MANZANITA

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Re-wilding Landscapes Through Restoration *by Allison G. Kidder*

Allison G. Kidder

A biodiverse mosaic of grassland and shrubland is actively managed on the southern slopes Mt. Tamalpais by interrupting the natural succession from coastal grassland to coyote brush (*Baccharis pilularis*) dominated shrubland to Douglas-fir (*Pseudotsuga menziesii*) dominated mixed evergreen forest.

A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise."

Aldo Leopold, "The Land Ethic," *A Sand County Almanac* (1949)

The topic of ecological restoration is untidy but it is necessary to get waist-high in the weeds to help heal our landscapes. Here we explore why we restore landscapes in the first place, how restoration is actually done, some of the ecological underpinnings of restoration projects, how we might approach restoring ecosystems that are in a constant state of flux, and the Regional Parks Botanic Garden's role in regional restoration projects.

Why restore landscapes?

We often know a degraded landscape when we see one but it takes a trained eye to know what exactly is "wrong" or unhealthy about it. Sometimes it is more difficult to determine if a landscape is degraded but once we learn how an area has been damaged our instinct is to repair it and make it healthy again. What does it mean to improve the health of a landscape? And how exactly do you fix it?

There are many ways an ecosystem can become degraded, including a loss of native plants and animals, invasion by exotic species, pollutants from and remnants of prior human land use, and, depending on land management goals, even natural processes like the succession from one vegetation type to another (for example,

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coastal grassland to coastal scrub to mixed evergreen forest). Restoring degraded landscapes is about figuring out what the problem is. As the late pioneering ecologist, Bob Paine, advised, "If you have to fix something you have to know what's broken."

Landscapes have also been restored to preserve aspects of human cultural history. Many areas have been managed to favor specific plants, animals, and ecosystem functions traditionally utilized by Native Americans for food, tools, clothing, and spiritual practices. Landscapes have also been restored and managed to honor historical ranching activities, such as the two historical ranching districts within Point Reyes National Seashore. A controversial example of restoring landscapes to preserve present-day human activity is removing nonnative eucalyptus trees to decrease wildfire hazard in the Berkeley Hills.

What do you restore a landscape to?

Deciding to restore and rejuvenate a tired and degraded piece of land is the easy part; the hard part of restoration—and maybe the hardest part—is deciding what to restore it to. Here in California people often gravitate to restoring land to a pre-European contact condition, when lands were managed by Native Americans to optimize the production of tools, food, and other resources. But how does one find out what an area looked and functioned like during this snapshot in time? Enter the environmental and ecological historians, or people who specialize in uncovering land use over time by analyzing historic documents such as maps, photos, and shipping records. These experts might reveal what kinds of trees existed along a riparian area before it was forced underground in a cemented conduit, or delineate the shoreline of San Francisco Bay before it was filled for urban development.

But is it wise to set our sights on nostalgic snapshots from the past in this era of rapidly changing climate? Or should we reach forward in time and set restoration goals based on idealized landscapes that accommodate predictions of future environmental conditions? Climate conditions that exist in a landscape today might not exist in forty or fifty years. Consider the dilemma of restoring coastal ecosystems in the face of expected sea level rise, or assisting the plant and animal species that are already starting to relocate to more suitable conditions as the climate warms, moving up the side of a mountain to higher elevation or moving from south to north-facing slopes to cooler, moister conditions. If restoration projects are expected to be successful into the future, practitioners must address these dilemmas.

Setting the goals

The goals of restoration projects can be many and varied. One of the most common and important reasons to restore a landscape—and one of the most difficult to achieve—is to reestablish a landscape's ecosystem services that society depends on, such as providing clean water, pollinating crops, and decomposing waste. Restoration successes depend on sound science and a deep knowledge of the ecosystem being restored. These kinds of projects typically take a long time (often years) to complete and are large in scale, with a single project having multiple stakeholders and requiring several kinds of experts such as soil scientists, hydrologists, botanists, and wildlife ecologists. Further, restoring ecosystem services might conflict with other restoration goals such as increasing biodiversity. For example, rare plants might not contribute much to ecosystem processes and might therefore be overlooked when setting the grand goals of the restoration.

One common practice for setting restoration goals is to establish a reference site, or a location that is not degraded and has a complete suite of ecosystem services. Depending on the scale of the restoration, reference sites can be in an area of land immediately adjacent to the landscape being restored or they can be miles from the restoration site and away from what might have caused the environmental degradation in the first place. For example, if land managers want to restore a central Californian coastal sand dune system that has been invaded by European beachgrass, they might consider areas of coastal dunes along the central coast that harbor native dune plant communities as reference sites (see article in this issue about the sand dune restoration at Abbotts Lagoon in Point Reyes National Seashore).

Many times restoration goals are quite straightforward: remove exotic species in the hopes that native species will reappear. Exotic species can enter a landscape deliberately or unintentionally. An example of a deliberate

United States Army Corp of Engineers and University of California Bodega Marine Reserve

In the 1940s the United States Army Corps of Engineers regularly planted non-native European beachgrass (*Ammophila arenaria*) to stabilize California's coastal dunes. This photograph from 1944 shows new European beachgrass plantings in the dunes north of Bodega Head, the future site of the UC Davis Bodega Marine Reserve.

introduction is the planting of groves of eucalyptus species (*Eucalyptus globulus, E. camaldulensis*) as part of a hopeful timber-producing scheme begun in 1856. While revered by some people for their beauty, these trees have become a serious fire hazard in fire-prone California. Another example of a deliberate introduction was the United States Army Corps of Engineers planting non-native European beachgrass (*Ammophila arenaria*) to stabilize California's coastal dunes (see the article in this issue about dune restoration at Abbotts Lagoon). Once considered great ideas, these acts of ecological tampering have harmed landscapes over time.

Examples of unintentional species introductions abound, from the introduction of non-native marine species from releases of ship ballast water to the spread of non-native grasses and forbs (non-grass plant species) that have permanently altered California's grasslands. The majority of restoration projects focus on exotic species removal across a complete range of ecosystems, from deserts and grasslands to forests and rivers. The goal of these projects is straightforward: remove exotic species. Projects can range from pocket-sized corners of a favorite trail to large swaths of land that volunteers and land managers work on over many years. A great example of what can be accomplished with this kind of dedication can be seen in the articles in this issue about restoration successes at Skyline Gardens and Edgewood Park and Natural Preserve.

Some landscapes are restored for aesthetic reasons because people appreciate the beauty of a certain type of landscape. For one example, trees that have become established through natural succession processes over time might be removed because people prefer seeing a view over an open expanse of grassland instead. Or, for another, the naturally-occurring vegetation succession from coastal prairie grasslands to coastal scrub dominated by coyote brush (*Baccharis pilularis*) to mixed evergreen forest dominated by Douglas-fir (*Psuedotsuga menziesii*) on the southern slopes of Mount Tamalpais State Park is often interrupted because people appreciate the beauty of the grassland-shrubland mosaic of vegetation types and the views of the Pacific Ocean. In this case, the grassland-shrubland mosaic preferred for its aesthetics is also more biologically diverse, which benefits the ecosystem overall and suggests that it is important to achieve a balance in project goals. Evolutionary biologist Sean B. Carroll reminds us in the film *The Serengeti Rules* that restoration "isn't about making the world pretty—this is about making the world productive and functional."

Decisions about restoration goals can be quite practical and are dependent on the outlook of the restoration practitioner. For example, a long-term elk exclosure experiment was established about twenty years ago in the Tule Elk Reserve in Point Reyes National Seashore to track changes that occur in coastal vegetation as elk populations increase after the grazing cattle were removed in 1979. As expected, in areas without the grazing pressure from the elk, native shrubs such as coyote brush have replaced the grasses, thereby resulting in a loss of forage availability for the elk. The edicts of restoration ecology declare this increase in biological diversity a success, but from the perspective of a range manager who wants to ensure the availability of forage for the elk, the results were undesirable.

The how of it: digging in

Once restoration goals are set, the next step is figuring out how to achieve them, be it removing exotic species (often by hand), rebuilding the soil profile, or reviving the river banks. Volunteers play an enormously important role in many projects, from big to small, and through diligent work, sometimes over multiple decades, volunteers can transform a landscape. The article in this issue about restoration activities at Edgewood Park and Natural Preserve is a great example of what volunteers can accomplish.

In some landscapes it is obvious what volunteers need to accomplish, such as removing patches of yellow star-thistle (*Centaurea solstitialis*), while in other landscapes it is less clear. When faced with a degraded landscape dominated by exotic species but with remaining areas of native plants, the Bradley method is a sound approach (see sidebar in this issue).

Regardless of whether a formal method is used or not, the sheer grit and determination of volunteers keep them hand-pulling non-native plants with their sights set on the long-term goals.

Large-scale, multimillion-dollar projects often require earth-moving equipment and professionals (and a fair amount of funding) in addition to volunteer power, particularly in the early stages of a restoration. This approach is often most effective for landscapes polluted by industrial practices or deformed from mining, but can also be applied to landscapes heavily invaded by exotic species. Good examples of large-scale restorations that benefitted from the use of heavy equipment are in this issue's case studies about restorations at Abbotts Lagoon and Drakes Estero in Point Reyes National Seashore.

Some landscapes are restored using other large-scale methods, such as prescribed burning. Prescribed burns, also known as controlled burns, restore landscapes by reintroducing a natural ecosystem process—removing thick stands of vegetation accumulated as a result of over a century of fire suppression. Regular prescribed burning reduces fire hazard and is a technique used by countless land managers and government agencies. Audubon Canyon Ranch's Bouverie Preserve performed prescribed burns in part of the preserve shortly before the October 2017 Nuns Fire and the treated grassland was barely affected by the highly destructive fire that torched the rest of the preserve.

Non-native European beachgrass (*A. arenaria*) covers sand dunes at UC Davis Bodega Marine Reserve in 2017, looking southeast from a dune located in the bottom right of the 1944 photo toward Bodega Bay.

Allison G. Kidder

Matteo Garbelotto

Ione manzanita (*Arctostaphylos myrtifolia*) is vulnerable to the non-native soilborne pathogen, *Phytophthora cinnamomi,* which is spread in the dust dispersed by vehicles along roads and trails. The photo below shows Ione manzanita at the Botanic Garden.

Wikicommons

Ironically, with climate change causing higher temperatures that dry out our wildlands and result in more intense—and deadly—wildfires, we should be prescribing burns to help keep our landscapes safe and healthy.

Considerations for rewilding

Once the stage is set with a newly reformed and cleared landscape, plans usually involve planting natives. But instead of dashing to the local native plant nursery, there are many important things to consider when selecting source material for habitat restoration. One of the most important considerations is using hyperlocal source material, with the plants raised from seed and cuttings collected on site or nearby. Doing so ensures the plants are well adapted to the restoration location and preserves the genetic integrity and diversity of the area. When possible, plants raised from seed collected from multiple individual plants are preferred because these seeds contain the genetic diversity that evolved over countless generations.

As Diana Brenner, MSc, shared in her article in the Winter 2009-2010 issue of this publication, sometimes plants selected for restoration are not the showy ones we might select for our gardens. Rather, plants important for restoring habitat often create the backbone of the restored habitat and serve vital roles in a properly functioning and genetically diverse ecosystem. These workhorse plants might serve more than one purpose in a restoration, such as providing habitat and food for insects, birds, or mammals and having roots that effectively penetrate clay-bound soils to contribute organic matter and increase nutrient and water retention of soils.

But even nurseries that specialize in growing plants to serve as source material for restorations may inadvertently introduce diseases to restored wildlands. One of the most well known examples in the central coast of California is Sudden Oak Death, a disease that primarily kills native coast live oak and tanoak trees, caused by the exotic pathogen *Phytophthora ramorum*. Sudden Oak Death was unwittingly spread throughout the state in the mid-1990s by horticultural garden plants sold from a nursery. Since then, nurseries growing plants used in restoration projects have instituted a number of preventative measures to avoid spreading the pathogen, including raising nursery stock off the ground, installing safe irrigation practices, and sanitizing visitors' shoes before entering the nursery.

Phytophthora ramorum is not the only pathogen restoration practitioners must refrain from introducing. In 2014, the non-native pathogen *P. tentaculata* was detected in restored landscapes by the California Department of Agriculture. It causes stem and root rot and was found in nurseries that grow source material for restoration projects. Many plants commonly used in restoration projects act as hosts for *P. tentaculata*, including mugwort (*Artemesia douglasiana*), California sage (*A. californica*), sage species (*Salvia* sp.), buck brush (*Ceanothus*

cuneatus), sticky monkeyflower (*Diplacus aurantiacus*), California coffeeberry (*Frangula californica*), coyote-mint (*Mondardella villosa*), and toyon (*Heteromeles arbutifolia*). Researchers in the Department of Environmental Science, Policy, and Management in the College of Natural Resources at University of California Berkeley surveyed a sample of restoration nurseries in Northern California and found that four out of five nurseries harbored *Phytophthora* pathogens (another common pathogen in California is *Phytophthora cinnamomi*). They are also studying levels of resistance to fungicides in these pathogens commonly used in agriculture environments and nurseries and the implications for introducing these resistant strains into wild landscapes.

In addition to ensuring genetic diversity and pathogen-free source material, restoration practitioners must decide what to plant in the face of our rapidly changing climate and its expected higher temperatures. Many native plants—especially long-lived species like coast redwoods (*Sequoia sempervirens*) and giant sequoia (*Sequoiadendron giganteum*)—are unable to relocate to areas with cooler temperatures (such as high elevation, north-facing aspects) quickly enough to survive. Some restoration workers are now considering the controversial idea of assisted migration, the deliberate act of moving plants from a habitat where they will not survive in a warmer climate to an area with an ideal bioclimatic "envelope." Restoration practitioners can apply this future-focused concept when selecting which plants that would be expected to survive in a restored landscape in fifty to a hundred years, and longer.

Reestablishing ecosystem processes so we can once again reap their benefits is sometimes as straightforward as reintroducing keystone species, or species that are integral to healthy functioning of an ecosystem. Compelling stories of ecological communities that have practically self-corrected when just one species was reintroduced reflect a trophic cascade of multiple species interactions. The southern sea otter (*Enhydra lutris nereis*) from California's central and northern coasts are predators of purple sea urchins (*Strongylocentrotus purpuratus*) that in turn eat our coast's iconic beds of kelp (*Macrocystis pyrifera*). If you remove the sea otter then urchins decimate the kelp. In Yellowstone National Park, the reintroduction of gray wolves dramatically increased the biological diversity in the park's riparian areas because one of the wolves' favorite foods is elk. Decreases in elk populations and their grazing habits meant an increase in woody plants, such as willows (*Salix* sp.) and quaking aspen (*Populus tremuloides*), which in turn provided habitat for bird species and forage for beaver (*Caster canadensis*) and bison (*Bison bison*). These cases suggest that reintroducing keystone species can be an effective passive restoration practice at very large scales.

When deciding on restoration goals it might be difficult to pinpoint the difference between restoration and land management. Although these concepts overlap in some characteristics, restorations are often viewed as single events whereas land management involves the day-to-day work of maintaining a landscape once it's restored. Volunteer power, heavy machinery, and prescribed burns are used both as land management tools, as well as restoration methods. Once a landscape has been restored you cannot simply lock it up and throw away the key.

Changing landscapes: the notion of novel ecosystems

Restoration does have its limits, and sometimes the act of restoring landscapes is an exercise in accepting those things you cannot change. Humans are transporting species around our planet (either deliberately or inadvertently) at break-neck speeds, and those species are readily becoming naturalized into their new landscapes. These new arrivals often change ecosystem functioning and disrupt native plant communities, resulting in what researchers call "novel ecosystems." In other words, in many cases there is simply no way to restore ecosystems to the way they used to function.

Related to this, the goals of some restorations might not be congruent with the ecosystem being restored, provoking philosophical debates. For example, when new plantings require ongoing maintenance such as watering and weeding, at what point is a restoration simply considered wildland gardening? In an extreme example, with new gene editing technologies at our fingertips, scientists are exploring the de-extinction of species that are no longer found on Earth.

Closer to home, the California Native Plant Society recently embarked on its De-extinction Project. This effort first encourages botanists to

Zoya Akulova-Barlow

San Francisco dune tansy (*Tanacetum bipinnatum)*

Allison G. Kidder

A springtime view of the biodiverse grassland-shrubland landscape on the southern slopes of Mt. Tamalpais overlooking the Pacific Ocean.

try and locate populations of rare plants thought to be extinct (CNPS Rare Plant Rank 1A). If these plants are not found in the wild then the botanists will explore raising these species from material (cuttings and/or seeds) from specimens in botanical gardens and use them in restoration projects. One of the primary missions of the Regional Parks Botanic Garden has been serving as a source of plant material of rare and endangered species for research and restoration.

The garden's role in restoration projects

One of the major functions of the Regional Parks Botanic Garden for founding garden director, Jim Roof, was to have the garden serve as a refuge for rare plants and their conservation. An early area of focus was preserving rare plants from the San Francisco (Franciscan) region as the area's open spaces dwindled in the face of urban development. According to former garden director Steve Edwards, Alice Eastwood visited the garden late in her life and wept when Jim Roof showed her a healthy *Arctostaphylos franciscana* growing in the garden. When San Francisco's Laurel Hill Cemetery was established in the 1850s to serve the city's burgeoning community, the property inadvertently preserved some rare species, including *A. franciscana*. When the approximately 35,000 bodies were exhumed from Laurel Hill and nearby cemeteries and moved to a cemetery in Colma, around 1940, in preparation for a new development, Roof and other local botanists, including Lester G. E. Rowntree, worked to save the manzanitas before the bulldozers demolished them in 1947. When Rowntree presented Roof with a freshly dug plant for the garden, she is said to have told Roof, "I garnered it ghoulishly in a gunny sack."

The garden's wild-collected accessions like the *A. franciscana* have been used as a resource for many restoration projects since its inception on January 1, 1940, including in the city of San Francisco. Decades ago Roof provided seeds and plant material from the garden for the reintroduction of *Arctostaphylos uva-ursi* var. *leobreweri* and San Francisco dune tansy (*Tanacetum bipinnatum*) on San Bruno Mountain. Roof also facilitated the reintroduction of Presidio clarkia (*Clarkia franciscana*) and helped save the one remaining specimen of *Arctostaphylos montana* subsp. *ravenii* within the Presidio.

The garden's plants have also served as source material for restoration projects farther afield. After the 1977 Marble Cone fire in Los Padres National Forest, a crew from the United States Forest Service used a "cherry picker" crane to collect seed from the garden's collection of Santa Lucia firs to help with reforestation of this rare endemic tree. The staff continues to regularly work with local agencies, particularly the East Bay Regional Parks District, to provide materials and expertise for restoration projects statewide.

More than anything, the garden serves as insurance for these rare wild plants, a just-in-case backup plan if a population is on the verge of blinking out. The garden regularly receives requests to collect rare specimens when their populations can afford it to help ensure their existence into the far future, such as when a new

squashberry (*Viburnum edule*) was discovered in the Shasta Trinity National Forest.

Conclusion

With all the change happening in the landscapes around us, we often long for the past, and desire to go back to the way things were, a sense of nostalgia for familiar wildlife or even certain trees. From wetlands to drylands, restoration has been—and will continue to be—an important part of land management, allowing us to recover some of our biological and cultural heritage amidst ever-changing conditions.

Allison Green Kidder became a garden docent in 2017 and serves on the Manzanita *editorial committee. She is fond of California natural history and obtained a PhD from UC Berkeley researching the ecophysiology of California's coastal scrub and grassland ecosystems. Allison manages UC Berkeley's Point Reyes Field Station (https://pointreyes.berkeley.edu).*

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On Mitigating Rare Plant Habitats

by Glenn Keator

Although there are many attempts to exchange parts of rare plant habitat for economic purposes by creating new habitats through mitigation, those attempts often end in failure. Why?

The reasons revolve around the complexity of the original habitat. And while many species of plants can be grown away from those habitats, it's an entirely different matter to successfully recreate whole habitats.

The fact is, that a habitat like a vernal pool, for example, has many interacting and not always well-known factors needed to recreate a successful ecosystem. What are the soils like? What is the microfauna and microflora of those soils? What organisms live in the pools themselves? Is there a fungal network that helps to hold the ecosystem together? Are the right pollinators present? Are there unknown predators, diseases, and pests to be found in the new area where the habitat is being "reclaimed?" The list could go on, but just looking at these factors can make a head ache.

Few things are as complex as soils, especially the topsoil layers where all sorts of often hidden activities occur. Soils are, in a way, our last frontier to understanding habitats, and each soil is unique. Factors of the soil particles themselves include grain size, nutrient availability, and range of pH (the measure of acidity, neutrality, or alkalinity).

The microflora among those soil particles includes algae, bryophytes, fungi, bacteria, and more, while the microfauna may include eggs of various organisms, insects, nematodes, other worms, and rotifers.

These are the considerations that make any recreation of a highly specialized habitat unlikely to succeed in an area marked for future mitigation.

National Park Service

Restoring Coastal Sand Dunes at Abbotts Lagoon, Point Reyes National Seashore *by Allison G. Kidder*

Some large-scale restoration projects require heavy machinery, such as this project at Abbotts Lagoon in Point Reyes National Seashore.

Late in the afternoon my gloved hands were tiring as I aimed my grip to pull yet another handful of non-native European beachgrass (*Ammophila arenaria*) from the dunes. Even though in front of me the hummocks covered by the grass seemed endless, the towering pile I and other volunteers were creating behind us was a heartening sight. We were taking part in one of many volunteer-driven restoration projects to remove non-native European beachgrass and iceplant from California's coastal dunes, and this project happened to be at Waddell Beach, north of Santa Cruz.

Introduced to California beginning the mid-1800s through the 1940s, European beachgrass was often planted to stabilize sand dunes to protect urban developments, such as San Francisco and Bodega Head. The non-native grass was a great choice because of its perennial nature and rhizomatous, clumping stems that can withstand—and even thrive on—extreme sand burial of up to 3.3 feet (1 meter) per year. (Barbour et al. 1985). Wind- and storm-driven sand buries the grass, promoting mostly vertical root and rhizome growth, often extending several feet deep, particularly in the ever-shifting foredunes close to the water. This invasive grass has changed the shape of our dunes from the softly rolling mounds dominated by native American

dune grass (*Leymus mollis*), to abruptly steep-sided hummocks that are reticent to move.

Once the plantings were established, European beachgrass easily spread north and south along the West Coast of North America because fragments of the grass remain viable even after prolonged immersion in seawater (Pickart & Sawyer 1998). By the end of the 20th century California's sand dunes were effectively stabilized, with European beachgrass covering coastal dunes in monotypic stands from about Point Conception northward into Canada. Although our dunes were becoming stabilized, we were watching our native dune flora rapidly disappear.

By the end of the 20th century thousands of acres of the West Coast had been invaded by European beachgrass, including beaches such as those in Golden Gate National Recreation Area and Point Reyes National Seashore. By 2009 approximately 758 acres of sand dunes along the Great Beach in Point Reyes National Seashore alone were completely or partially covered in European beachgrass (NPS 2009). In addition to European beachgrass, nearby dunes had been invaded by iceplant (*Carpobrotus edulis*), a dense, mat-forming plant native to South Africa that smothers native flora (Pickart & Sawyer 1998). But here we will focus only on European beachgrass removal efforts.

Plants and animals of our native dune community were hard pressed to survive in these new conditions, and of particular concern were the eleven rare, threatened, and endangered species that called these dunes their home. The native dune grass, which prefers a fair amount of elbow room between its nearest neighbor, provides perfect spots for the federally threatened Snowy Plover (*Charadrius alexandrinus nivosus*) to nestle their clutches of eggs in the sand, while enabling the birds to keep a close eye on any predators (NPS 2015). Unfortunately, those dense, monotypic stands of beachgrass provide the perfect cover for approaching red and gray foxes and ravens, the main predators of the precious plover eggs, resulting in declines in Snowy Plover populations, as the acreage covered by European beachgrass increased.

Close clumps of European beachgrass also created the perfect habitat for our native deer mouse (*Peromyscus maniculatus*), giving it easy access to one of its favorite meals, the flowering racimes of the federally endangered Tidestrom's lupine (*Lupinus tidestromii*), which hug the sand to keep out of the wind that pounds the dunes. These big-eared mice can eat as much as 82 percent of this endangered plant's seed, preventing the plants from reproducing and their populations persisting (NPS 2009, Dangremond 2010).

Flowering native dune flora also suffered with the invasion of European beachgrass, such as curlyleaf monardella (*Monardella sinuata* ssp. *nigrescens*, CNPS List 1B.2) and the federally

Eleanor Pardini

Tidestrom's lupine (*Lupinus tidestromii;* California Rare Plant Rank 1B.1) seed pods rest on the sand and are an easy meal for the native deer mouse (*Peromyscus maniculatus*).

Eleanor Pardini

Tidestrom's lupine (*L. tidestromii*). Deer mice eat away holes in the plant's fruit to access the nutrient-rich legume seeds inside.

Steven Perry

A tiny Beach Layia (*Layia carnosa*) seedling rises from the dunes near Abbotts Lagoon.

endangered beach layia (*Layia carnosa*) with its tiny pea-sized daisy-like flowers. Both of these plants are more successful in the actively-shifting and open dune habitats found amidst the native American dune grass. These plants join yellow sand verbena (*Abronia latifolia*), beach pea (*Lathyrus littoralis*), seaside daisy (*Erigeron glaucus*), gumplant (*Grindelia stricta*), and other flowering plants in the dunes and nearby coastal prairie grassland as nectar sources for the federally endangered Myrtle's silverspot butterfly (*Speyeria zerene myrtleae*) (USFWS 2017). The population of the butterfly at Abbotts Lagoon is one of two in the Seashore and several in Sonoma County (NPS 2015) where its larval host plant, Western dog violet (*Viola adunca*), can be found.

In light of the dramatic loss of dune habitat and decline of rare species, in 2011 Point Reyes National Seashore embarked on a large scale, multi-phase restoration of the dunes around Abbotts Lagoon. The results of their multi-year pilot restoration projects beginning in 2001 indicated that the most efficient way to remove the deep-rooted European beachgrass was by deploying large excavators to dig up the roots and then burying the rhizome-contaminated sand with clean sand. Their original goal was to mechanically remove non-native beachgrass from 132 acres of dunes in a 300-acre project area, but the total cost was prohibitively high so acreage for removal was reduced to 80 acres in a 190-acre project area (Parsons 2015). The European beachgrass in the rest of the original project area was removed by hand or mechanically in or adjacent to wetlands or near organically-managed pastures, while the rest of the remaining acres were treated chemically (Parsons 2015). Overall cover of the non-native dune grass was reduced from approximately 80 percent cover to zero.

Although recovery of native plants in the mechanically-treated areas was initially slow—and no doubt influenced by California's drought—Tidestrom's lupine relished the newly cleared, mouse-free landscape and came back in force, colonizing almost 16 of the 80 acres in the first year where removal occurred. In one area that was mechanically restored, the number of individual Tidestrom's lupine plants increased from 15,884 in 2012 to approximately 74,000 plants in 2014, a 365 percent increase (Parsons 2015). In another mechanically restored area, the number of plants increased 33 percent, from approximately 150,000 plants in 2011 to approximately 200,000 plants in 2014. Additionally, approximately 900 federally endangered beach layia and 1,500 curlyleaf monardella became established in this same restored area (Parsons 2015).

Removing the European beachgrass has also benefited the Snowy Plover populations. Based on long-term monitoring data maintained by Point Reyes National Seashore, the number of nesting attempts by Snowy Plovers has declined, since a high of 74 nesting attempts in 1987, and

Larry Wan

Although successes of Snowy Plover nesting attempts fluctuate year to year, chicks, like this one photographed at University of California's Coal Oil Point Natural Reserve near Santa Barbara, have a greater chance of survival in restored dune landscapes. In contrast to the dense stands of non-native *Ammophila arenaria* grasses, native dune grasses (e.g., *Leymus mollis*) and other plant species provide just the right amount of protection so Snowy Plover families can see predators coming.

the plovers continue to struggle, plummeting to only seven nesting attempts in the entire park in 2014. Even so, three of those seven 2014 nesting attempts were in the Abbotts Lagoon restored dune habitat, and that trend has continued. Monitoring surveys of Snowy Plover nests in the park showed that 20 of 45 nests were located in the restoration area, a success that should be celebrated. However, Snowy Plover populations continue to be challenged by habitat disturbance by people, dogs, and egg and chick predation, as ten of those 20 nests had eggs hatch and only three of those ten eggs actually fledged (NPS 2015). Park ecologists attempt to protect Snowy Plover seasonal nesting areas from disturbance by cordoning-off large areas of beach and dunes.

Given their goal of removing the invasive non-native beachgrass to benefit native dune vegetation and wildlife interactions, Point Reyes National Seashore considers the Abbotts Lagoon restoration a definite success. Park ecologists continue to monitor plant and animal populations closely and there are many aspects of the restoration that still need to be studied, such as surveys of Myrtle's silverspot butterfly populations. Seeing the beauty of this newly restored flowering native dune landscape is both inspiring and definitely worth a visit.

Allison G. Kidder

Restored dune ecosystem, Abbotts Lagoon, Point Reyes National Seashore

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National Park Service

Restoring Drakes Estero: A Journey Back to Eelgrass

by Allison G. Kidder

An excavator, precariously balanced on a floating barge, removes wood oyster racks from Drakes Estero in Point Reyes National Seashore, September 14, 2016.

The heavy excavator balanced precariously on the floating barge as it lowered its gaping maw over the edge and into the water, bringing up a dripping pile of algae- and mud-covered PVC pipe and pressure-treated wood from the bottom of Drakes Estero in Point Reyes National Seashore. This was part of a large-scale restoration of the estuary after the controversial departure of Drakes Bay Oyster Company, a business that began in 1932 when the Point Reyes peninsula was private land.

To say the departure of Drakes Bay Oyster Company was controversial is putting it mildly. The oyster farm was located smack dab in the middle of the largest part of Drakes Estero, an estuary in the 33,370-acre Phillip Burton Wilderness Area within the boundaries of Point Reyes National Seashore. The controversy revolved around whether the 80-year-old commercial operation could renew their lease with the National Park Service and sparked lively debates about the meaning of wilderness and whether the oyster farm was negatively affecting the Drakes Estero ecosystem and its inhabitants.

Drakes Estero is one of only two federal marine wilderness areas in the United States (the other is in Alaska) and is also a California Marine Protected Area. The protected estuary supports about 1,000 acres of rare eelgrass (*Zostera marina*), some nine percent of all eelgrass found in California. Eelgrass beds serve as nurseries for many species of fish and actively sequester carbon from the atmosphere, especially important with the rising levels of atmospheric carbon dioxide and resulting ocean acidification. In addition to supporting eelgrass beds, the estuary provides habitat for leopard sharks (*Triakis semifasciata*),

coho salmon (*Oncorhynchus kisutch*), tens of thousands of shorebirds and waterfowl, and harbor seals (*Phoca vitulina*) that haul out to give birth to 300–500 pups every year.

Drakes Bay Oyster Company began life as the Coast Oyster Company that raised non-native Pacific oysters (*Crassostrea gigas*), which were introduced from Japan by the United States Fisheries Service (precursor to the National Marine Fisheries Service) and the California Division of Fish and Game (precursor to California Department of Fish and Game) to help reinvigorate the lackluster west coast oyster industry.

A man named Charley Johnson, who learned the oyster trade while employed by Coast Oyster Company, bought the company in 1957 and renamed it Johnson Oyster Company. Eventually he negotiated with the National Park Service for a 40-year lease and permits to continue growing and harvesting oysters and maintaining its packing facilities in Drakes Estero. His son Tom eventually inherited the Johnson Oyster Company, but it was plagued by poor finances, government code violations, and a resulting cease and desist order from the state. Flummoxed, in 2005 Tom sold the company to Kevin Lunny, a nearby rancher within the park, with a solid reputation for wise land management on land his family had ranched for multiple generations. Mr. Lunny changed the name to Drakes Bay Oyster Company and promised to improve the oyster farm operations and facilities to resolve the code violations, but the lease was still required to end in 2012.

Drakes Bay Oyster Company developed a large following and a thriving business and Mr. Lunny worked to renew the lease for another ten years to 2022. But the National Park Service had its hands tied: Drakes Estero comprised most of the 8,003 acres designated by the United States Congress as potential wilderness, a portion of the Phillip Burton Wilderness area that would become wilderness once non-conforming uses (such as commercial operations) were removed. The United States Congress expected the National Park Service to eventually designate Drakes Estero as wilderness, therefore renewing the oyster farm's lease was not legal. Even so, because of the raging debate, the National Park Service initiated an environmental review of the lease renewal and received more than 4,000 comments during the seven-week initial comment period during fall of 2010. The renew versus not-renew controversy had passionate supporters on both sides, oftentimes forcing a division between both the environmental and the organic sustainable food communities, but ultimately the government decided to not renew the oyster farm's lease. Once the farm ceased

These two photos show an area of Drakes Estero where rectangular oyster racks were removed. The top photo was taken shortly after rack removal and the bottom photo is the same area one year later. The eelgrass has already begun repopulating the vacated floor of Drakes Estero. Thomas W. Bell photos

Max Castorani

Tom Bell, of Earth Research Institute at University of California Santa Barbara, flies a drone over Drakes Estero in Point Reyes National Seashore to document changes in eelgrass coverage after the removal of oyster racks.

operations and departed the site in December 2014, the Drakes Estero was ripe for a large-scale restoration project.

The goal of the $4 million restoration project was pretty straightforward; remove the buildings and facilities from the shoreline and remove oyster racks and debris from the water in order to increase eelgrass cover, reduce invasive species, and help restore ecosystem processes, such as nutrient and tidal flows through the estuary. By the time the ten month restoration project was completed, in November 2017, more than five miles of pressure-treated wood from 95 oyster racks, 1.5 acres of plastic mesh that were buried in sediment beneath the oyster racks to prevent the oysters from burrowing, and over 1,300 tons of plastic debris, PVC pipe, metal rebar, cement blocks, and shell debris were removed from the estuary. Excavators perched on floating barges removed about 7,000 wooden posts buried five feet deep in the mud and retrieved debris from the bottom where there was no eelgrass. Divers removed the rest by hand in areas where eelgrass was growing.

The removal of the all the debris is obviously good for the estuary, but is the restoration considered a success ecologically? Like any restoration project, the budget for the project included monitoring, and much of that part of the project is still in the early stages so it's a bit too early to know. Monitoring harbor seal and bird populations can readily be accomplished using binoculars and spotting scopes, but how

does one monitor increases in the cover of eelgrass beds without disturbing the bottom full of fragile roots and shoots? Use drones!

Although flying "unmanned aircraft systems" by hobbyists is generally not allowed in national parks, the National Park Service allows researchers to apply for special permits to use drones in their research to monitor large areas of hard-to-reach terrain using various kinds of aerial imagery. The requirements to fly drones in national parks are many, and include an extensive permitting process and many signatures of approval, as well as a current drone-flying license with the Federal Aviation Administration.

Researchers Max Castorani of University of Virginia and Tom Bell of University of California Santa Barbara's Earth Research Institute are working (NPS Permit PORE-2018-SCI-0005) to capture post-restoration aerial imagery of Drakes Estero using a three-pound, four-propeller DJI Phantom 4 Pro drone. They flew several sets of flights over the restoration area during 2017 and 2018 and will complete at least one set of flights in 2019 with the goal of photographing the entire Estero once per year, and individual bays within the Estero two or three times per summer, one square kilometer at a time.

As long as the sun angle and tide and wind conditions cooperate, their imagery allows them to look at eelgrass recolonization into the restoration areas and document how the eelgrass populations change between years and within years. Making use of the fact that eelgrass reflects light differently and is more structurally complex than nearby wet sand and water, the researchers have just begun a painstaking pixel-by-pixel analysis of their images in order to develop a computer algorithm that will

Aerial view of Drakes Estero, February 12, 2015. Abbotts Lagoon is just left of upper center of photo. Bobbi Simpson/National Park Service

National Park Service

A growing pile of French tubes and other debris removed from Drakes Estero in Point Reyes National Seashore sits in the foreground, with a large excavator in the background, (January 5, 2017).

automatically classify eelgrass habitat. (Each pixel represents about a 4 cm x 4 cm area.) This new approach to birds-eye-view imagery of the estuary will help the National Park Service—and people busily restoring eelgrass populations in other parts of the world, including San Francisco Bay—to easily monitor the recovery of this important, yet rare, aquatic habitat in years to come.

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Should the restoration of Drakes Estero include the re-introduction of California's native oysters?

Did California's native Olympia oyster (*Ostrea lurida*) historically grow in Drakes Estero? These native bivalves range from Baja California to British Columbia, and abound where their tiny larvae can attach permanently to hard surfaces like rocks and older oyster shells, forming beds. Archeologists examined seventeen documented middens (also known as shellmounds) surrounding the estuary and found scant evidence of native oyster shells in the lower strata of these prehistoric shellmounds, with the youngest shellmound being 1,100 years old. Large numbers of native oyster shells have been found during investigations in shellmounds on the eastern shores of San Francisco Bay, which isn't surprising given the presence of pre-Gold Rush commercial oyster fisheries.

However, the low numbers of native oyster shells in shellmounds next to Drakes Estero suggest that the native oyster simply wasn't prevalent in Drakes Estero. This finding is supported by the fact that oysters require a hard surface to grow on and such features are noticeably absent in this estuary, (hence all the man-made underwater substrate that was in place for the oyster farming operation). Instead, the muddy and sandy bottom of Drakes Estero supported large populations of native clams like the California butter clam (*Saxidomus nuttallii*) and Pacific gaper (*Tresus nuttallii*) that burrow in the sandy bottom of the estuary.

Efforts to restore populations of our native Olympia oyster in nearby San Francisco Bay have been ongoing for more than a decade. In fact, in 2006 Kevin Lunny, the Point Reyes National Seashore cattle rancher and former owner of Drakes Bay Oyster Company, worked closely with the National Oceanic and Atmospheric Administration (NOAA) and financially supported attempts to reestablish native Olympia oysters in San Francisco Bay. Recent reintroduction efforts continue today through a coalition of researchers from universities throughout the state and several state and federal government agencies. As one might suspect, with oysters that thrive in areas with plenty of underwater rocky substrate, their reports suggest that sedimentation is the primary threat to oyster re-establishment.

For more information about efforts to reintroduce our native Olympia oyster, view the researchers' full report here: http://www.sfbaysubtidal.org/OYSTERGUIDE-FULL-LORES.pdf

Skyline Gardens Restoration Project *by Glen Schneider*

Glen Schneider

Figure 1. Three days after vinegar sprayed (left side) on a raffish section of annual grassland

The Skyline Gardens Project involves both a botanical census and restoration of 250 acres of watershed in the High Ridge Volcanic Area between Tilden Regional Park's steam train and Highway 24. It is sponsored by the East Bay Chapter of the California Native Plant Society under a special permit from East Bay Municipal Utilities District (EBMUD).

This area is a Noah's Ark of native plants and is the most botanically diverse area of its size in the East Bay. We have verified 278 native species to date. The project is nearly 3 years old. We hold workdays twice a week and have held over 250 workdays totaling nearly 1,800 volunteer shifts.

This article focuses on restoring the native flora in the "High Ridge Meadows" section of the project. Based on the Bradley method, our strategy is to first exhaust the seed bank of the invasive species. Our motto: Remove the Exotics! These include Italian thistle (*Carduus pycnocephalus*), poison hemlock (*Conium maculatum*), filarees (*Erodium* spp.), false dandelion (*Hypocharis* spp.) and grasses such as wild oat (*Avena fatua*) and bromes (*Bromus* spp.). The seeds of most invasives are actually quite short-lived in the soil, making it possible to eradicate them in a three-year time frame.

One of the pioneering techniques we're using is vinegar spray to kill young invasive seedlings. This is quite effective, especially on dicots. Horticultural grades of vinegar are available at 20 to 30% acetic acid, but we find that a dilution to 5% acetic acid is effective—by the way, this is the concentration of ordinary household distilled vinegar and is much cheaper.

Vinegar is a natural product made from fruit or grain. It is a simple molecule that breaks down naturally to water and CO2. Vinegar used as a "contact spray" burns the foliage of plants, but unlike systemic weed killers like Roundup (glyophosate), is not taken into the stems and roots. Vinegar may require a second spray, especially on large-seeded grasses like wild oats.

See figures 1 and 2 for examples of vinegar's effectiveness. For some reason, vinegar is particularly deadly on Italian thistle (*Carduus pycnocephalus*), an annual, and most Asteraceae seedlings. It even kills the taproot in the rosette stage (up until early March).

Cynthia Adkisson

Figure 2. The dead Italian thistle (*Carduus pycnocephalus*) (left) two days after being sprayed. The live one (right) was unearthed a minute before the photo for comparison.

All plants in Figure 3 (early April 2018) are natives: blue dicks (*Dichelostemma capitatum*), California poppies (*Eschscholzia californica*), biscuitroot (*Lomatium* spp.), soap plant

(*Chlorogalum pomeridianum*), goldenaster (*Heterotheca* sp.), and California buckwheat (*Eriogonum fasciculatum*). There are also several species of native grasses: purple needlegrass (*Stipa pulchra*), California melic (*Melica californica*), and June grass (*Koeleria macrantha*). Gone are the blanket of thistles, rose clover (*Trifolium hirtum*), filaree, and false dandelion that had blanketed and choked the natives growing underneath.

In the third year, once the invasive seed bank is under control, we will sow with a mix of locally gathered native annuals. After that, our job is to keep tabs on the occasional weeds and let the natives sort themselves out.

See the chart below for a summary of our restoration scheme.

In Figure 4, we look east from the Skyline Trail. Two years ago this trail edge was a menacing thicket of Italian thistle. Underneath were a few poppies and popcorn flowers (*Plagiobothrys* sp.). With the thistles gone, the natives have come roaring back. Our spirits soar as we nurture this beautiful land back to wholeness.

Glen Schneider is a Bay Area naturalist and native plant specialist. He is the organizer of the Skyline Gardens Project, a habitat restoration effort in the Berkeley Hills above the Caldecott Tunnel. An East Bay native, he grew up in a local nursery family and has been a native plant garden landscape designer/builder for over forty years. He is currently writing a nature field guide to the East Bay. His own native plant garden in Berkeley is on the Bringing Back the Natives Garden Tour every year. In March of 2018, Glen and Skyline Gardens received a Jefferson Award for Public Service and were featured on KPIX Channel 5 TV
http://sanfrancisco.cbslocal.com/2018/03/08/skyline-garden-project-restores-native-plants-to-east-bay-trail/

Visit the Skyline Gardens website: skylinegardens.org, or on Facebook at: https://www.facebook.com/SkylineGardensEBCNPS

Restoration Sequence

Year	Major activity	Method	Other
1	Prevent Seed formation	Weed-eater	Hand cut
2	Prevent new seedlings	Vinegar spray	Hand weed
3	Sow natives	Seed banks	Broadcast; weed

Glen Schneider

Figure 3. A high-ridge terrace, looking west, after one year of mowing, spraying and hand weeding

Meredith Nielsan

Figure 4. Along the Skyline Trail, with Mount Diablo in the background

Thirty Years of Habitat Restoration Work at Edgewood Park and Natural Preserve

by Ken Himes

Kathy Korbholz

Serpentine grasslands at Edgewood Natural Reserve

Edgewood Park and Natural Preserve, in San Mateo County, has one of the longest-running habitat restoration programs on the San Francisco Peninsula. Much has been learned from our work, much has been accomplished, but threats remain such as the recent arrival of stinkwort (*Dittrichia graveolens*).

The program has had three leaders: Elly Hess from 1989 to 1999, Ken Himes from 1999 to 2006, and Paul Heiple from 2007 to the present. A major strength has been the consistent effort of volunteers under this leadership.

In the 1960s, the state of California purchased the Edgewood site for a proposed

Ron Vanderhoff

Stinkwort (*Dittrichia graveolens*)

Edgewood Hills State College. It was never built. During state ownership, trespassing off-road vehicles and motorcycles tore up much of the grassland habitat on both sides of the Central Ridge. The disturbances left these non-serpentine grasslands vulnerable to invasion by non-native plants. It wasn't until San Mateo County purchased the site from the state of California in 1980, with partial funding from the federal government and the Midpeninsula Regional Open Space District, that the off-road vehicles were excluded from the site.

The county's plan was to build an 18-hole golf course at Edgewood, which would have destroyed much of the grassland habitat, especially the serpentine grasslands. The California Native Plant Society (CNPS), Santa Clara Valley Chapter (SCVC), as part of a coalition of local environmental groups, was very involved in a thirteen-year effort to prevent the development of the golf course. In 1993, Edgewood was declared a Natural Preserve. For the full story, see the article in the CNPS journal *Fremontia*, Vol. 36, No. 1, Winter 2008, entitled "Edgewood County Park and Natural Preserve: How it Happened" by Carolyn Curtis. The article is valuable as it gives a full list of the special status plants at Edgewood.

A member of the Edgewood Park Committee and our first leader, Elly Hess, was definitely ahead of her time. Her early work at the preserve was extremely significant, partly because she returned to sites to follow up year after year. Elly had noticed an increase in certain invasive non-native plants. Although SCVC was applying for permission to control certain invasive plants, the permit was yet to be granted, and Elly was actually cited in 1989 by park staff for working without a permit. According to Elly's notes of January 7, 2000, the county would not give permission to weed through CNPS because CNPS had filed a lawsuit in 1983. "However, the county people knew me, so they gave me permission to work in the park." Eventually, SCVC was able to obtain permits from San Mateo County.

Elly further mentioned in her 2000 notes that "this was before the founding of the California Invasive Plant Council (Cal-IPC). You have to realize that there was very little attention being given to weeds even from CNPS or the County." Elly recruited many of her friends from the Loma Prieta Chapter of the Sierra Club. They formed the nucleus of her team for the next decade. The Friends of Edgewood was formed in 1993 and also contributed members.

In the early 90s, Elly and her team of volunteers worked tirelessly on wild teasel (*Dipsacus fullonum*), which occupied more than 25 acres of the preserve. Much of the late winter and early spring sessions were devoted to digging out its large tap roots. By the time

Kathy Korbholz

Wild teasel (*Dipsacus fullonum*). Cutting off the heads won't work!

Elly retired from weeding in 1998, the teasel was under control and only occasional rosettes of leaves could be found. During the winter, Elly and her team also began removing five and one-third acres of French broom (*Genista monspessulana*), which occurred mostly in the northeastern part of the preserve, near the Day Camp Picnic Area. By 1995, all large plants had been removed, and sweeping (looking for and removing) for broom seedlings had begun. We continue sweeping broom sites and are still removing thousands of seedlings. The size of the seed bank is unknown, but sweeps will be needed for many years, well after we retire.

The mid 90s brought an end to our five-year drought with heavy rainfall, including the 1998 El Niño. It was Elly who noticed an increase in yellow star-thistle stands (*Centaurea solstitialis* aka YST). Ken Himes, who joined the team in 1995, also noted a YST expansion towards a colony of fragrant fritillary (*Fritillaria liliacea*). A 1999 photo shows the huge expanse of YST. In June, instead of brown, the grasslands of Edgewood would be colored blue-green, the color of YST leaves.

We also discovered isolated star-thistle colonies beyond the Fritillary Meadow that potentially could threaten a colony of state and federally listed Marin western flax (*Hesperolinon congestum*). These isolated colonies were targeted by Elly early in 1993.

Below is a sample timeline of volunteer hours to remove an isolated yellow star-thistle colony on the edge of the Fritillary Meadow.

1996	4 people worked 3.0 hours each for a total of 12 hours.
1997	6 people worked 1.5 hours each for a total of 9 hours.
1998	2 people worked 2.0 hours each for a total of 4 hours.
1999	1 person worked 1.5 hours for a total of 1.5 hours.
2000	1 person worked .75 hours for a total of .75 of an hour.
2001	a sweep removed 118 plants for a total of 30 minutes.
2002	a sweep removed 42 plants for a total of 10 minutes.
2003	a sweep removed 9 plants.
2004	3 people (Paul Heiple, Drew Shell, and Ken Himes) swept the site and found no plants present.
2005	Paul Heiple swept the site and removed one plant before seed formation.
2006	no plants present.

Kathy Korbholz

Highly invasive yellow star-thistle (*Centaurea solstitialis*), also known as YST

Proper timing and persistently returning to the site were key to reaching zero plants. We still monitor the site. All work was done manually.

Hand removal is fine for dealing with small colonies of YST, but we had acres throughout much of the non-serpentine areas. University of California publication 21541, *Yellow Starthistle Biology and Control*, indicated that well-timed mowing repeated once or twice a season could be very effective for managing YST stands. And so a partnership of SCVC and Friends of Edgewood approached the county in 1999 to begin a mowing program.

We selected a dense stand of YST adjacent to the Fragrant Fritillary Meadow. The county was able to mow 5.69 acres and repeated their mowing about six weeks later. Meanwhile, volunteers started removing re-sprouts and plants in coyote brush (*Baccharis pilularis*) that were missed by mowing. Naturally, we call this site Mow Site One. We also had an isolated site in the northeast part of the park where we monitored progress better; it was only three-quarters of an acre, and we named it Mow Site Two.

As we reduced densities in the original mow sites, we expanded acreage to include additional mow sites. We doubled our acreage in 2001 to fourteen-and-one-third acres. It was now a challenge for volunteers to keep up with removal of re-sprouts. We bagged all flowering YST plants to prevent any chance of seed production. Filled bags were picked up by the county and hauled offsite.

By the end of 2004, our partnership had treated almost 26 acres of formerly dense stands of yellow star-thistle. We expanded again in 2005 and 2006 by another 5.34 acres. Our monitoring covered seven transects showing a decrease from 20.6 percent cover in 2001 to 0.20 percent cover in 2015. It will be difficult to get YST completely down to zero in large sites. Small plants hiding amongst the dry grass in non-mowed sites are difficult to spot. Nevertheless, there has been a tremendous improvement in the health of Edgewood grasslands as a result of controlling YST stands. Our volunteer hours at Edgewood increased from 739 hours in 1995 to 3046.5 hours in 2006.

At the end of 2006, Ken Himes passed the leadership over to Paul Heiple, the Invasive Plant Chair for the Santa Clara Valley Chapter of CNPS.

As we celebrate 30 years of restoration work at Edgewood, an exciting new project is about to begin in 2019, the Green Grass Project 467.

Though Ken Himes has been a member of the California Native Plant Society since 1974, he became a very active and influential member of the Santa Clara Valley Chapter beginning in 1983. He was named a CNPS Fellow in 2006 in recognition of his exemplary service to CNPS and to the California flora.

Kathy Korbholz

Fragrant fritillary (*Fritillaria liliacea*)

The Bradley Method *by Maggie Ingalls*

This article is based on a small handbook called *Bringing Back the Bush: the Bradley Method of Bush Regeneration*, by Joan Bradley (1988). It is worth tracking down for the information about the most helpful tools and detailed instructions on how to remove bigger plants with a minimum of disturbance to the native plants.

It was developed in Australia by two sisters, Elaine and Joan Bradley, during the 1950s and 60s. They developed their method by trial and error combined with careful observation and documentation—the classic methods of science. Devoted naturalists and "keen gardeners," they could see that the Australian bush was being overrun by non-native plants. Lantana and privet were the most common large culprits, along with a host of smaller invasives. The common method of tackling invasive plants—removing large plants by brute force—started with the most heavily infested areas, where the results are immediately obvious. Smaller weeds were also removed and then the newly cleared area replanted with native plants.

The sisters were working on their own as volunteers without the manpower and tools to take this labor-intensive approach. Instead, they weeded during their daily walks, working when the weather and soil were favorable (not during rain, and not when the soil was rock hard). In the mid 1960s they were able to observe the effects of the brute force method, when part of Ashton Park was cleared by park staff. Two years later the lantana was back in full force. But the areas that they had cleared with their gentler method were covered with thriving natives.

The Bradley method calls for a change in perspective: this is not about weeding a natural area, it is about assisting a natural area to regenerate itself. The heart of this method is to avoid damaging the natives and disrupting the soil and its natural cover of mulch. "Weed control fails when you treat the work like farming or gardening—clearing away the plants that you do not want, and cultivating plants that you do. … Direct your mind always, not towards the slaughtered weeds, but towards the growing natives."

The Bradley method is based on three principles:

• Work outwards from "good" bush areas, towards areas of weed.

Continued on page 31

A 1999 photo (above) shows the huge expanse of YST. In June, instead of brown, the grasslands of Edgewood were colored blue-green, the color of YST leaves. Compare with photo (below) taken ten years later, after years of removing the thistles and making periodic sweeps. Photos courtesy of Ken Himes

The Edgewood Weeders *by Paul Heiple*

Writing about the Edgewood Weeders is telling a story of devotion and persistence. The project I now lead has a history that goes back to 1989, five years before I moved to California, a time when I might have been able to name a dozen California native plant species and Edgewood was being considered for a golf course or some other "useful" purpose.

The earliest leaders focused on large, visually obtrusive weeds like teasel, bull thistle (*Cirsium vulgare*), and fennel (*Foeniculum vulgare*). At that time there was not much information on the best ways to control some of these exotic species. The first attempt to control teasel was to cut off the flower heads. The plants responded by growing more flower heads. The next strategy was to cut off the rosettes, but we learned that the root can sprout a new rosette from about a four-inch depth. These lessons had to be learned the hard way.

I got involved at Edgewood in order to learn the plants in the state in which I had just taken up residence. It was then that I heard about the effort to stop yellow star-thistle (YST) from advancing into rare plant habitat. I started

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Wild Weeders: from left to right, Dave Hershey (kneeling), Diana Quon, Alf Fengler, Ken Himes, Matt Amorose, and Cathy Castill

weeding on a more regular basis with our leader Ken Himes. Sometime around 1998, Ken showed me the University of California publication, *Yellow Starthistle Biology and Control.* This gave us information on the timing of mowing. We got the San Mateo Parks Department to set up a mowing experiment. Mow Site One showed a marked decline in plants against a control. We had a successful method and started a program to control YST.

The UC Publication also contained information on the plant's life cycle, insects that feed on it, the effects of an infestation, and methods of insect population control. I also learned about Cal-IPC and their "California Invasive Plant Inventory." This opened the door to weed science: we learned weed life cycles, how to evaluate weeds based on their damage to the ecosystem, and different experimental control methods. We learned to target the most damaging species if a workable technique for control could be developed. Ken and I began biology and ecology talks with docents and volunteer weeders so that we could evaluate the invasive plants in Edgewood. A surprise to us, Italian thistle (*Carduus pycnocephalus*) had not made Table 1 of the Cal-IPC Inventory, yet at Edgewood we found it to be a highly invasive and difficult weed. (Our work was vindicated in the next version of the inventory where it made Table 1.)

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Italian thistle (*Carduus pycnocephalus*)

Ken led the weeders from 1995 to 2007, establishing the Wednesday evening group during the summer for volunteers who could not come out Friday mornings. Volunteer hours virtually doubled in seven years, from about 2,100 hours in 2000 to just over 4,000 hours in 2007. This workforce attacked over eighty species of invasive plants in Edgewood. Many of these species dropped to very low levels. Mowing of YST with follow-up hand pulling proceeded at a rate of about eight acres a year.

In 2007, I took charge of the Friday weeding. My goal was to step up the removal of YST and eventually remove it from Edgewood. The first year went as planned, a site of eight acres was mowed, followed by hand removal. The next year the plan went off the rails—the great recession was under way, and money for mowing dried up. The weeders were back to hand pulling only.

I began to look for ways to continue the momentum by changing the way we handled the weeds. Most of the time the weeds were bagged and removed from the park. The remote locations in which we were now working made this a major use of time. Experiments showed that making piles on site did not cause bigger infestations. Further, YST is never found in the shade—this observation led me to try putting the pulled weeds under nearby oaks or in thick brush instead of bagging them. Both methods worked well and gave the weeders about fifty percent more time to remove plants.

Another benefit of keeping the pulled plants in the park came when the plants began to flower. Many of those seed heads contained the larvae of bio-control agents, insects released in California to damage YST seeds and reduce the number of seeds produced. Bagging had been removing these insects from the park; keeping the weeds on site meant that as the insects reached the adult stage, they could go after the remaining stands of YST.

I also found that, at no time from the first seed maturation to plant senescence, did pulling become totally ineffective at control. Yellow star-thistle has two types of seeds: one that is ready to disperse as soon as the head ripens, and a second type that is embedded in cotton-like fiber on the receptacle. These seeds do not drop from the head until the entire head begins to disintegrate in the rains. Removing these plants to places they will not survive disables about fifty percent of the seed production.

The project remained in hand-pull mode until

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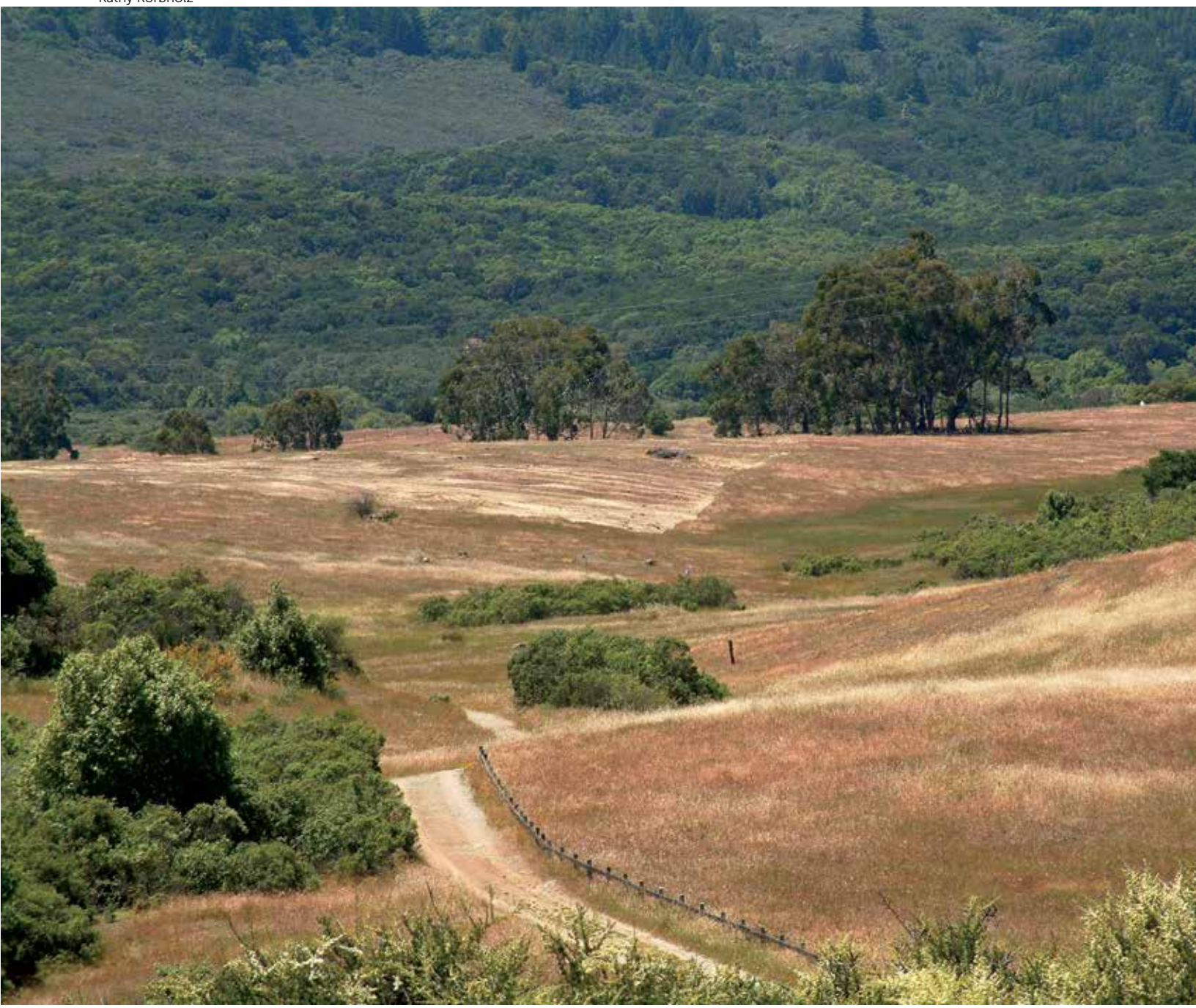

Hand pulling grass doesn't work so mowing is necessary. Mowed butterfly habitat can be seen in the rectangular grass area at the center of the photo.

late 2013, at which time the San Mateo County Supervisors voted to form a parks department and hire a resource manager. The county began mowing again in 2015. The program was back on track. By 2018, mowing was no longer necessary. All YST sites were under treatment and only hand pulling was required. If the plan continues, every year we should see a reduction in the number of YST plants. Instead of sitting in one place and pulling many plants, we will sweep through the sites looking for the few plants that remain. Each year these should become fewer and fewer. The seeds endure underground for ten years, so we have a bit of time to work, but the park looks very good.

Our new Green Grass initiative aims to restore Edgewood's non-native grasslands to their former floral beauty and species diversity by reducing or eliminating weeds and promoting greater cover of native plants. Approximately forty percent of Edgewood Park consists of grassland, and almost all of Edgewood's grasslands have been significantly degraded due to the invasion of

weeds, especially non-native grasses. While the Weed Warriors can effectively remove thistles and other non-grasses, it's just not feasible to remove grasses by hand.

By employing the best practices of grassland management, including mowing, de-thatching, and selective chemical treatments, the Green Grass initiative will significantly increase native cover. Because non-native grasses also threaten the bay checkerspot butterfly, San Mateo thornmint (*Acanthomintha duttonii*), and white-rayed pentachaeta (*Pentachaeta bellidiflora*), we expect Green Grass to deliver benefits to these related projects as well.

Paul is a naturalist, interested in all aspects of science in the natural world. He is an active member of the California Native Plant Society Santa Clara Valley Chapter, San Mateo County Weed Management Area, and Portola Valley Conservation Committee. He also volunteers as head Friday weeder at Edgewood County Park and at Jasper Ridge where he participates in the biannual ant survey. A geologist by training, Paul worked for Getty Oil Company exploring for oil in the Williston Basin of North Dakota.

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White-rayed pentachaeta (*Pentachaeta bellidiflora*)

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The weeders are winning. Notice the grasses returning as the yellow star-thistle is hand pulled.

- Make minimal disturbance to the environment.
- Do not over clear.

Principle One means that you do not start with the worst areas of infestation, but rather start in the best areas. Clearing the worst areas first is actively harmful, disturbing the soil and exposing it to daylight, which favors the weeds. These areas will be harder to regenerate on the next try. And do not remove any plant that you cannot identify. Take a sample to an expert before you pull it!

Principle Two applies to the soil, the roots of the natives, and their canopy. "Undisturbed bush soil under its natural mulch is superbly resistant to weed invasion." Whenever you disturb the soil while removing non-natives, put it back in its original order: subsoil, topsoil, and then the mulch of decaying plant matter. Therefore, when weeding, keep the original layers of soil together in piles so that you can restore them in the correct order.

Principle Three means that you cannot work faster than the native areas can regenerate. Clean the areas of scattered weeds, then work into the heavy infestations very slowly, in little strips. Assisting a natural area to regenerate takes patience. You must wait for the native plants to respond positively before you move to the next step.

The Bradley Plan of Action:

- Prevent deterioration of good areas (check them periodically)
- Improve the next best areas (not more than one weed to two natives). Start with an easily accessible strip no more than nine feet wide and short enough that you can weed it all in one session. Check it once a month.
- Hold your ground. Don't start clearing more until the natives have almost completely covered the work area. Light that reaches the soil encourages weed seeds to germinate, so your area will not be stable until the natives shade the ground.
- Cautiously move into really bad areas. Keep working along the edges, making small clearings into the weeds. But don't focus on just one weed species at a time: focus on your little area and clean it of all the exotics.
- Then very cautiously move into the worst areas. Be particularly careful when tackling the strips of bad weeds on the edges of roads, clearings, and paths. If you are forced to bulldoze an area, regeneration is possible only if it is surrounded by healthy native growth. Mulch the infested center heavily, tapering the mulch as you reach the native growth.

THE BRADLEY METHOD IS BASED ON THREE PRINCIPLES:

- **Work outwards from "good" bush areas, towards areas of weed.**
- **Make minimal disturbance to the environment.**
- **Do not over clear.**

Small tools are used, and great care is taken to damage only the invasive plants. Take care not to step on natives. Put your toes down first and then ease your heel down lightly. Be very careful on steep slopes: sliding down them will damage the natural mulch, the soil, and native plants. (Our garden director, Bart O'Brien, adds that when working on hills, start at the top and the edges. When working on streams, start at the headwaters.) Do not create paths. Hand pull weeds whenever possible. If the weed is too big to pull up easily, carefully dig up its roots and cut them off as deep into the soil as you can. If they are well buried, they should not regrow. Do not work when the weather is too dry. The soil will not pack down properly when you are done. And do not work when the soil is wet enough to compact. Natives don't grow well in compacted soil.

You can use most of the weeds that you pull as mulch. Put them on the ground with their roots exposed, to dry. But don't leave seed heads: bag them up and dispose of them. (Bart suggests especially watching out for legume seeds, such as broom, that are particularly long lived.) And don't pile the weeds into a heap. They must be spread out so they will dry up and not regrow.

Local examples of successes using the Bradley Method include two examples that are discussed elsewhere in this issue: Edgewood Park in Redwood City and Skyline Gardens in Oakland.

(Bart relayed a last last tip: if you want cows to eat cattails, paint them with maple syrup.)

Maggie Ingalls has been a passionate gardener for more than 35 years. Her interest in native plants began with the prairie plants of the Midwest, but she switched to California natives when she moved to Benicia in 2007. She has been a docent at the Regional Parks Botanic Garden since 2009.

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