California Native Grasslands Association

GRASSLANDS

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California Native Grasslands Association

Mission Statement

The mission of the California Native Grasslands Association is to promote, preserve, and restore the diversity of California's native grasses and grassland ecosystems through education, advocacy, research, and stewardship.

P.O. Box 72405, Davis, CA 95617

www.cnga.org

530.902.6009 admin@cnga.org

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From the President's Keyboard

One of the things I love about grasslands is their diversity at every level. They can be found all over the state (and the world), in sizes of less than an acre to thousands of acres; typified by hundreds of species, the same and yet not the same.

Spring is one of the best times to see the diversity within a grassland, particularly the interplay between wildflowers, insects, and birds. Taking the statewide view, hundreds of native grasses and thousands of other plant and animal species call these areas home. But even at the local level, you may be focused on the part of a preserve with a great lupine and poppy show, or the golden-crowned sparrows passing through, or what's up in your yard.

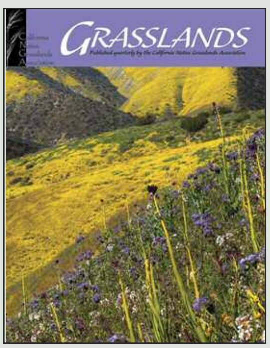
CNGA works at all levels, too, from gathering and presenting research in Grasslands, to offering grass identification courses, advocating for best practices in preservation and management, and increasing our presence in landscaping with natives.

At whatever level you appreciate and understand grassland systems, you always have more to see and learn—and I hope CNGA is part of it!

Andrea Williams, President

Support California's Grasslands on May 3rd when CNGA, along with hundreds of other local nonprofits, participates in the Big Day of Giving. (Or Big DOG as you can see from our supporting member above.) You have 24 hours to donate on May 3, OR you can schedule a pre-donation. Go to **cnga.org** for a direct link, or **bigdayofgiving.org** and search for ***California Native Grasslands Association***.

In this issue



Grasslands Submission Guidelines

Send written submissions, as email attachments, to **grasslands@cnga.org**. All submissions are reviewed by the *Grasslands* Editorial Committee for suitability for publication. Written submissions include peer-reviewed research reports and non-refereed articles, such as progress reports, observations, field notes, interviews, book reviews, and opinions.

Also considered for publication are high-resolution color photographs. For each issue, the Editorial Committee votes on photos that will be featured on our full-color covers. Send photo submissions (at least 300 dpi resolution), as email attachments, to Kristina Wolf at grasslands@cnga.org. Include a caption and credited photographer's name.

Submission deadlines for articles:

Summer 2018: 15 May 2018 ❊ **Fall 2018**: 15 Aug 2018 ❊ **Winter 2019**: 15 Nov 2018 ❊ **Spring 2019**: 15 Feb 2019

2018 CNGA Workshops & Events

Upcoming:

SERCAL 25th Annual Conference

In the Blink of an Eye, *with CNGA-led Session: Restoration of Native Grassland Ecosystems*

May 9–11 in San Diego — Register online at **sercal.org**

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Identifying and Appreciating Native and Naturalized Grasses of California

May 19: Marin Municipal Water District Headquarters, 220 Nellen Ave, Corte Madera

June 2: Trudeau Conference Center, Redwood Regional Park, 11500 Skyline Blvd, Oakland

Look for more workshops and updates at **www.cnga.org**

Flashy warrior's plume (*Pedicularis densiflora*) along City View Trail (see page 20 for article). *Photo: Emily Allen*

Natural History (for a Natural Future) in California's Grasslands

by Nate Chisholm[1]   Photos courtesy the author

At Sonoma Mountain Institute and Grounded Land and Livestock, we work with non-profits, agencies, and private landowners to manage properties. Our goals include increasing plant biodiversity, and our main tool for accomplishing this is grazing livestock. I came to this work from a middle school love for native grasslands. Growing up in Wisconsin, I loved big bluestem (*Andropogon gerardi*), pasque flower (*Pulsatilla* spp.), and prairie blazing star (*Liatris pycnostachya*). I volunteered on the weekends and my first jobs involved wielding chainsaws, drip torches, and herbicide sprayers in service of nature. But as an ecologist, I felt that there was something missing from that approach.

Yesterday, I spent the whole day wandering over a steep 500-acre pasture of oak and bay savanna. I was clearing this pasture of our cattle so that the purple needlegrass (*Stipa pulchra*) all around my feet had a chance to take advantage of this unusually productive, warm February. This gave me too much time to muse. Yesterday my musing centered on ecology and what it means to be an ecologist.

Ecology is the discipline of Darwin, and if we do not understand the evolutionary history of the ecosystems around us, we do not understand those ecosystems. For example, if someone graduated with a political science degree without having knowledge of any history before 1980, it would be a scandal. No one can understand all the things we do in politics without understanding Watergate, the Magna Carta, or Julius Caesar. Yet students of ecology can spend decades in the discipline without learning about the incredible suite of large mammals that occupied the California landscape and shaped all the organisms on it just 15,000 years ago.

Our ecological understanding has, itself, evolved over time (Leopold 1949). In ecology, a process that happens over a long period of time becomes essential. Amongst California ecologists, fire and flooding are generally recognized to be 'ecological processes' — they have been part of the ecosystem for hundreds of millions of years (Scott 2000). Without fire and flooding we lose certain components of biodiversity. In 1950, the idea that fire and flooding might be 'good' was very avant-garde. I think we are in the middle of just such a sea change in our understanding of grazing as an ecological process.

Grazing was probably more influential in the evolution of California's native grasses than fire and flooding combined. Flooding is extremely localized. There is only a very tiny sliver of the landscape that can be flooded for more than a week or two each year. As a result, even though there are some plants that are highly adapted to this environment, there are not very many such plants. Fire can leave an evolutionary mark over much more of the landscape, but can generally only do so once a year. Where grazing is present, fire will happen far less frequently than that. In contrast, almost all of the landscape can be grazed, and it can happen two, three, or ten times a year.

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[1]Nate Chisholm is employed by the Sonoma Mountain Institute, and is a partner in Grounded Land and Livestock. Nate earned a Bachelor of Sciences in Forestry and Range Management from the University of Montana and has traveled the world to study the relationship between large animals and grassland habitats. He currently manages ranches in the North Bay and Oregon. His first book, *Savanna*, captures the thoughts, experiences, and observations he collected from those experiences. His book and blog can be found at **meadowsbrooksandgroves.com**.

I suspect that the bite marks on the *Stipa* at my feet are not significantly different than the bite marks left by the native bison, camelids, and horses that inhabited this landscape 15,000 years ago. These grazing animals were part of a suite of large mammals that were as diverse and abundant as those in any African game park (Kurten et al. 1980). Large grazing and browsing animals have been shaping the course of evolution of these plants for hundreds of millions of years. In that time there have only been brief periods without large herbivores in North America.

The past 15,000 years have been one such interruption. Before 15,000 years ago, we would probably have to go back 65 million years to find a period without large herbivores (Martin et al. 1984). Some would say that those 15,000 years have changed the equation for grazing in California. But what evidence do we have for that? Fifteen thousand years seems like a long time to us, but to plant genera, it is the blink of an eye. The purple needle grass at my feet is morphologically identical to fossil needle grasses from 15,000 years ago. And needlegrass (like all grasses) has dramatic adaptations for grazing. For example, grasses, unlike trees, have lost the ability to drop their own leaves. Over the course of the evolution of these grasses, there have always been grazing animals that were more than happy to consume any extra leaves a grass plant might have laying around. Grasses need herbivores. They have eschewed the process of leaf abscission and become dependent upon grazers to remove the old growth that would soon block out sunlight and stifle growth.

In addition, virtually all grasses everywhere have leaves that are nutritious to grazing animals. Compare a grass plant to a spruce tree or a lupine. Grasses make no attempt to protect themselves from grazers. Grass becomes *less* palatable as it matures. But this is a result of a shift in priorities. Once the plant starts to flower, lignin and indigestible cellulose form so the plant can keep itself erect for better pollination/seed dispersal. But even then, our opinions of grass digestibility are colored by the number of large animals this continent has lost. If we still had mammoths and ground sloths, we would call even the most mature grass plant 'palatable.' High palatability might seem like a dumb adaptation to herbivory, but let me show you how it is dumb like a fox.

To understand how this could be, take the third adaptation that grasses have to grazing — the ability to quickly marshal soil resources to rebuild tissue lost to defoliation. This allows a grass plant to recover from defoliation much more quickly than, say, a tree seedling. Grasses present all these fantastic leaves to herbivores, free of charge. Those herbivores eat them and then go off to find another place with more grass. The grasses are able to regrow their leaves very quickly, in a few weeks or a few months, enticing the herbivores to return again. This process happens again and again.

Compare this to a tree seedling growing amongst these grasses. Soon that tree seedling is not doing so well. It cannot regrow tissue nearly as fast as the grasses. At the same time it is swamped by the vigorous roots and leaves of its herbaceous neighbor. Grasses and forbs have adaptations to grazing that allow them to survive grazing better than other plant taxa. Therefore grasses encourage grazing, and grazing can in turn encourage grasses. Grass leaves are not donations, they are kickbacks. This co-evolutionary process between grasses and grazers shaped global ecosystems. The tree form is a 400 million year old adaptation to allow plants to get their leaves above the plant next to them. So why build a tree trunk when dinosaurs, mammoths, or bison are leveling the playing field for all plants? Grasses, along with their partners, grazing animals, have been the great levelers and disruptors in the political economy of global ecosystems.

It seems increasingly likely that the large mammals of the Pleistocene went extinct due to human hunting (Sandom et al. 2014). I believe this means that if we want to both preserve biodiversity and increase production in global ecosystems, we need to restore the eons-old ecological processes that once characterized this ecosystem. Fire was

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the only land management tool that the first humans on this continent had. Human-induced fire mimics certain aspects of grazing reasonably well, but there are many other aspects of grazing that fire does not approximate (e.g., soil disturbance and compaction or aeration, trampling, manuring). It has a role in the ecosystem, but that role is different from the role that grazing has. Lastly, in the modern world of liabilities and degraded air quality, there are many times when grazing is a much more practical management tool than fire. If we are going to restore ecological processes in California we must get serious about using our most potent (and under-appreciated) land management tool: Domestic grazers.

Not all grazing is equal. California livestock management over the last four hundred years may not have been so great for native grasses. Since the arrival of livestock in California, all large predators have been removed and many barriers to animal movement have been put up (e.g., fences, freeways). These changes in the physical environment have translated into extreme changes in grazing animal behavior. Our cattle can't and won't move the way prehistoric grazers could. This has resulted in major problems for grasses. The ancient interaction between grass and grazer was based on the fact that for millions of years those grazing animals would leave any particular area ungrazed for some period of time. Human-controlled grazing in the state bears no resemblance to the grazing that happened over the evolutionary history of these plants. It might as well be called something different. But it was the *management*, not the livestock, that brought on the damage to native grasses.

Turning to the future, we need to be realistic about grazing as a management tool. While it would be hard to overstate the importance of grazing for California's native grasses from an evolutionary perspective, it is easy to over-promise. Some might hope for a tool that can selectively filter out non-native plants. Grazing cannot be that tool, particularly without mindful management. Remember, the Eurasian plants that occupy so much of the California landscape today have an equally long evolutionary history with grazing animals and they have just as many adaptations for grazing. Like fire, grazing is a management tool and an ecological process, but not a time machine.

That being said, Sonoma Mountain Institute has collected seven years of vegetation monitoring data from our grazing treatments and this data gives us plenty of reason to be cautiously optimistic. On steep, north-facing slopes with lots of trees we have a high proportion, or even dominance, of natives. However, even on highly disturbed flat ground we are seeing a slow, steady increase in the native component under our management. We achieve these results by using electric fencing to control grazing periods, recovery periods, density, and timing of grazing.

Whatever these ecosystems end up looking like, we need to remember that the future is going be different from the past. It always has been so. However, as ecologists, a failure to understand the past will be a failure to create our future.

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SPECIES SPOTLIGHT: *by Felix Ratcliff*[1]

Loggerhead Shrike (*Lanius ludovicianus*):

A Small Grassland Bird with a Big Appetite

A fence lizard basks on a cozy sunbaked rock. A rare moment, when there's no need for alarm. No snakes, no kestrels in sight—just warm sunshine and the melodic voices of songbirds. Suddenly it is pinched, lifted from the rock, and skewered on a barbed-wire fence. In its shock, it barely notices the gray and black songbird flying away, uttering a metallic trill.

Loggerhead shrikes (*Lanius lodovicianus*) are among the more unusual songbirds to inhabit California's grasslands. Weighing only 50 grams — somewhere between a towhee and a blackbird — these voracious hunters do not content themselves with seeds and small invertebrates. The prey they hunt places them in a foraging guild with their larger cousins: Birds of prey (raptors). Their carnivorous diet mostly consists of large insects, but also includes a variety of small vertebrates: Lizards, rodents, and even other birds. Unlike hawks, falcons, and owls, these small songbirds did not inherit large, strong feet or talons to grasp and kill vertebrate prey on the spot. However, their bills are tipped with a sharp, decurved hook with a tomial "tooth" on either side (Yosef 1996, Sustaita and Rubega 2014), which allows them to sever the neck of small vertebrates (Yosef 1996, Cade and Atkinson 2002). Shrikes will also kill and store their prey by impaling them on sharp objects in their environment—cacti, agaves, plum trees, acacias, and yes… barbed wire. Noxious prey, such as the darkling beetle (see photos next page), is impaled for longer periods to allow the noxious exudate to dissipate before consumption (Yosef 1996).

Although not as abundant as some grassland birds, Loggerhead Shrikes are widespread throughout California grasslands and savannas and are year-round inhabitants of lowland areas across the state (Humple 2008). They require a mixture of open and shrubby vegetation for foraging and nesting, and can frequently be seen perched along fence lines (Yosef et al. 1996).

Between 1966 and 2015 Loggerhead shrike populations fell by 76% across North America (Cornell Lab of Ornithology 2017), and they are declining in California at a rate of approximately 2% per year (Sauer et al. 2017). Major threats to shrikes are bio-accumulation of pesticides (Anderson and Duzan 1978), habitat loss to intensive agriculture or housing development (Humple 2008), habitat conversion in shrub-steppe due to cheatgrass (*Bromus tectorum*) invasion (Humple and Holmes 2006), and collisions with automobiles (Humple 2008). In California's Central Valley, shrikes prefer grasslands grazed by cattle (Pandolfino and Smith 2011), and grazed rangelands can be a good place to see these exceptional birds.

So the next time you're roaming the lowland Californian range, keep an ear out for a metallic trill, and watch for quick wing-beats and the telltale

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Inset: Loggerhead shrike. *Photo: Zach Smith*

[1]Felix Ratcliff is a postdoctoral researcher at the University of California, Berkeley, where he studies the effects of rangeland management practices on plants and animals in California. He first became interested in Loggerhead Shrikes in 2007 while walking miles of barbed wire fence line in eastern Contra Costa County and encountering a surprising diversity of shrike prey items.

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Loggerhead Shrikes hunt a variety of small vertebrates and large invertebrates; impaling prey on sharp objects. These photos of shrike prey were taken on barbed wire fences in eastern Contra Costa County, California. *Photos: Felix Ratcliff*

Loggerhead Shrike *continued*

black and white flicker of feathers that identify the shrike. Even if you don't see the bird, you might see the remnants of their last meal on a barbed-wire fence, a sharp stick, or a cactus spine.

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Mechanical Removal of Coyote Brush *(Baccharis pilularis)*

by Jeffrey Stackhouse[1], Lenya Quinn-Davidson[2], and Josh Davy[3]

In the absence of a natural fire regime or alternative disturbance cycle, California's coastal grasslands offer an ideal nursery for invasive woody vegetation: The moderate climate, coastal moisture, and innate hardiness of many coastal shrub species enable their rapid expansion, often to the great detriment of the herbaceous biodiversity and livestock forage production for which these grassland systems are known and valued (Hobbs and Mooney 1986, Kidder 2015). In many parts of California, coyote brush (*Baccharis pilularis*, hereafter *Baccharis*) is the primary invader of coastal grasslands (McBride and Heady 1968, Williams et al. 1987). A native shrub, *Baccharis* thrives across a wide range of climates and habitat types, from warm, dry, annual-dominated systems to cooler, perennial-dominated systems (Kidder 2015). The versatile and hardy nature of *Baccharis*, and its ability to aggressively resprout, have posed a consistent management challenge in California's coastal grasslands. Historically, prescribed burning, coupled with sheep browsing, successfully limited *Baccharis* dominance. As both the sheep industry and the prescribed fire culture have waned on the north coast, both ranchers and restorationists have struggled to find tools that are cost-effective and enduring.

Several options are available for managing *Baccharis* — herbicide, prescribed fire, mechanical removal — and each has its own set of social and/or operational challenges. In many parts of California, there is low tolerance for herbicide use, and social pressures or organic marketing structures may push land managers to stick with non-chemical control options. Likewise, prescribed fire poses a host of challenges that can be difficult for individual landowners to navigate, including narrow burn windows, air quality regulations, lack of qualified crews, and liability (Quinn-Davidson and Varner 2012). Furthermore, both herbicide and fire are tools that come with legal limitations in the state of California, adding an additional barrier for some landowners. Given these complications, mechanical removal is often the most widely available and politically benign option, yet the effectiveness and costs of various mechanical options are not well documented or understood.

In this study, we compared the effectiveness and cost of three mechanical treatment options — chainsaw, bulldozer (D4 Caterpillar), and excavator — at a site in coastal Humboldt County, California. The research took place in the Bear River watershed, 10 miles east of the Pacific Ocean. The site is cool and wet, receiving an annual average of 70 inches of rain. Woody encroachment is widespread throughout the region and is a focal management concern for landowners in the Bear River watershed.

Methods

To compare mechanical control options for *Baccharis*, we installed monitoring plots on south-facing slopes (25–40% slope) in areas with relatively uniform shrub cover. For each treatment type — Chainsaw ("Saw," cutting plants within 4 inches of the soil surface), D4 Caterpillar ("Cat," a bulldozer scraping at the soil surface), and Excavator ("Exc," plucking whole plants) — we flagged two 60–m x 30–m plots, and used three modified 10–m belt transects per plot. All transects were monitored for resprouts in September 2017, 16 months post treatment. Assessments included ten readings of percent cover of *Baccharis*, bare ground cover, and frequency of *Baccharis* per meter squared, per transect, at one meter intervals (60 readings per metric). Treatments took place in May 2016 and included full (100%) removal of all above-ground shrub cover in each of the 60–m x 30–m plots. Treatment time and cost were recorded for each of the three treatment types.

Statistical analysis was conducted using a multifactor analysis of variance for three metrics including *Baccharis* frequency, percent reduction, and bare ground as a percentage of ground cover. Variables included treatment, plot site (1 or 2), transect (1-3), distance down each transect (1-9), all associated interactions, and a covariate of initial cover in Statgraphics XVII (Statpoint Technologies, Inc. 2014). A covariate was included due to observed initial variances in cover. The covariate was only significant in the percent cover of *Baccharis* treatment and was therefore removed from the other models. When treatment was identified as significant ($P<0.05$), we ran Fisher's least significant difference (LSD) test to determine treatment differences at 95% confidence.

[1]University of California Cooperative Extension, Humboldt and Del Norte Counties, Eureka, CA; Livestock and Natural Resources Advisor; California Certified Rangeland Manager #113. Jeffery is a wildlife biologist and range ecologist with research experience in a wide variety of habitats, from North Dakota to California. His current research program is focused on woody encroachment in coastal woodlands and grasslands, with an emphasis on *Baccharis pilularis*.

[2]University of California Cooperative Extension, Humboldt, Mendocino, Siskiyou, and Trinity Counties, Eureka, CA; Area Fire Advisor. Lenya has a background in fire ecology and restoration, and is interested in the effects of fire suppression on community composition and biodiversity in California's fire-adapted ecosystems.

[3]University of California Cooperative Extension, Tehama, Glenn, and Colusa Counties, Red Bluff, CA; Livestock, Range, and Natural Resources Advisor/County Director. Josh is both a Certified Range Manager and Diplomat in the American College of Animal Science. His program provides research and educational support in the areas of livestock, range, irrigated pasture, and natural resource management.

Treatment Costs

Costs differed greatly by treatment, with the Exc treatment costing almost three times more than the Cat treatment (Table 1). Costs are the product of the hourly rate of the equipment and operator as well as the efficiency of the method. For example, the Exc had a high hourly rate ($125/hour) compared with the Cat ($85/hour), and was also less efficient, taking almost twice the time (7.8 hours/acre versus 4 hours/acre, respectively). At $15/hour, the Saw had the lowest hourly rate, but it was the least efficient, requiring more than 32 hours of effort per acre of treatment. Cat was the most cost-effective option of the three mechanical removal options assessed in this study (Table 1).

Table 1: Cost and time estimate of *Baccharis* removal by removal technique.

Treatment	Hours/acre	Average $/acre
Cat ($85/hr)	4	$340
Saw ($15/hr)	32.5	$487
Exc ($125/hr)	7.8	$975

Treatment Effectiveness

Treatment type and transect number were significant in post treatment *Baccharis* frequency (P <0.01 and P=0.03, respectively), but neither site, distance down each transect, nor any associated interactions impacted frequency (P>0.05; Table 2). Likewise, treatment significantly influenced *Baccharis* cover reduction (P <0.01; Table 2), as did site (P=0.04), transect number (P=0.02), initial cover (P<0.01), and the treatment site interaction (P=0.04). Again, distance down each transect (P=0.59) and all other interactions were not significant (P>0.05). As expected, post-treatment bare ground was increased by treatment (P<0.01, Table 2) and differed by site (P=0.01), yet neither transect (P=0.09), nor distance down each transect (P=0.97) were significant.

Table 2: LSD mean frequency and cover reduction of *Baccharis* and bare ground by treatment

Treatment	Exc	Cat	Saw
Plants/m^2	0.07[a]	0.45[a]	1.32[b]
Baccharis Reduction (%)	68[b]	65[b]	53[a]
Bare Ground (%)	22[b]	19[b]	3[a]

Within a row, means with the same letter do not differ.

Of the three treatments included in the study, the Saw was the least effective at reducing cover and frequency of *Baccharis*. It also proved to be the most variable, with differing success at each site. When the plots were monitored 16 months after treatment, the Saw plots had over three times the frequency of resprouts when compared to the Cat or Exc plots (P<0.05). Additionally, the Saw treatment was not the least expensive, and if this treatment were implemented, a follow-up herbicide treatment of resprouts would likely need to be planned, further increasing associated costs. Though the Saw treatment is the easiest in terms of obtaining equipment, if a single treatment is to be used, without a follow-up herbicide application, the number of resprouts seen in the Saw treatment would make it the least desired of those tested.

In general, the Exc and Cat treatments worked similarly in reducing *Baccharis* between sites and were not different from each other in any of the three metrics analyzed. However, they were largely different in cost, with the Exc treatment costing nearly

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CALIFORNIA NATIVE SOD VARIETALS

triple that of the Cat treatment. With this dramatic difference in cost, this would heavily point to the Cat treatment being the choice for a single treatment event.

Bare ground is an important consideration in these treatments, given that shrub removal is often focused on restoring or maintaining herbaceous cover and/or forage. Of the three treatments, the Saw treatment retained the most herbaceous cover ($P<0.01$; Table 2), indicating less potentially negative, short-term effects from soil disturbance. Even 16 months after treatment, both the Exc- and Cat-treated areas still had approximately 20% bare ground, indicating that the recovery of grass and herbaceous plants may take multiple growing seasons in areas where heavy equipment are used to remove brush. Reseeding of desirable forages in these areas would likely be a good management practice to discourage weed invasion, capitalize on treatment efforts with desirable forage, and prevent erosion. On these sites specifically, invasive or noxious weeds were not observed as a problem, but practitioners should be mindful of herbaceous weeds when planning and implementing a project that results in high proportions of bare ground.

Conclusions

Woody encroachment into coastal grasslands is a major conservation concern throughout California, with implications for biodiversity, wildlife habitat, and livestock forage. In the absence of disturbance, coastal rangelands will continue to transform from coastal prairie to coastal evergreen forests. Mechanical removal may temporarily allow an influx of herbaceous weeds, but a landscape void of disturbance in these wet, coastal climates is certain to transition to timberlands of relatively low economic value. *Baccharis* is the primary encroacher in these coastal systems, and land managers are challenged to find cost-effective, enduring options for *Baccharis* removal. Mechanical treatments offer a viable option, especially in areas where herbicide and fire are not feasible or preferred. However, this study shows that mechanical options vary in both cost and effectiveness. Land managers should consider the cost, time commitment, soil stability, and practicality of different treatments based on the attributes of the sites that they are treating and the tools available.

This study suggests that bulldozers offer a comparatively effective and inexpensive option for removing *Baccharis*. Though equally effective as the excavator, the bulldozer used in this study (D4 Caterpillar) was nearly one third the price, took half the labor time, and was more nimble on steep slopes. Further monitoring will reveal whether the long-term effectiveness of bulldozers and excavators is more divergent than the short-term effectiveness, in which case the added cost of excavator treatments may prove worthwhile.

Chainsaws offer relatively few benefits, beyond the widespread availability and user-friendliness of the tool and the comparatively light-touch treatment that it provides. Areas treated with chainsaws had far less bare ground; however, the long-term forage benefits gained through sod retention are likely diminished by the rapid redevelopment of a *Baccharis* monoculture, which was quick to resprout and regain cover in chainsaw-treated areas. It is likely that chainsaw treatments would need to be followed by an herbicide application to maintain brush control for any length of time.

Currently, this study provides only short-term insight on the relative costs and benefits of mechanical brush removal techniques. Further monitoring of our plots will increase understanding of the long-term effectiveness of these options; further research is needed to understand how mechanical treatments may compare with or complement herbicide- and fire-based treatments. Lastly, a cost-benefit analysis of livestock productivity post-*Baccharis* removal is a necessary next step for future research of *Baccharis* control for private landowners.

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GETTING TO KNOW GRASSLAND RESEARCHERS

Felix Ratcliff

What is your study system?

As a graduate student—and now a postdoctoral researcher—at UC Berkeley, I've worked in rangelands across California. Most of my research has focused on riparian areas in the San Joaquin Valley, but I've also worked in Valley grassland, Sierra Nevada meadows, and coastal prairie. Most of the places I work are managed for multiple uses, like livestock grazing, public access, and conservation values. I'm interested in doing research that supports planning and management activities to meet these human demands and also achieve desirable conservation outcomes, like increasing native plant cover in California grasslands.

What are your primary research goals?

My primary research goals are to better understand the factors shaping rangeland plant communities and develop models that can be used to predict the impact of rangeland management practices, like livestock grazing, on plant communities.

Who is your audience?

Agencies and land managers use my research to plan management activities and achieve conservation management outcomes. For my dissertation, I worked closely with the Tejon Ranch Conservancy. I've also written monitoring and management plans for Yosemite National Park, Sequoia/Kings Canyon National Park, Point Reyes National Seashore, and the East Bay Regional Parks District.

Who has inspired you, including your mentors?

My first inspiration in the world of California grasslands came from an undergraduate class at UC Santa Cruz — Natural History Field Quarter, taught by an amazing duo, Steve Gliessman and Breck Tyler. They introduced me to the natural wonders and diversity of our state. Birds were the first taxonomic group to get me hooked, and I spent many early mornings birding with the then-curator of the UCSC Natural History Collections, Tonya Haff. Tonya also showed me the value of being a natural history generalist, inspiring me to learn more about plants, insects, and other (non-bird) vertebrates.

After graduating from UC Santa Cruz, I had the great fortune of working for Wendy Dexter at Condor Country Consulting. Wendy was very active in the wildlife conservation community and got me excited about some of California's rare and elusive grassland critters like California red-legged frogs, tiger salamanders, and snakes of all stripes.

When I went back to school in 2011, I met a variety of interesting and inspiring people. Principle among them was my advisor, professor James Bartolome. His vast knowledge of California's grasslands demonstrated the benefits of a lifetime of sustained interest and critical thought. Through my dissertation research I also worked with Michael D. White, the founding Science Director of the Tejon Ranch Conservancy, who showed me what a science-based conservation program looks like, and how to use research to achieve your conservation goals.

How has or will your research align with the mission of CNGA "to promote, preserve, and restore the diversity of California's native grasses and grassland ecosystems through education, advocacy, research, and stewardship"?

The goal of my research and work has been to promote science-based management of rangelands to meet conservation goals. I recently joined the CNGA Board of Directors because I'm interested in engaging with a greater community of conservation-minded grassland enthusiasts. I'm very excited to promote grasslands through outreach, research, and education through CNGA.

Why do you love grasslands?

There are so many reasons I love California's grasslands. I'm drawn to their vastness, beauty, and wildness. I appreciate their multiple uses, and the diverse values we derive from them. Most of all, however, I'm captivated by their seemingly infinite potential for exploration. Every location and every year brings different shows of forbs and grasses. Each rock and burrow harbors different lizards, snakes, and salamanders. And against the backdrop of incredible taxonomic and geographic diversity—and annual variability—there is so much still to learn about ecological interactions, management strategies, and natural history.

California Range and Natural Resources Camp

by Michelle Cooper[1] *Photos courtesy Dr. Marc Horney, Cal Poly SLO*

Since 2013, I have made my way every summer to the University of California's Elkus Youth Ranch in Half Moon Bay, CA to introduce 20 to 25 high school students from across California to the basics of plant identification at "Range Camp". We talk about the differences between grasses and forbs, annuals and perennials, native and naturalized species. I show them how to carefully collect and label specimens and we walk a mixed riparian-upland trail, identifying and gathering the plants they will be tested on later that week. This year the stakes are high, as they will all be competing for the opportunity to travel to Minneapolis, MN, in February 2019 for the national high school youth forum event at the Society for Range Management annual conference.

The California Range and Natural Resources Camp (Range Camp) is six days of hands-on environmental science and management experience for high school sophomores, juniors, and seniors interested in natural resource management and range science. First organized in 1984 by professional members of the Society for Range Management's California Pacific Section, Range Camp has been held annually for the last 34 years.

At Range Camp, students receive an introduction to ecological principles, including characteristics and interrelationships of plants and animals, fire ecology, hydrology, geology and soils; and management of grassland, brushland, forest, and stream and river ecosystems. Field activities include learning to read wildlife "signs"; outdoor navigation using compasses, maps, and GPS; forest management; visits to working ranches and conservation projects; and a beach BBQ with volleyball. Students practice public speaking skills; pitch in to complete on-farm, ranch, and household chores; and develop collegial friendships.

Classes and field units are led by experts from many institutions, including faculty and students from the University of California and Cal Poly San Luis Obispo, the California Association of Resource Conservation Districts, the California Native Grassland Association, and several other agriculture and conservation organizations.

It is with mixed feelings that I pass on the opportunity to lead Range Camp's plant identification section to CNGA board member Michele Hammond this year. I have no doubt that Michele's knowledge, enthusiasm, and sense of humor will inspire yet another year of students to appreciate the critical and endlessly interesting world of plants and California rangelands in particular.

Range Camp is an excellent opportunity for junior high and high school students and runs annually beginning Father's Day (a Sunday) and extending through Friday of that week. In 2018, it runs from June 17th through the 22nd. More information and applications are available at **http://www.rangelands.org/casrm/HTML/rangecamps.html**. Applications will be accepted until May 15th if spaces remain.

[1]Resident Biologist and Preserves Manager. Michelle recently joined Audubon Canyon Ranch (ACR) as the resident biologist and manager of the 3,000-acre Modini Mayacamas Preserves, located northeast of Healdsburg, where she oversees the conservation science, education, and stewardship programs. She earned a B.S. in botany from the University of Washington and a M.S. in biology from Sonoma State University.

Invasive Annual Weeds — Problems or Symptoms?

by Richard King[1]

Introduction

Invasive annual and biennial species are of great concern to land managers who value the health, beauty, and productivity of California's grasslands. While many non-native annual species have dominated the landscape for over two hundred years, other introductions are more recent and these species continue to spread. We spend millions of dollars and countless hours using equipment, chemicals, fire, and livestock in our efforts to eradicate or control many of these species so that we can enjoy the many ecosystem services we want desirable grasslands to provide. Whether we manage grasslands for native species preserves, livestock production, wildlife habitat, crop production, roadsides, backyards, open space, recreation, or any combination thereof, all have areas dominated by invasive annual weeds. Despite current efforts, the extent of the grassland weed problem grows ever larger.

Invasive annual species include a great variety of grasses, thistles, and forbs. Most of these were introduced to California's grasslands accidentally, and others purposefully. Just few of the invasive annual grasses are medusahead (*Elymus caput-medusae*), red brome (*Bromus madritensis* ssp. *rubens*), hedgehog dogtail (*Cynosurus echinatus*), Japanese brome (*Bromus japonicus*), and barbed goatgrass (*Aegilops triuncialis*). Widespread and invasive thistle species include yellow starthistle, tocalote (*Centauria melitensis*), blessed milk thistle (*Sylibum marianum*), Italian thistle (*Carduus pycnocephalus*), and bull thistle (*Cirsium vulgare*). Other introduced and potentially invasive annual forbs include mustards (*Brassica* spp. and *Hirschfeldia incana*), several filarees (*Erodium* spp.), and poison hemlock (*Conium maculatum*). They all have the potential to invade and suppress a grassland community when they form dense patches that transform the previous community. Despite their widespread introductions and abundance, these species do not always behave invasively: They may be present without ever becoming thick, dense stands that dominate a site. Even large dense patches of an invasive species can diminish over time when certain management practices are applied and other plant species replace them.

This article describes how simplified grassland communities allow invasive annual and biennial weeds to thrive, and is the first of a two-part series explaining the four factors that grassland managers can address to develop more biologically complex and resilient communities. The first of these factors is bare ground.

[1]Richard King is a CNGA board member who worked for 36 years with USDA-Natural Resources Conservation Service as a rangeland specialist. Richard earned a Bachelor's degree in Wildlife Management and a Master's degree in Biology. He enjoys seeing native perennial grasses and forbs 'invading' the non-native annual grasslands on his ranch in Petaluma.

When Weeds Thrive

Annuals invade simplified communities of life, and nature loves to fill a vacuum. A vacuum means fewer species are present and competition between plant species for sunlight, moisture, and nutrients is limited. Simplified communities also occur when certain functional groups of plants in our grasslands are not present, such as perennial grasses and forbs, warm season plant species, and woody species such as the oaks that grace California's grasslands. Functional diversity creates a more complex community of life than we find in grasslands dominated by only cool season annual species. Together, higher plant species diversity and functional diversity provide far more complex communities, as evidenced by rooting depths and root shapes, time and duration of growth, and countless other associated microbial, invertebrate, and vertebrate species present that have symbiotic or facultative relationships with certain plant species. The community, both aboveground and belowground, is one biological community — and in grasslands, more life is found below the soil surface than above it, whether measured by number of species or their mass. The biological community also interacts with the abiotic components of the environment. Complex grassland communities of life tend to fill the vacuum, creating environments much less suitable for opportunists like invasive annual weeds. Complex communities have greater resiliency than simplified communities, which becomes important when disturbed (e.g., by fire, herbivory), and greater resistance to invasive opportunists like the invasive annual species that abound.

Contributing to their success, invasive annuals additionally thrive in a vacuum because they produce large numbers of seed that can establish quickly; the plants only need to live long enough to make seed for the next rainy season. Moreover, seed is transported readily by wind, water, or animals of all kinds — whether livestock, birds, rodents, or humans. When their seeds find a vacuum, invading annuals can rapidly establish, reproduce, and become abundant. All species thrive in the environments in which they are best adapted. Likewise, invasive annual species will diminish when their environment becomes more complex, where they are less well adapted.

Four Ecosystem Processes

In nature, grassland environments can be viewed as comprised of four major ecosystem processes: Energy flow, water cycle, nutrient cycle, and community dynamics (or biological diversity). They are four different faces of the same environment, interacting at every scale (Savory and Butterfield 2016). ***Energy flow*** through the community of living organisms begins when sunlight energy is converted to a simple sugar (glucose) by plant photosynthesis. Sugar provides the chemical energy needed for growth,

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maintenance, and reproduction of every cell and organism. Sunlight powers all life in grasslands through photosynthesis, including the 20–40% of sugar manufactured that is exuded by plant roots directly into the soil to feed microbial life. Energy cannot be fully recycled because every time it is used to build or dismantle molecules, some is lost as heat. How effectively sunlight is converted into plant energy relies on the amount of photosynthesis occurring during the year and the other three ecosystem processes, all of which affect photosynthesis. Ineffective energy flow means a vacuum exists in the community that invasive annuals can sometimes fill to utilize available sunlight. Energy flow to sustain life in grasslands can be increased or decreased, depending on the composition of the plant community, how it is managed, and how it affects the other three ecosystem processes. Many of our invasive species are successful when they grow faster or taller than other plant species and shade them.

The ***water cycle*** in any grassland environment consists of precipitation, evaporation, plant evapotranspiration, surface runoff, soil infiltration, and internal drainage through the soil profile. Effective water cycles slow runoff, reduce erosion, allow more infiltration, increase soil water storage and plant growth, recharge and extend stream base flows, refill aquifers, and extend the growing season. Effective water cycles depend on the composition of the plant community and root distribution through the soil profile and below, how the site is managed, and how the other three ecosystem processes are functioning. Ineffective water cycles support more simplified communities in which invasive annuals can find a niche to thrive. Water is lost as evaporation, runoff, or is not utilized by plants from the deeper portions of the soil profile. Invasive annual grass species often more effectively deplete soil moisture within the shallow root zone than do native perennials. Some invasive annuals thrive when deeper soil moisture is not used by other plant species present, and can access it with their taproots. The water cycle can be made more effective or less effective with management, which is especially important in seasonal rainfall environments like California — the *effectiveness* of the rain that falls becomes much more important than *how much* falls.

Nutrients cycle from and through land, air, water, and the living organisms that require them to live. All elements that a living organism requires cycle in the community and its environment, including carbon, nitrogen, copper, molybdenum, selenium, calcium, phosphorus, oxygen, aluminum, boron, among others. Effective nutrient cycling requires complex communities that are active as long as possible through the year and can effectively utilize the full soil profile. Critical nutrients may be present but remain unavailable for plant growth without the complex web of life and its symbiotic relationships to make them available through a variety of biological and chemical reactions. Effective nutrient cycling also depends on the status of the other three ecosystem processes — energy flow, and water and nutrient cycles. Ineffective nutrient cycling can create a vacuum for invasive annual species to thrive by limiting the health and vigor of other species. Excessive nutrient availability can similarly create an opportunity for invasive species that thrive on that excess (e.g., from high nutrient deposition from the atmosphere or runoff). Some invasive annuals are successful in nutrient-poor environments; productivity may not be high, but they don't need much to successfully reproduce and spread. Some invasive annuals are able to grow very aggressively in nitrogen-rich environments. Nutrient cycling in the community can be made more effective or less effective through our management.

A fourth ecosystem process, ***community dynamics***, includes species and functional diversity, productivity, and the community's interactions with the abiotic environment. As John Muir astutely observed well over 100 years ago: "When we try to pick out anything by itself, we find it hitched to everything else in the universe." Community dynamics is either increasing or decreasing in complexity. Community dynamics changes with the abiotic environment. The chemical, physical, and biological transformation of mineral soil to nutrient-rich, well-aerated topsoil with higher plant available water storage is one example. And while plants provide the energy for all soil life, the rest of the work is largely done by microbial life in the soil that relies on the sugars and other compounds that plants exude into the soil or into mycorrhizal networks that transport information and nutrients to other plants, even to other plant species, directly from the plant root. The fungal hyphae network is a two-way street, transporting water, nutrients, and enzymes *to* the plant, in exchange for energy and other compounds *from* the plant. Changing community dynamics can even change weather patterns locally, regionally, and globally as the other ecosystem processes change too. As the community's environment changes, organisms adapted to these new conditions increase and others no longer well-adapted to the site will decrease. In summary, when community dynamics are simplified, a vacuum for invasive species increases. The complexity of community dynamics and the resilience it provides can be increased or decreased by our management.

Biological controls that attack and suppress a particular weed species can be very helpful. Scientists have found and safely introduced successful controls for only a few invasive weed species, such as the perennial forb St. Johnswort (Klamathweed) that is now held in check by the introduction of beetles that dramatically suppress the weed populations. However, introducing an organism that kills only the target species is a challenge. Some biological controls that would effectively suppress invasive species are not used because they would also harm other species we deem important to keep. Adding one species can dramatically change community dynamics and even affect the other ecosystem processes. Researchers found that adding a variety of soil bacterial species that is native to western states —*Pseudomonas flourescens* strain ACK55 — effectively eliminated invasive annual grasses like medusahead, cheatgrass (*Bromus tectorum*), and jointed goatgrass (*Aegilops cylindrica*) for the past four or five years without adversely affecting native plant species (Bean and Gornish 2016).

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Microbiologists who study life in soil estimate we may have identified only a fraction of the bacteria species present. Our understanding of how many species are present, how they differ, and how they all interact is an exciting new field of study because we still know so little. Some regard soil as having the least understood community of organisms in the world, yet we walk on it every day. Note that in both examples of biological control, success occurred not by removing a species, but by adding another — increasing complexity in the community. Similarly, removing a single species from a community could potentially have surprising effects on community dynamics and other ecosystem processes. We may have removed countless species that are not plants from our grassland environments because of our past and current management, and may have added countless others. Even the joy of removing an invasive species has the potential of it returning or being replaced by another invasive species if the focus is not on managing to increase the complexity of community dynamics. Community dynamics determine the success of invasions by non-native plants (Lodge 1993).

Where do we go from here?

While many invasive control efforts have been successful using all manner of herbicides, fire, tillage, mowing, grazing, seeding, and biocontrol, few have focused on the importance of managing the ecosystem processes— the whole community's point of view. Instead, we tend to direct management toward what we *don't want*, such as an invasive species. Likewise, we often make the same mistake when we focus on species we *want* and lose sight of the fact that our management decisions and plans will affect the entire community and all the interrelationships occurring, not just the desired species. Each species in the community, whether it is a microbe, invertebrate, plant, or animal, has its own habitat requirements. Managing the four ecosystem processes can be used to change available habitats. If higher energy flow (more photosynthesis and productivity), more effective water and nutrient cycles, and more diversity of species and functions are desired outcomes in your grassland, and if these processes are degraded because of past or current management, then the most powerful tool in your toolbox for biological control of invasive species will be management that lets nature do the real biological work for us. That means shifting our focus to the management of the ecosystem processes.

Four major factors occur on our grasslands that strongly affect these four ecosystem processes, creating simplified communities that allow invasive annuals to thrive: 1) bare ground, 2) over-resting land, 3) over-grazing plants, and 4) over-fertilization. We will start with a closer look at public enemy number one — bare ground.

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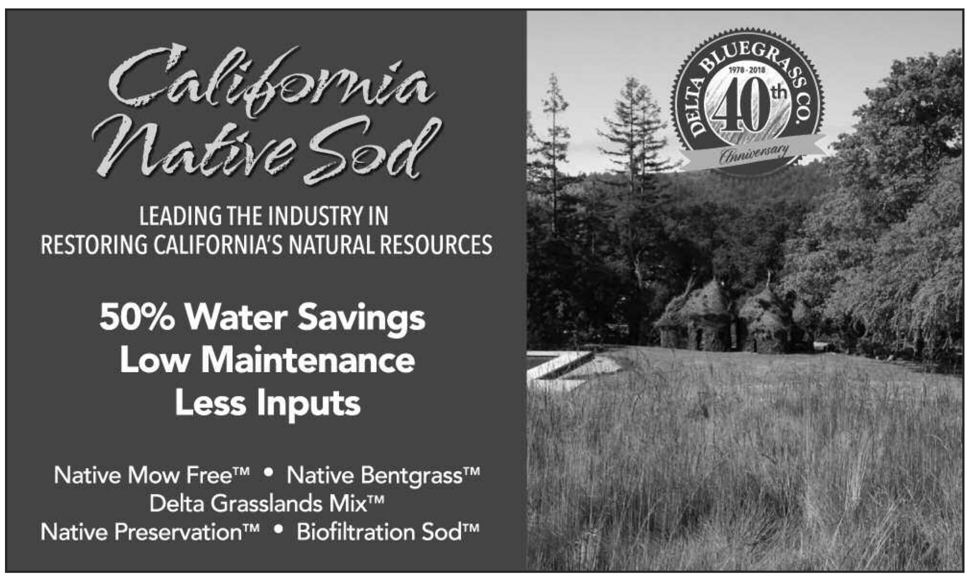

MARIN MUNICIPAL WATER DISTRICT

JONI L. JANECKI & ASSOCIATES
Landscape Architect
515 Swift Street, Santa Cruz
www.jlja.com (831) 423-6040

Pacific Restoration Group, Inc.
PO Box 429 Perris, CA 92572
951.940.6069

Invasive Annual Weeds — Problems or Symptoms? *continued*

Bare Ground

When I use the term 'bare ground', I mean inadequate soil cover compared to what is possible on that site. Inadequate soil cover directly threatens all four ecosystem processes. It affects water and nutrient cycles, amount and duration of photosynthesis during the year, and the diversity and productivity of life in the community. Inadequate grassland soil cover: a) Accelerates erosion from rain, wind, and surface run-off; b) Reduces soil aggregate formation and stability that facilitates water infiltration and soil aeration; c) Increases day and night soil temperature extremes that directly kill soil microbial life; d) Accelerates evaporation loss of soil moisture; e) Creates soil crusting (capping) that reduces diversity of microsites necessary for plant seeds to successfully establish; and f) Decreases overall productivity in the community due to the absence of plant cover.

Bare ground can result from tillage, herbicide use, construction equipment, fire, or mass wasting (landslides). Sometimes wildlife such as gophers or ground squirrels create areas of bare soil that can turn to invasive weed patches. Excessive livestock grazing and trampling can expose the soil surface. George Work, who ranches near San Miguel, calls excessive removal of plant cover 'over-baring' the land. I might call it 'over-utilization', 'heavy use', 'close grazing', 'severe grazing', or 'severe trampling' of soil cover, but 'over-baring' the soil really is the point. When walking through grassland and looking down at your feet, you can easily see how much soil surface is exposed directly to the rain and direct sun. Looking across the grassland at an oblique angle will seriously underestimate the amount of bare soil present. 'Over-baring' soil means fewer plants fill those spaces and biodiversity is reduced in the grassland community. Some species may drop out altogether, which further simplifies the community. Simplified plant communities are less healthy and prone to invasion (Vitousek 1990).

When management practices increase bare soil, the invasive annuals are not the problem; they are a *symptom* of the biological vacuum created. The real problem is how land is being managed — not the invasive annuals. We can slow, stop, and even reverse the invasion of our grasslands by invasive annuals if we stop management practices that simplify grassland communities. As water and nutrient cycling become more effective, as photosynthesis supporting all life in the community increases, and as plant species and functional diversity increase, invasive annuals will diminish or disappear as community complexity grows. Greater biological complexity creates more resistance to invasion and more resilience to other disturbances as well. But bare ground is not the only factor that promotes invasive behavior of our invasive annuals and biennials. In the next paper, a closer look at over-resting land, over-grazing plants, and over-fertilizing land will reveal other opportunities to focus our time and money on — treating the root causes of the invasive behavior of these annuals, rather than spending it on treating symptoms.

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SNAPSHOT: *by Billy Krimmel*[1]

Springtime Observations in Your Native Garden

Spring is an exciting time in the garden. Plants are growing in earnest, flowers are beginning to bloom, and birds and insects are buzzing around. In a native plant garden, one can be confident that many of the insect and bird species are also native and connected to broader ecological processes such as metapopulation dynamics, insect-plant coevolution, and habitat restoration (see box next page).

In this issue of *Grasslands*, we highlight some of the fascinating things that can be observed in your native garden. Native gardens are unique from conventional, non-native gardens — they share an evolutionary history with this fauna, which means that plant traits and animal traits can be interpreted within an evolutionary context. In this article, we will focus on a few that are fairly easy to observe in the spring.

Figure 1: Bush monkeyflower (*Mimulus aurantiacus*) flowers. The flower on the left has its stigma closed (and the bug *Closterocoris amoenus* inside), while the flower on the right has its stigma open. Poking the stigma with a small twig, pine needle, or toothpick will cause it to close.

Bush monkeyflower (*Mimulus aurantiacus*) is a beautiful native shrub that grows throughout much of the state, from the coast to the foothills, and Southern to Northern California. Along its range it exhibits wide variation in floral and leaf traits, resulting in a swath of cultivars that are commonly used in landscaping. Because it grows along such a wide range, it is adaptable to many different settings (i.e., sun, shade, soil type) and thus widely used in native landscaping.

Bush monkeyflower is pollinated primarily by hummingbirds. As it blooms in the spring, hummingbirds seek its nectar and often hang around native gardens where it is growing. And bush monkeyflower has a fascinating adaptation to being pollinated by hummingbirds: a touch-sensitive stigma (Figure 1) that helps it avoid self-pollination (see box next page) (Fetscher and Kohn 1999). The stigma is the part of the flower that receives pollen (compared with the anther, which produces and releases pollen). While some plants readily self-pollinate, many others (such as bush monkeyflower) have evolved means to avoid it.

Imagine a hummingbird carrying pollen from one bush monkeyflower flower to another. The hummingbird's beak and face are coated in this pollen as the hummingbird arrives to stick its face into another plant's flower. The stigma sits close to the entrance of the flower, wide open and bright white — take a look for yourself in your own garden! The nectar and pollen sit behind the stigma — this is the hummingbird's final destination, but it is forced to first bump into the stigma. As it does so, some of the pollen on its beak and face stick to the stigma, and upon contact it closes and clears the path for the hummingbird to access the nectar and pollen. As the hummingbird pulls its face out of the flower, the stigma is already closed, thus preventing the pollen from one flower from reaching the stigma from the same flower.

The mere touch by the hummingbird initiates the closure of the stigma, and one of the fun parts about this for the native gardener is that by merely touching the stigma with a finger or twig, the stigma will immediately begin to close. In a few minutes it will open up again, unless your finger or stick had pollen on it, in which case the stigma will remain closed as the flower initiates the fertilization process. Give it try in your garden or on your next hike!

There are many other interesting things to look for on bush monkeyflower. The plant bug *Closterocoris amoenus* (Hemiptera: Miridae) (inside a flower in Figure 1), can be found on plants in the wild and occasionally in gardens. During juvenile development, it resembles an ant (Figure 2), which is presumably a way to ward off predators. In Figure 2 it is feeding on the pupa of a gall midge (Diptera: Cecidomyiidae), which is a type of fly. To make matters more complicated, the fly feeds on a fungus that grows on developing flower buds of bush monkeyflower. These fly-managed fungal farms are called galls, and resemble normal flower buds except for being more rigid and lumpy. So, in Figure 2 we have a bug mimicking an ant feeding on what looks like a flower bud but is in fact a gall, inside of which is a fly growing and feeding on fungus. A lot is going on in this coevolved system! I encourage readers to do their own research on galls, gall midges, and other gall-forming insects (including wasps and aphids).

Another interesting plant-pollinator interaction to look (and listen) for in your garden involves buzz pollination. Buzz pollination has evolved in a range of plant and pollinator species and involves plants with tightly-held pollen that needs to be vibrated at a certain frequency in order to be released (e.g., Harder and Thomson 1989). It is common among many plants in the *Solanaceae* family, and a

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[1]CNGA Board Member Billy Krimmel holds a PhD in Ecology from UC Davis. He is the owner of Restoration Landscaping Company, a Sacramento design/build firm.

Springtime Observations in Your Native Garden *continued*

variety of solitary bees including many bumblebees (*Bombus* spp.). Other plants — including our native manzanitas — require buzz pollination. These bees, like all solitary bees, rely upon both nectar and pollen in order to feed their young; the pollen and nectar are combined into little nutritional balls that are placed alongside eggs in their nests, so that when the young bee larva hatch they immediately find provisions. These nests are typically made in the soil — look for small holes in bare dirt — the bees tend to be most active in the early morning and evening.

When you are observing pollinators in your garden, keep an eye — and ear — out for bees that produce one pitch of buzzing when they fly, and another, higher-pitched buzz (a "middle C") when they interact with flowers. This special vibrating frequency serves to dislodge the pollen from the plant, allowing it to disperse among the bee's hairs. Subsequently the bee will groom the pollen from its hairs and put it into specialized structures on its legs, which are used to transport the pollen efficiently from foraging forays to their nests.

This process can be mimicked easily with a tuning fork, which makes for a fun backyard science experiment. Place a sheet of paper below a flower, then touch the flower with a tuning fork that is vibrating at a middle C frequency. Observe the amount of pollen released visually. Now try it on another flower with a tuning fork at a different frequency. For a more rigorous study, compare the weight of the pollen to get a more accurate measurement of any differences pollen quantity. You can also try this on some species that are not buzz-pollinated for an additional comparison. This is also a great way to pollinate your tomato plants by hand.

The bees that buzz-pollinate also tend to make small nests in the soil for their young. Their buzzing skills are used to compact the soil in small chambers as well, so make sure to keep an ear open as you observe them enter their nests in your garden! To encourage native buzz-pollinating bees to reproduce in your garden, plant some native species in the *Solanaceae* family and maintain some bare patches of soil.

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Important ecological processes related to your native garden

Metapopulation dynamics involve the dynamic consequences of migration, local extinction, and recolonization that result in regional persistence of species (Hanski 1998). In other words, a population of a particular species may persist over a broad range even as local populations become extinct until they are subsequently recolonized. This process is very important as it relates to creating robust populations of native species in urban areas — your native garden is part of a native garden metapopulation throughout your city, with each one adding resilience and robustness to the larger population.

Insect-plant coevolution describes the back-and-forth evolutionary process between plants and insects which share an evolutionary history and whose traits affect each other, resulting in each one affecting evolutionary selection on the other and each one shaping the other's evolutionary trajectory and resulting set of traits, including morphology and behavior. This framework and body of theory provides a way to ask why plants and insects interact in certain ways, and can only be applied to systems where the species evolved together — like the species in your native garden!

Habitat restoration is the practice of renewing and restoring ecosystems and habitats that have been degraded. As mentioned previously in this column, we (Americans) have converted more than half of our land in the continental United States into cities and suburbs that tend to have very few native species of plants. Planting a native garden means restoring a piece of this back to a functional habitat — with enough native gardens, we can restore our urban and suburban metapopulations.

Self pollination is when plants pollinate themselves with their own pollen. This can refer to the pollen within an individual flower pollinating that same flower, or to different flowers on an individual plant pollinating one another. Plants exhibit a wide range of adaptations to encourage or prevent self pollination, depending on their evolution and ecology.

Figure 2 (inset): The plant bug *Closterocoris amoenus* feeds on the pupa of a gall midge (Diptera: Cecidomyiidae) on bush monkeyflower. Its mouth (referred to as a beak) penetrates into the center of the gall, where it sucks the flesh out the midge pupa.

Grasslands Explored at Los Angeles CNPS Conference

by Jim Hanson, CNGA Board Member

Presenters at February's California Native Plant Society Conservation (CNPS) Conference in Los Angeles brought forth new research about the variability, ecology, and management of grassland systems.

In a workshop on vegetation in conservation planning, Todd Keeler-Wolf of the California Department of Fish and Wildlife, and Julie Evens of CNPS, explained the detailed methodology used to determine rarity rankings for California grassland and other plant communities. Other workshop presenters described how they included conservation of rare plant communities in project environmental reviews. The next day, during a morning session devoted to grasslands and prairies, CNPS vegetation ecologist Jennifer Buck-Diaz summarized the current status of grassland community classifications: To date, fifty California upland grassland and prairie community types, or alliances, have been categorized and described — 32 native and 18 semi-naturalized, non-native alliance types (Buck-Diaz and Evens 2018).

Managing a dynamic plant community

Several presentations on native grass and forb management and conservation were also included throughout the conference (to read full conference abstracts of the brief research summaries that follow, search on **cnga.org** for "Abstracts — CNPS Conservation Conference 2018").

Some examples are as follows:

Vernal pool management research from northeastern California indicated that livestock use had no significant effect on the grass, *Orcuttia tenuis*, in some years, but *Orcuttia* was twice as abundant in unfenced than in fenced exclusion plots in other years. At the same time, high hoof print cover, especially early season, could negatively affect *Orcuttia* (Merriam et al. 2018).

A report from the Modoc Plateau looked at the timing and intensity of grazing on habitat generalists and annual and perennial vernal pool specialists. Long-term fencing exclosures may result in the loss of annual vernal pool specialist plant cover, whereas long-term, repeated grazing may result in loss or significant reduction of perennial vernal pool specialist plants. Habitat generalists are mainly affected by annual precipitation rather than grazing. Therefore, management that includes various area and timing applications for both fencing and grazing may be most effective at supporting the entire suite of species endemic to montane vernal pool habitats (Bovee et al. 2018).

A study from U.C. Riverside conducted in the East Bay tracked how grazing enhanced purple needlegrass (*Stipa pulchra*) plant growth in "high resource areas" where *Stipa* growth rates were already increasing, with opposite results in "low resource areas" where the bunchgrasses were in decline (Larios and Hallett 2018).

Research from U.C. Santa Cruz reported that grazing appeared to help maintain native annual forb diversity and reduce shrub cover, while "the cover and richness of native annual forbs is strongly affected by other factors, including variability in annual precipitation and localized site conditions" (Lesage and Holl 2018).

And, while grazing is the most commonly used grassland management tool, a study from the Mojave National Preserve (MNP) reported that "information from charred stumps and historic information indicate that wildfire played a significant role in pre-settlement times in maintaining perennial grass-dominated landscapes in this region." However, since many areas dominated by perennial grasses in the Mojave Preserve are currently zoned for full wildfire suppression, pre-settlement fire history could help inform management approaches to wildfire today (McAuliffe 2018).

Looking at seed collection source effects, a U.C. Santa Barbara study investigated the establishment of *Stipa pulchra* from seeds collected adjacent to the planting site and seed collected from six populations within 1.25 miles away. They found that "in ambient and drought conditions, the mixed seeding produced more biomass and seeds than the local populations over the first growing season." And, since *Stipa* adapts to local variations in water availability, using mixed seed sources may increase establishment success, especially as droughts become more common in California's future (Nolan and D'Antonio 2018).

Yet, regardless of what we do as land managers, several researchers reminded us of the considerable influence that precipitation patterns and quantity have on the character of grassland, meadow, and prairie sites each year.

The Birds and the Trees

Doug Tallamy, an entomologist from the University of Delaware, energized the conference in an early morning plenary talk on the intricate interrelationships of nature (available online at **https://m.youtube.com/watch?v=PVcl5tJWn6I**). Through research and photos, he described how insects specialize as feeders on different native plants by getting around that particular plant's defenses. Insect caterpillars are essential in the diet for bird fledglings. Tallamy noted how oak, *Prunus*, and *Salix* (i.e. willow) species can support over 400 species of insect caterpillars. At the same time, research by one of his students showed that many commonly used non-native trees and shrubs used for landscaping in his region supported fewer than ten caterpillar species. Tallamy

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From left: Miner's lettuce (*Claytonia perfoliata*) along N. Orr Creek Trail. Native bees visiting common blennosperma (*Blennosperma nanum*). A Pacific banana slug (*Ariolimax columbianus*) along N. Orr Creek Trail. *Photos: Emily Allen*

VISITING CALIFORNIA GRASSLANDS: *by Emily Allen, CNGA Board Member*

Low Gap Park, Ukiah, Mendocino County

Nestled in the Coast Range Mountains of Mendocino County, less than two miles off Highway 101, Low Gap Park is worth exploring for just a quick trip or, better yet, a full day! The easily accessible 80-acre park in the city of Ukiah was the site of an old lumber mill with worker housing and, up until 1955, a portion of the park was used as a city dump (Neale et al. 2013). The development of the park began in the 1970s and it continues to be expanded and updated. Current features include ample parking, bathrooms, a skate park, dog parks, an archery range, playgrounds, various sports fields and courts, a fitness course, picnic tables, and a disc golf course. The trails throughout the park are well-maintained and there are several longer hiking trails that connect the lower and upper sections of the park as well as many other shorter trails to explore.

The park is located on both city and county land, which makes management a challenge. Several groups work to ensure the park is well-kept, and that the fragile and diverse ecosystems are protected. The Ukiah Valley Trail Group and their many volunteers do an enormous amount of work to develop plans, build and maintain trails throughout the park, install fences to help keep hikers on trails, and install signage to educate and inform park visitors (Frederiksen 2017). Other groups, including the local California Native Plant Society (CNPS) Sanhedrin chapter, remain very active in the continued discussions about how to best protect the diverse and sometimes fragile ecosystems throughout the park. CNPS offers several guided walks through the park each spring that are a fun way to explore and gain a further appreciation for the park.

A wide range of native plant species can be found as soon as you enter the park, and if you take your time along the trails to take a closer look you will continue to find many surprises. There are varied and unique soils and geological features throughout the park, which each have their own subtleties to appreciate. Make sure to also keep an eye out for the intriguing native wildlife that includes Pacific banana slugs (*Ariolimax columbianus*), red-bellied Newts (*Taricha rivularis*), native pollinators and insects, and many species of birds. As you enter the park and pass the dog park, there is a large serpentine hill that in early spring is splashed with yellow common blennosperma (*Blennosperma nanum*) and followed by California goldfields (*Lasthenia californica*). Later in the year you may find other species blooming, including hayfield tarweed (*Hemizonia congesta*) and naked buckwheat *(Eriogonum nudum*).

There is an easy walk along the North Orr Creek Trail that begins to the right of the hill and follows Orr Creek, a tributary to the Russian River and home to several fish species, including steelhead trout and rainbow trout (Neale et al. 2013). There are many colorful springtime blooms including shooting stars (*Primula hendersonii*), baby blue eyes (*Nemophila menziesii*), and California buttercups (*Ranunculus occidentalis*). You will find different species of ferns, mosses, fungi, and lichen throughout the park, but especially along this trail. Miner's lettuce (*Claytonia perfoliata*) can be found along most of the trail in spring, and a unique species to keep an eye out for in early spring in wetter areas is hairy woodrush (*Luzula comosa*) with its distinctively hairy blades. The Orr Creek Trail circles around Orr Creek Meadow, which contains several native

continued next page

Visiting Low Gap Park, Ukiah, Mendocino County *continued*

species including California oatgrass (*Danthonia californica*), Yampah (*Perideridia kelloggii*), and annual native clovers (*Trifolium* spp.) (Neale et al. 2013).

One of the newest trails is the longer City View Trail, which begins by a vernal pool and opens into the City View Meadow, where you can find several upland natives including Idaho fescue (*Festuca idahoensis*). Well-defined switchbacks lead into the hills and meander through oak woodlands and hardwood and conifer forests that include Douglas-fir (*Pseudotsuga menziesii*), redwood (*Sequoia sempervirens*), tanoak (*Notholithocarpus densiflorus*), madrone (*Arbutus menziesii*), and many of the seven oak species (*Quercus* spp.) found in the park. Large clumps of California fescue (*Festuca californica*) can be found along some of the slopes. Two perennial understory flowers that you can find in spring along this trail include the hound's tongue (*Cynoglossum grande*) and the flashy warrior's plume (*Pedicularis densiflora*). In the summer you can find the vibrant red firecracker flower (*Dichelostemma ida-maia*) among the redwoods and mixed evergreens (Monroe 2016). At the top of the trail, there is an oak meadow and a welcoming bench that rewards you with a view of the valley below.

Several groups have developed helpful and detailed resources that are worth looking at before you visit the park. The Sanhedrin CNPS chapter website has a brochure developed by classes of the California Naturalist Program with names and photos for 30 wildflowers found in the park, as well as a self-guided nature hike through the park that includes descriptions of the soils, vegetation, and unique highlights. On their website you can also find a Low Gap Park plant list which is now 10 pages, and was created and updated based on findings from botanical walks in the spring that have been held in the park since 1983. The iNaturalist (**inaturalist.org**) website has a Low Gap Park and City View Trail checklist with a robust list of species, including photos of fauna and flora of the park. The Ukiah Valley Trail Group's website is a wonderful resource for maps and current information for the park.

The park is open sunrise to sunset and dogs are allowed on leash. When visiting the park, as with all grasslands, make sure to stay on the designated trails, respect signs, take only photos, and "leave no trace" (your trash with you when you leave). Together we can protect the natural areas of Low Gap Park and allow it to be a source of learning and enjoyment for many for years to come.

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Grasslands Explored at Los Angeles CNPS Conference *continued*

demonstrated that plants that evolved in concert with local animals provide for their needs better than plants that evolved elsewhere.

Drawing on this big picture of role of diverse native plant communities, CNGA launched a video several years ago that introduces elementary and middle school students to the ecological richness of grasslands and prairies. Available on YouTube and the CNGA website, the video highlights the birds, insects, and other species that are dependent upon grassland habitat and their grass and forb structure and elements. Interest in landscaping and land conservation for pollinators, native bees, and bird habitat is fortunately growing. Looking to the lessons from the insects, birds, trees, as well as other conference talks, the intricate ecological story of California's grasslands, meadows, and prairies is just beginning to unfold.

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Back cover: Baby blue eyes (*Nemophila menziesii*) along N. Orr Creek Trail. *Photo: Emily Allen*