a visitor who does not remain, . . . which is protected and managed so as to preserve its natural conditions." Wilderness designations provide the highest legal and legislative protection for wild lands, and therefore are a critical tool in protecting native plant habitat.

The second notable anniversary concerns the California State Parks system, which turns 150 this year. In 1864 President Abraham Lincoln signed a bill granting 39,000 acres of Yosemite Valley and the Mariposa Big Tree Grove to the State of California. Never before had land been set aside to protect its natural state for the public to enjoy. Today California State parks has grown to be the largest state park system in the US.

The third anniversary is most likely known to many CNPS members, namely the 50th anniversary of the California Native Plant Society in 2015. CNPS was founded in 1965 and has become the most important organization working to protect the state's native flora. The year-long celebration will begin with the upcoming CNPS Conservation Conference next January (see cnps.org/cnps/conservation/conference/2015).

—Bob Hass