



California
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Association

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From the President's Keyboard

This time of year, I'm noticing more and more offspring off on their own. From a young bobcat making its way past my office last month, to the fall harvest, the young are making their own way in the world.

I find the different life strategies fascinating—thousands of thistle seeds float by from an annual plant; a pair of young sister does bound across the road; a juvenile raccoon pops up from a culvert to check his surroundings; a coworker sends his daughter off to college; pale bentgrass shoots sprout from the edge of a patch. Some species invest their reproductive energy in making many offspring; others invest a great deal of energy in just a few offspring. Some plants can do both, like certain grasses: a single plant produces hundreds of thousands of tiny seeds from diminutive flowers throughout its life, but generally the successful stalks are daughter clones which sprout from the rhizomes of a parent plant and take nourishment through the difficult juvenile time of establishment.

Being a species which invests a great deal in its offspring, we tend to value that strategy more, thinking it superior at least morally. What kind of parent would toss thousands of copies of itself into the harsh world with no guidance or care? But then, look at how many thistles there are! And how many goldfinches eating those seeds; fewer finches than thistles, but still more finches than hawks, that feed on the finches and other small birds. But those seeds, those young finches and hawks have sprung off (mostly) on their own now to succeed or fail; and by their success or failure feed others making their own way in the world.

People, though, often invest effort in non-biological reproduction: the formulation and dispersal of ideas or care to help non-human animals, plants, other humans, living systems...our cultures and society reflect the output of our separate or combined work. CNGA, its members and donors, make these efforts every day; during harvest season we hope to reap some of this generosity on Giving Tuesday and through member renewals to disperse our ideas and care into the next season, and produce new ideas through our new GRASS Grants program.

Andrea Williams, President

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.

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Don't Forget to Vote!

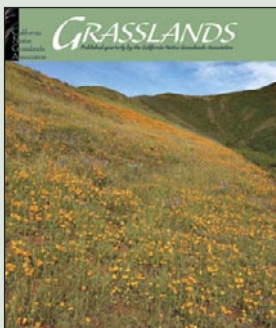
The CNGA Board of Directors elections are coming up — online voting is open from December 1–20.

On December 1, we will send out an email announcement to all members. You may then go to our website, **cnga.org**, sign in as a member, or create your account if you have not done so already. From the Members page, follow the link to "2019 Elections" to read the candidate statements and access your ballot.

If you have any questions, please email **admin@cnga.org** or call 530.902.6009.

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Richard King's *A View from the Field* series will return in the next 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:

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



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SNAPSHOT: *by Billy Krimmel*¹

Native Landscaping and Metapopulations: *Thinking beyond the individual garden*

When we use native plants to landscape our gardens, we create habitat for the myriad species of animals that depend on these plants for food, shelter, and other needs. To native fauna, native landscapes are beacons of livable habitat amidst a bleak expanse of non-native plants and pavement. So how do native birds, bees, and butterflies find our gardens in the first place? What happens when they leave? As individual native gardens flicker in and out of existence, what happens to the faunal species that occupy them?

The Metapopulation Concept

These questions all steer us to think about cities, suburban areas, rural areas, and 'wild' areas as interconnected metapopulations of species. At its most basic, a metapopulation is a group of spatially separated populations that interact through dispersal and migration. The metapopulation concept arose in the biological sciences as a way to explain population dynamics of agricultural pests in a patchy environment by considering how habitat quality, population extinction, and patch colonization impact the pest population as a whole (Levin 1974). The concept is now applied widely (e.g., Hanski 1998, Hanski and Gaggiotti 2004) when thinking about the connectivity of interbreeding populations, from predicting species resilience in the face of disturbances like climate change (e.g., Opdam and Wascher 2004) to reintroducing endangered species to the wild (Akçakaya et al. 2006) and managing fisheries (e.g., Kritzer and Sale 2004).

In landscaping, the concept of metapopulations guides us to design human-occupied areas in ways that support wildlife resilience by connecting patches of habitat to one another. The concept applies not only to thinking about how individual species persist and move through these patches, but also how connectivity affects genetic diversity of a given species (e.g., Pannell and Charlesworth 2000).

Metapopulation theory uses the language of corridors, sources, sinks, death, extinction, reproduction, colonization, and migration. Corridors are strips of habitat that connect patches to one another. Exactly what a corridor requires for species movement depends upon the needs of the species and the limitations of the broader land use, but in general a corridor enables species to move between patches. Sources, or source populations, are patches of habitat where species reproduction is greater than death — these are where species move *from*. A source may be a wild area with lots of native species, or it could be a native garden where a particular species reproduces in such high numbers that its kin colonize other areas. Source populations increase the resilience of the metapopulation. Sinks, or sink populations, are

patches of habitat where death outpaces reproduction — these are where species move *to* and die in greater numbers than their reproductive output. Sink populations reduce the resiliency of the metapopulation. Colonization refers to a species initially occupying a previously unoccupied patch (i.e., a monarch finds your patch of milkweed, lays eggs and you have monarch larvae for the first time).

This type of thinking can apply both to the wildlife that move throughout patches, and also to the species of plants that comprise the patches. Their connectivity is important, because it allows more flow of genes between populations, reducing genetic isolation and the long-term dangers that come with it (i.e., Husband and Barrett 1996),

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A mini-grassland of *Festuca californica* growing under a backyard coast live oak tree (*Quercus agrifolia*). Photo courtesy Bob Battagin, 27 August 2018, Woodacre, California

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Native Landscaping and Metapopulations *continued*

creating more resilient plant populations. This is particularly important as we face unprecedented changes to our climate that will demand genetic adaptation by species in order to deal with changing environmental conditions.

Your Garden is Part of a Metapopulation

Your native garden is a small patch of habitat for populations of native plants and animals. If other small patches with native populations exist nearby (e.g., if your neighbors have native gardens, or if native plants are growing as volunteers or ‘weeds’ nearby), individuals from the population in your patch may interbreed with the individuals from those other populations. If either population becomes locally extinct (i.e., ceases to exist in a particular patch), it can be recolonized by migrating individuals from the other patches. More patches means easier recovery from local extinctions because dispersal between patches enables recolonization of unoccupied patches, and thus a more resilient metapopulation of the species. But without migration and dispersal and the corridors required for these vital processes to occur, patches cannot be recolonized.

Corridors are particularly important to native species in human-occupied landscapes (e.g., Anderson and Danielson 1997) because of how extensively we have fragmented habitat through development of buildings, roads, fences, etc. In recognition of this, human-made corridors (e.g., tunnels and bridges) have been built across roads to enable large mammals to move between populations (e.g., Shilling and Girvetz 2007). Rivers and streams also serve as important migration corridors for a number of species (e.g., Lake et al 2007) because they are often the most contiguous corridors of vegetation within cities (see Figure 1) and thus the best options for movement across long distances. Unfortunately, when not well-managed, these riparian areas can also function as corridors for invasive species (Stohlgren et al. 1998). Similarly, roadsides and railroad rights-of-way offer tremendous opportunities for connecting small populations to one another and also to larger populations like national forests and parks; however, these can also serve as corridors for invasive species, many of which may have been planted along them intentionally (e.g., US DOT 2000). Imagine if we seeded the sides of our highways with appropriate native plant species — suddenly all the planning and money we put into these rights-of-way connecting human populations could also connect native species of plants and animals.

Moving Forward

Applying the metapopulation concept to habitat restoration in human-occupied areas allows us to focus on the key factors that determine the resilience of native species populations and apply our efforts accordingly.

What are the key source populations for species we want to support in human-occupied spaces? These source populations may be wild areas



Figure 1: A modified map depicting vegetation patches in the Sacramento area. The most continuous patches are along the American and Sacramento Rivers (the solid bands). Riparian areas like these can be important corridors for native and/or invasive species, depending on how they are managed. *Graphic by Emily Schlickman*

outside of city limits, riparian areas with healthy populations of native species, or other large, well-established native species populations.

How can we connect key source populations to uncolonized patches within human-occupied landscapes? Corridors between wild and fragmented areas are particularly important to establishing gene flow between wild and human-occupied areas.

How do we create high-quality patches for species within cities? Many animals require certain types of plants for food and habitat, and also may require other habitat features like places to nest or take shelter from adverse weather. Many plants require certain pollinators in order to reproduce, which may not be present without nearby populations or effective corridors for movement. Holistic design and implementation of native gardens is important for them to function as viable habitats.

How do we facilitate movement between patches within human-occupied spaces? If patches are close enough together, many species may be able to move through flight (e.g., birds, insects, etc.) or may be carried by the wind (e.g., seeds, small insects, etc.). Unfortunately, the reality is that native gardens are rare within human-occupied spaces, so movement between them may require smaller corridors to connect them to one another. The sides of city roads, bike paths, and sidewalks are good opportunities for such corridors.

Opportunities and Challenges

Cities and suburban areas are designed so that people can move efficiently within them. Thus, much of the heavy lifting of building corridors for native species has already been done via construction of roads and train tracks. On small scales, neighbors can create contiguous habitat patches in their front yards and sidewalks, or individual patches in their backyards, schools, or community centers,

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Native Landscaping and Metapopulations *continued*

where migration between patches is high due to spatial proximity. Homeowner associations can create resilient habitats in their communities by requiring local native plants in landscapes and along sidewalks.

The metapopulation concept provides a powerful framework for thinking about how we can restore native species in human-occupied landscapes. There are both opportunities and challenges ahead in establishing metapopulations of native species in cities and suburbs. As public awareness of forest fires, invasive species, and climate change increase, there is more motivation for investing in long-term ecological resilience, which is exactly what metapopulation theory considers. This is particularly important for large-scale seeding projects, such as post-fire erosion control, where non-native seed is widely used because it is less expensive than native seed. But if we think bigger — and consider the added value of these large spaces as source populations for native species rather than isolated patches — our cost:benefit calculus might conclude that native seeds are worth the short-term cost.

The next time you drive around your community or to a wild area, think about what it would take to connect your garden to other gardens and wild areas through migration corridors. What opportunities and challenges exist? And keep an eye out for native populations of tarweeds (*Hemizonia congesta*, *Holocarpha heermannii*, *Madia elegans*, *Madia sativa*), fiddleneck (*Amsinckia menziesii*), turkey mullein (*Croton setiger*), sacred datura (*Datura wrightii*), and evening primrose (*Oenothera californica*) growing along roadsides. Many California native plants already thrive in highly-disturbed conditions like roadsides and could make good candidates for future seeding projects.

Additional resources can be found at www.urbangardenecology.com and Helpabee.org.



References cited

Akcakaya H.R., G. Mills, and C.P. Doncaster. 2006. "The role of metapopulations in conservation." Pp. 64–83 in *Key Topics in Conservation Biology*, D.W. MacDonald and K. Service, eds. Oxford: Wiley-Blackwell.

Anderson, G.S., and B.J. Danielson. 1997. "The effects of landscape composition and physiognomy on metapopulation size: The role of corridors." *Landscape Ecology* 12:261–71.

Hanski, I. 1998. "Metapopulation dynamics." *Nature* 396:41–49.

Hanski, I., and O.E. Gaggiotti. 2004. "Metapopulation biology: Past, present and future." Pp. 3–22 in *Ecology, Genetics, and Evolution of Metapopulations*, I. Hanski and O.E. Gaggiotti, eds. Burlington: Elsevier Academic Press.

Husband, B.C., and S.C.H. Barrett. 1996. "A metapopulation perspective in plant population biology." *Journal of Ecology* 84(3):461–469.

Kritzer, J.P., and P.F. Sale. 2004. "Metapopulation ecology in the sea: From Levins' model to marine ecology and fisheries science." *Fish and Fisheries* 5(2):131–140.

Lake, P.S., N. Bond, and P. Reich. 2007. "Linking ecological theory with stream restoration." *Freshwater Biology* 52(4):597–615.

Levin, S.A. 1974. "Dispersion and population interactions." *The American Naturalist* 108(960):207

Opdam P., and D. Wascher. 2004. "Climate change meets habitat fragmentation: Linking landscape and biogeographical scale levels in research and conservation." *Biological Conservation* 117(3):285–297.

Pannell J.R., and B. Charlesworth. 2000. "Effects of metapopulation processes on measures of genetic diversity." *Philosophical Transactions of the Royal Society B: Biological Sciences* 355(1404):1851–1864.

Shilling F., and E. Girvetz. 2007. "Physical and financial barriers to implementing a nature reserve network in the Sierra Nevada, California, USA." *Landscape and Urban Planning* 80(1–2):165–172.

Stohlgren, T.J., K.A. Bull, Y. Otsuki, C.A. Villa, and M. Lee. 1998. "Riparian zones as havens for exotic plant species in the central grasslands." *Plant Ecology* 138(1):113–125.

[US DOT] United States Department of Transportation, 2000. "Beware of invasive species." *Public Roads* 63(5). <https://www.fhwa.dot.gov/publications/publicroads/00marapr/invasiv1.cfm>. Updated January 2017.

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Monitoring Long-term Change in Coastal Prairies of the Marin Headlands

by Eric Wrubel¹ and Marie Denn² Photos courtesy of Eric Wrubel

Introduction

The Plant Community Monitoring Protocol of the San Francisco Bay Area Network of National Parks (SFAN) was established to track long-term change in vegetation composition and structure in four national park units located along the central California coast. Here we present the first three years of monitoring results in the coastal prairies of the Marin Headlands, colloquially referred to as bald hills prairie (Holland and Kiel 1995).

California's coastal prairies are celebrated for their biodiversity and endemism, yet have been significantly diminished in extent and quality by development and invasive species (Holland and Keil 1995, Stromberg et al. 2001, Jantz et al. 2007). Coastal prairie is defined here as grassland located in close proximity to the shoreline, with frequent exposure to maritime fog and salt spray, and typically situated on a terrace, bluff, or coastal headland in central or northern California (Sawyer et al. 2009). Competition from introduced annual grasses has been implicated in declined abundance of native species (Corbin et al. 2007).

The windswept Marin Headlands are located in southern Marin County in the Golden Gate National Recreation Area (GGNRA). It is a largely treeless peninsula of shrublands and grasslands bordered on the southwest by the Pacific Ocean and the Golden Gate, and the San Francisco Bay to the northeast. The bald hills prairies of the Marin Headlands are primarily situated on shallow soils derived from Franciscan chert. The chert of the Marin Headlands is high in silica and iron oxides, and is resistant to weathering (Elder 2001), forming red-colored balds on many of the ridgelines. These chert-derived soils appear to be less productive than many other Franciscan soil types since cover of bare, mineral soil and bedrock can be high and vegetation coverage is often sparse (Steers and Spaulding 2013).

The bald hills prairies are dominated by introduced annual grasses and forbs, but are notable for their richness of native perennial grasses and forbs, which are diagnostically present with over 10% relative cover. The dominant native perennial grasses are Idaho fescue (*Festuca idahoensis*) and purple needlegrass (*Stipa pulchra*), and the dominant

native perennial herb is coastal soap plant (*Chlorogalum pomeridianum* var. *divaricatum*). These grasslands are best described as an Idaho fescue-purple needlegrass association, a provisional association within the Idaho fescue alliance (Sawyer et al. 2009), intermediate between the purple needlegrass-dominated bald hills of the Central Coast Ranges, and Idaho fescue-dominated bald hills of the North Coast Ranges. Associated native grasses and herbaceous perennials include California oatgrass (*Danthonia californica*), Hall's bentgrass (*Agrostis hallii*), short-stem sedge (*Carex brevicaulis*), golden aster (*Heterotheca sessiliflora* ssp. *bolanderi*), and California plantain (*Plantago erecta*). Dominant non-native species include rattlesnake grass (*Briza maxima*), brome fescue (*Festuca bromoides*), slender wild oat (*Avena barbata*), and hairy cat's ear (*Hypochaeris radicata*).

The coastal prairies of the Marin Headlands provide vitally important habitat for wildlife, including critical habitat for the federally endangered mission blue butterfly (*Icaricia icarioides* ssp. *missionensis*). These grasslands also support high densities of Botta's pocket gopher (*Thomomys bottae*); gopher disturbance and herbivory have been shown to play a significant role in vegetation dynamics here and in other California grasslands (Steers and Spaulding 2013, Schiffman 2007).

Composition and structure of California grasslands fluctuates seasonally and annually at multiple temporal and spatial scales (Heady 1956, Hobbs and Mooney 1995, Jackson and Bartolome 2002). Species and functional groups (annuals, perennials, legumes, etc.) in California grasslands have long been known to respond differentially to weather patterns (Pitt and Heady 1978), which interact with numerous other factors such as fossorial mammal disturbance, grazing, and edaphic conditions. Temporal change in grasslands is also subject to hysteresis — lag effects from causal factors in previous years. Annual grasses and forbs especially vary widely in abundance and cover from year to year with annual variations in precipitation, with some years favoring grasses, some years favoring legumes such as clovers, and some years favoring filarees (*Erodium* spp.), or other tap-rooted forbs. The Plant Community Monitoring Protocol is designed to detect a 20% change in vegetation structure and composition metrics between sampling events. To understand the significance of long-term change in this and other grassland vegetation types, we need a better understanding of typical short-term variance in structure and composition. Therefore, we are currently monitoring these grasslands annually, and we may be able to lengthen the sampling interval to every two or more years in the future, when we can better predict the normal range of interannual change.

The first three years of bald hills prairie monitoring (2015, 2016, and 2017) coincided serendipitously with historic precipitation extremes,

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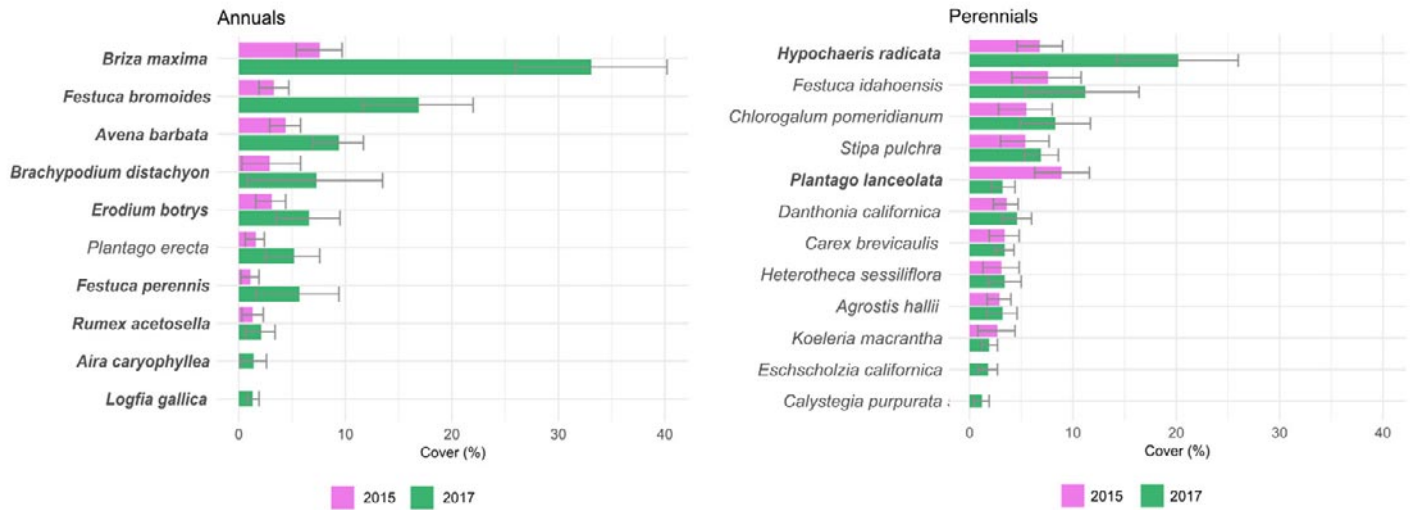


Figure 1. Percent cover of annual (left) and perennial (right) vascular plant taxa with 1% or greater cover found in 1-m² quadrats in 2015 (magenta bars), and 2017 (green bars). Non-native species names in bold. Error bars show bootstrapped 90% confidence intervals around the means.

Monitoring Long-term Change in Coastal Prairies *continued*

allowing us to compare vegetation response to the range of precipitation that may be expected in the future. The year 2015 marked the fourth consecutive year of record-breaking drought in California, perhaps the most severe period of drought in a millennium, due to accumulated moisture deficits caused by historically low precipitation and high temperatures (Griffin and Anchukaitis 2014). At the San Francisco Downtown weather station, less than 10 km from the Marin Headlands, the driest and hottest years on record were logged between 2013 and 2015 (NOAA 2015). This historic drought period was followed by above-average precipitation in calendar years 2016 and 2017.

Methods

In 2015, we established permanent monitoring plots in 12 randomly selected grassland stands in the Marin Headlands. One plot was established at the center point of each stand. These stands were all located on chert-derived soils, with Idaho fescue and purple needlegrass diagnostically present. The full methodology for site selection and plot establishment is described in the document *Plant Community Monitoring Protocol for the San Francisco Bay Area Network of National Parks* (Steers et al. 2016a, b). The protocol is designed to sample vegetation attributes across a wide variety of physiognomic types. Here we report on the sampling protocols for herbaceous plant richness and cover.

In each of the plots, we established three transects radiating from the center point. We measured vascular plant cover in three 1-m² quadrats, each placed at 4.57-m from the center point along one of the three transects. Within each quadrat we evaluated plant presence at 50 regularly dispersed points, by dropping a small-diameter pin flag vertically at each point. We recorded the name for each plant less than 3-m in height that was “hit” by the pin, identifying all vascular plants to the minimum taxonomic rank (species, subspecies, or varieties), the smallest taxonomic units recognized by the *Jepson Manual*

(Baldwin et al. 2012). Hereafter in this article we will refer to subspecies and varieties simply as “species” for the sake of simplicity. At points where no plants were observed, we recorded ground variables at the point, such as “litter” and “bare ground”. We estimated cover of each plant taxon encountered by first averaging the cover among the three 1-m² quadrats measured in each plot, then averaging cover for each taxon among all plots. For all these metrics we created bootstrapped 90% confidence intervals around the estimated mean (Efron 1981).

The area of a circle of radius 7.32-m from the plot center point was searched for all vascular plant taxa, and tallied to derive the metric species richness per 168.3-m². Species richness was then averaged among all plots to derive the mean. Richness within the 1-m² plots was also recorded, but is not reported here. We estimated diversity using iNEXT (Chao et al. 2016), to compute rarefaction and extrapolation sampling curves of Hill numbers for $q = 0$ (richness) and $q = 1$ (Shannon diversity) (Chao et al. 2014). The computation unit is the effective number of species, which is the idealized number of equally abundant species that would give the same proportional species abundance as a given dataset, in which all species may not be equally abundant.

Results

The cover of many species fluctuated markedly between 2015 and 2017. Figure 1 shows the mean cover of all vascular plants with 1% or greater cover within the 1-m² quadrats in the driest year (2015), and the wettest year (2017). Introduced annual grasses including rattlesnake grass and brome fescue, showed the greatest variance in cover between years, along with the introduced perennial forb, hairy cat’s ear. Mean cover of annual plants was about half that of perennials in 2015 (21.4%) and increased considerably to 101.5% by 2017,

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Monitoring Long-term Change in Coastal Prairies *continued*

exceeding cover of perennials by about 25% (Figure 2, values are for plant taxa with >2% cover in the plots). Perennial cover also increased at a more modest rate from 54.4% in 2015 to 74.5% in 2017.

Figure 3 shows sample-based rarefaction and extrapolation diversity accumulation curves comparing results from 2015, 2016, and 2017 for species richness, and Shannon diversity in the 7.32-m radius plots (168-m²). These curves represent the cumulative number of effective species discovered by sampling 12 plots, and extrapolated to the number of species expected to be discovered with additional sampling of up to 30 plots. Observed (*Sobs*) species richness was significantly lower in the drought year of 2015 (*Sobs* = 80, 95% CI [72.4, 87.6]), than it was in 2016 (*Sobs* = 98, 95% CI [88.8, 107.2]) and 2017 (*Sobs* = 99, 95% CI [90.7, 107.3]), based on non-overlapping confidence intervals. Shannon diversity was also significantly lower in 2015 (*Sobs* = 56.7, 95% CI [52.8, 60.6]) than it was in 2016 (*Sobs* = 66.3, 95% CI [61.1, 71.6]), and 2017 (*Sobs* = 70.7, 95% CI [65.62 75.2]). Richness and Shannon diversity were not significantly different between the two wetter years of 2016 and 2017, based on overlapping confidence intervals, though the confidence intervals for richness showed almost complete overlap, whereas the confidence intervals for Shannon diversity showed only partial overlap.

Conclusion

The grasslands in this study varied markedly in structure and composition in a short time frame between dry and wet weather years, supporting previous work in California grasslands (Heady 1956, Pitt and Heady 1978, Hobbs and Mooney 1995, Jackson and Bartolome 2002). Total vegetative cover increased with increased precipitation, driven mostly by increased cover of non-native annual grasses and forbs (Figures 1 and 4). Annual rattlesnake grass dominated the community in all years, but was far sparser during the drought of 2015, and increased dramatically in cover in 2016 and 2017 (Figure 1), accompanied by increases of two other non-native species: hairy cat's ear, a short-lived perennial, and brome fescue, an annual grass. The

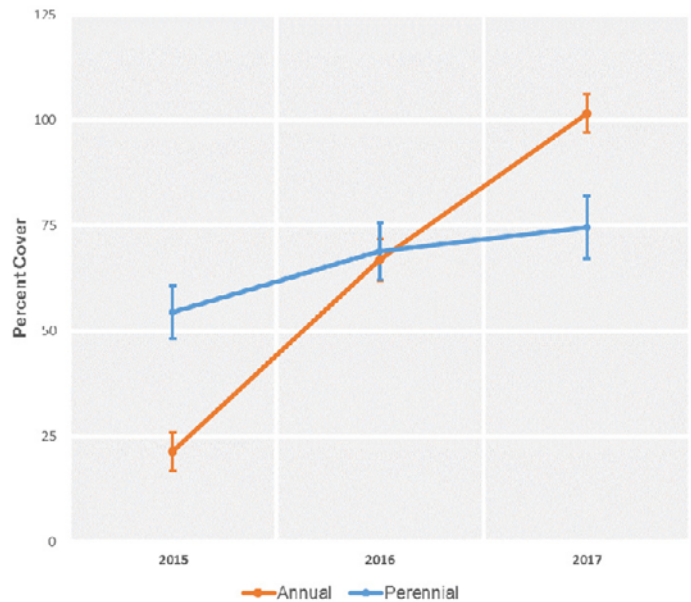


Figure 2. Mean percent cover of live annual and perennial plants with >2% cover found in 1m² quadrats in 2015, 2016 and 2017. Error bars show the standard error of the mean.

native perennial grasses, Idaho fescue and purple needlegrass, and the native perennial bulb, soap plant, increased only slightly in cover from 2015 to 2017. Cover of most species shifted significantly between 2015 and 2017 (Figure 12), although the frequency of most species in the plots remained relatively stable between years.

Annual and perennial plant cover both increased from lows in the 2015 drought year to highs in the wettest year of 2017 (Figure 2). Annual plant cover was much less than that of perennials in 2015, but well exceeded perennial cover by 2017. The bulk of the annual plant cover was contributed by non-native species, although the native annual California plantain contributed modest cover each year, reaching a high of 5.2% mean cover in 2017. Cover values for annual and perennial plant groups showed a high degree of variance between plots, as may be expected from an examination of plant guilds composed of many species.

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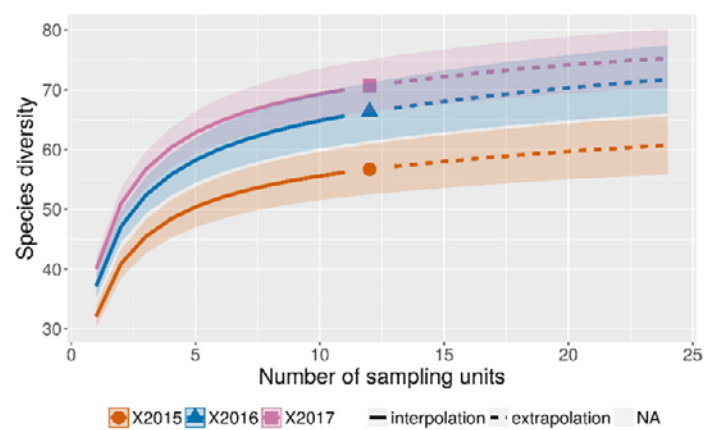
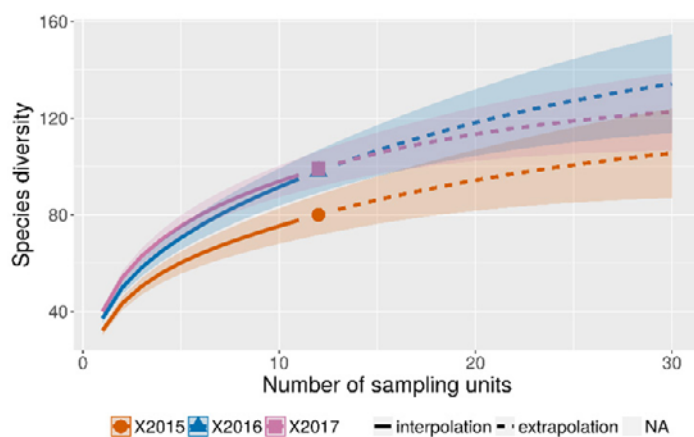


Figure 3. Rarefaction curves, showing effective species richness (left), and effective Shannon diversity (right) for the 7.32-m grassland plots sampled in 2015, 2016 and 2017. The curves show cumulative species diversity observed (*Sobs*) in the 12 plots sampled; interpolated below 12 samples, and extrapolated to an endpoint of 30 samples (95% confidence intervals shown in lighter colors, based on bootstrap methods with 200 replications).

Monitoring Long-term Change in Coastal Prairies *continued*

Alpha diversity, or site diversity in the 7.32-m radius plots, also varied significantly between dry and wet years. Effective species richness and diversity both increased from low points during the historic drought of 2015, with increased precipitation during 2016 and 2017 (Figure 4). This effect is likely due to numerous direct and indirect causal factors which could include, but are not limited to: favorable germination, seed production, and dispersal during wet years; dormancy of seeds or underground structures during drought, and dormancy release during wetter years; and plant-animal interactions. Increased cover of introduced annual grasses during wet years did not appear to have a negative effect on alpha diversity, which also showed a positive relationship with increased precipitation. However, a significant increase in diversity was seen between 2015 and 2016, the driest year and the first wet year, respectively, and diversity was not significantly different between the two wet years, 2016 and 2017, which could indicate that competitive interactions of the dominant annuals had a damping effect on overall diversity in the second consecutive wet year (see Corbin et al. 2007).

The results of this study support the hypothesis that the cover of annual species in bald hills prairies may be expected to fluctuate dramatically between wet and dry years, and that these fluctuations are quite variable by site. This study also showed that the cover of native perennial grasses and herbs also increased during wetter years, but more slowly. Moreover, we showed that alpha diversity in bald hills prairies of the Marin Headlands is subject to significant annual variation between wet and dry years, indicating that temporal flux in species richness must be accounted for in comparative studies of grassland biodiversity. We anticipate that longer-term annual sampling will better elucidate the vegetation responses to weather patterns and other environmental factors in these coastal prairies.

Acknowledgements

Many thanks to Robert Steers, who authored the first formal study of the chert prairies of the Marin Headlands, *Native Component Grasslands of the Marin Headlands* (Steers and Spaulding 2013), as pilot work for the *Plant Community Monitoring Protocol for the San Francisco Bay Area Network of National Parks* (Steers et al. 2016 a, b); and to the many staff and interns who have implemented the monitoring protocol.



References

Baldwin, B.G., D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilken, eds. 2012. *The Jepson Manual: Vascular Plants of California*, 2nd ed. Berkeley: UC Press.



Figure 4. Time series of a coastal prairie monitoring transect. From the top: April 2015, during historic drought conditions, with sparse vegetative cover, bare ground and exposed bedrock; April, 2016, showing vegetation response to increased precipitation; April, 2017, showing dramatically increased vegetative cover in response to historically wet year, with little exposed bare ground or exposed bedrock.

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A view from the trail at Brushy Peak Regional Preserve. Photo: Michele Hammond

VISITING CALIFORNIA GRASSLANDS: by Michele Hammond, CNGA Board Member

Brushy Peak Regional Preserve, Alameda County, California

Part of the Diablo Range, Brushy Peak Regional Preserve, is part of an extensive corridor of preserved public grasslands and oak woodlands that reach all the way north to Mt. Diablo State Park. Located at the north end of Laughlin Rd. off Highway 580 in Livermore, the preserve is accessible from a parking lot at the base of the peak. Visited mostly in the spring and fall, Brushy Peak is an open grassland, managed with cattle grazing, with spectacular views of the Livermore area when you reach the top. Summer heats up in the eastern part of the county but, for those who want to get out of the foggy coast, there are alkali wetland plants and tarplants to enjoy!

Brushy Peak Loop trail connects with the Westside Loop trail to make a gradual 6 mile hike that passes just below the peak (1,702 ft.) for an amazing view. Starting out of the parking lot, the alkali wetland, or salt grass (*Distichlis spicata*), meadows are first, leading to open purple needlegrass (*Stipa pulchra*) grasslands with scattered spring wildflowers like yarrow (*Achillea millefolium*) and lupines (*Lupinus* spp.). Near the top of the peak, sandstone rock outcrops occur with scattered coast live oaks (*Quercus agrifolia*) and buckeye (*Aesculus californica*).

Spring is the loveliest time to visit both for true green rolling hills and wildflower displays. In February and March, the lilies begin to bloom including the rare stinkbells (*Fritillaria agrestis*) often surrounded by blue dicks (*Dichelostemma capitatum*), Ithuriel's spear (*Triteleia laxa*) and soapplant (*Chlorogalum pomeridianum*). Later in the spring, the phenology of the grassland shifts to wildflowers like harvest brodiaea (*Brodiaea elegans*) and native Douglas silverpuff dandelions (*Microseris douglasii*) nodding in bud. Native bunchgrasses also begin to shoot up their inflorescences in the upland grasslands near the peak,

including purple needlegrass, blue wild-rye (*Elymus glaucus*), and California melic (*Melica californica*).

In summer, one can visit the ugly (or beautiful, depending on the observer) tiny blooms of rare alkali wetland plants like Brittscale (*Atriplex minuscula*). In the grasslands, yellow spikeweed (*Centromadia pungens* subsp. *pungens*) and the white-flowered hayfield tarplant (*Hemizonia congesta* subsp. *luzulifolia*) rise above the grasses with color and that sticky native smell that insects, birds and California botanists have learned to love.



There is abundant wildlife to watch like western kingbirds and western bluebirds perching on the fence watching for a meal to fly by. About halfway up towards the peak, you can often spot a burrowing owl in the middle of a California ground-squirrel burrow complex. You can also sometimes find the small avian carnivore, loggerhead shrike, or, if you're lucky, spot its prey pinned to a barbed-wire fence.

Brushy Peak is loaded with local history. It served as both an ancient center of Native American trade routes and an historic hideout for Mexican bandits like Joaquin Murietta. For more information about the history of the area and access to the park check out the website: https://www.ebparks.org/parks/brushy_peak

Access to the preserve is free. Dog walking is permitted on leash only in order to protect the natural and cultural resources.



Inset: *Fritillaria agrestis* is a species of lily endemic to California.

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- Chao, A., N.J. Gotelli, T.C. Hsieh, E.L. Sander, K.H. Ma, R.K. Colwell, and A.M. Ellison. 2014. "Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies." *Ecological Monographs* (84):45–67.
- Chao, A., K.H. Ma, and T.C. Hsieh. 2016. "iNEXT (iNterpolation and EXTrapolation) Online." Accessed August 1, 2018. http://chao.stat.nthu.edu.tw/wordpress/software_download/
- Corbin, J.D., A.R. Dyer, and E.W. Seabloom. 2007. "Competition interactions." Pp. 156–168 in *California Grasslands: Ecology and Management*, M.R. Stromberg, J.D. Corbin, and C.M. D'Antonio, eds. Berkeley: UC Press.
- Elder, W.P. 2001. "Geology of the Golden Gate Headlands." Pp. 61–86 in *Geology and Natural History of the San Francisco Bay Area: A Field-Trip Guidebook*, P.W. Stoffer, and L.C. Gordon, eds. U.S. Geological Survey Bulletin 2188.
- Griffin, D., and K.J. Anchukaitis. 2014. "How unusual is the 2012–2014 California drought?" *Geophysical Research Letters* 41:9017–9023.
- Heady, H.F. 1956. "Changes in a California annual plant community induced by manipulation of natural mulch." *Ecology* 37:798–912.
- Hobbs, R., and H. Mooney. 1995. "Spatial and temporal variability in California annual grassland: Results from a long-term study." *Journal of Vegetation Science* 6:43–56.
- Holland, V.L., and D.J. Keil. 1995. *California Vegetation*. Dubuque: Kendall Hunt Publishing Co.
- Jackson, R.D., and J.W. Bartolome. 2002. "A state-transition approach to understanding nonequilibrium plant community dynamics in Californian grasslands." *Plant Ecology* 162(1):49–65.
- Jantz, P.A., B.F. Preusser, J.K. Fujikawa, J.A. Kuhn, C.J. Bersbach, J.L. Gelbard, and F.W. Davis. 2007. "Regulatory protection and conservation." Pp. 420–422 in *California Grasslands: Ecology and Management*, M.R. Stromberg, J. Corbin, and C.M. D'Antonio, eds. Berkeley: UC Press.
- National Oceanic and Atmospheric Administration (NOAA). 2015. "NOWData — NOAA Online Weather Data. Monthly total precipitation, San Francisco Downtown 1900–2015." Accessed August 1, 2018. <https://w2.weather.gov/climate/index.php?wfo=mtr>
- Efron, B. 1981. "Nonparametric estimates of standard error: The jackknife, the bootstrap and other methods." *Biometrika* 68(3):589–599.
- Pitt, M.D., and H.F. Heady. 1978. "Responses of annual vegetation to temperature and rainfall patterns in northern California." *Ecology* 59(2):336–350.
- Sawyer, J.O., T. Keeler-Wolf, and J.M. Evens. 2009. *A Manual of California Vegetation*, 2nd ed. Sacramento: California Native Plant Society.
- Schiffman, P.M. 2007. "Ecology of native animals in California grasslands." Pp. 180–190 in *California Grasslands: Ecology and Management*, M.R. Stromberg, J. Corbin, and C.M. D'Antonio, eds. Berkeley: UC Press.
- Steers, R., M. Denn, E. Wrubel, A. Forrestel, B. Johnson, L. Parsons, and F. Villalba. 2016a. "Plant community monitoring protocol for the San Francisco Bay Area Network of National Parks: Narrative Version 2.0." Natural Resource Report NPS/SFAN/NRR—2016/1284. National Park Service, Fort Collins, Colorado.
- Steers, R., M. Denn, E. Wrubel, A. Forrestel, B. Johnson, L. Parsons, and F. Villalba. 2016b. "Plant community monitoring protocol for the San Francisco Bay Area Network of National Parks: Standard operating procedures Version 2.0." Natural Resource Report NPS/SFAN/NRR—2016/1284.1. National Park Service, Fort Collins, Colorado.
- Steers, R.J., and H.L. Spaulding. 2013. "Native component grasslands of the Marin Headlands." Natural Resource Technical Report NPS/SFAN/NRTR—2013/832. National Park Service, Fort Collins, Colorado.
- Stromberg, M.R., P. Kephart, and V. Yadon. 2001. "Composition, invisibility, and diversity in coastal California grasslands." *Madroño* 48(4):236–252.



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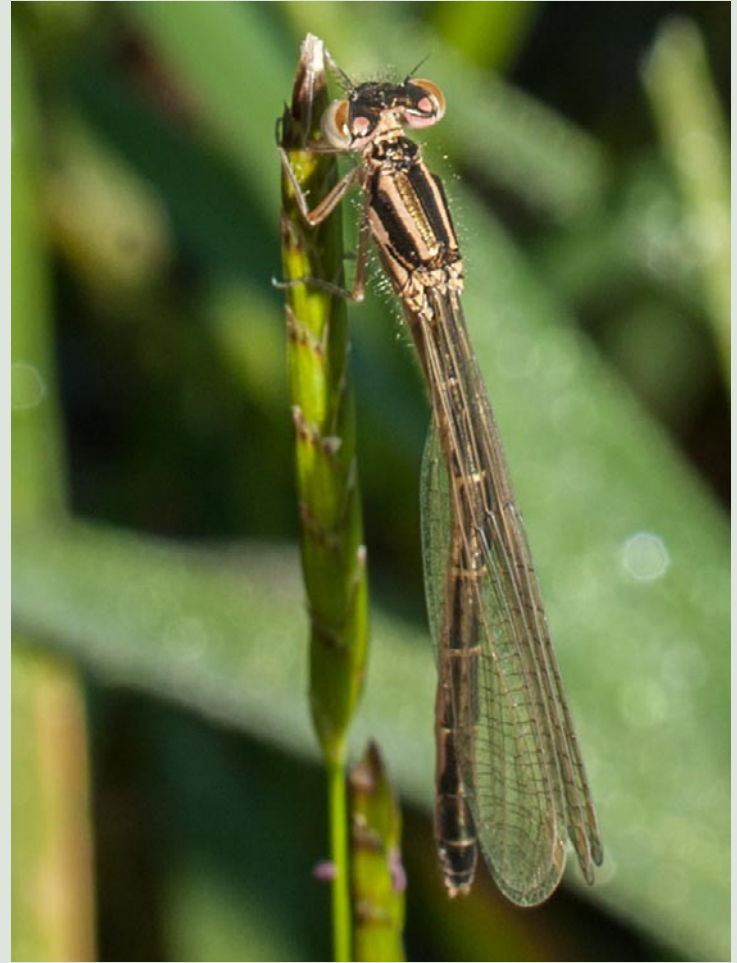
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From left: Photo 1. Open panicles of narrow manna grass (*Glyceria leptostachya*). Photo 2. The structural properties of manna grass provide shelter and substrate for organisms, such as damselflies.

SPECIES SPOTLIGHT: by Jeffery T. Wilcox¹ Photos courtesy of the author

The Sweet Green of Narrow Manna Grass (*Glyceria leptostachya*)

When I first read that the late 19th century botanist Joseph Burt-Davy collected narrow manna grass (*Glyceria davyi* or Davy manna grass, now *Glyceria leptostachya*) in a marsh near Guerneville in 1899 (Baldwin et al. 2012), I wondered if his attention had been caught by one of the few green things growing in mid-summer. Long before 1893, when Davy arrived from his native England to study botany at University of California, Berkeley (Gunn 1940), California's native grasslands had been largely subsumed by alien annual species brought here by early European settlers. In much of California, the month of May brings a transition from green spring landscapes to the golden browns of summer, evidence of the senescence of these invasive annual grasses.

In 1896, Davy took a job as the botanist for the Agricultural Experiment Station at Berkeley where, over the next 5 years, he conducted an extensive survey of rangelands in northwestern California. The areas he surveyed included the immediate San Francisco Bay Area, along with Lake, Mendocino, Humboldt, Trinity, and parts of Siskiyou counties. Davy reported rangelands impoverished by overstocking and injudicious grazing methods, consisting primarily of alien annuals such as soft chess (*Bromus hordeaceus*), wild oat (*Avena* spp.), and alfilaria (now filaree; *Erodium* spp.), but noted that these species seemed to provide decent forage. Only in protected areas did he observe native ryes (*Elymus* spp.), bromes (*Bromus* spp.), hair grasses (*Deschampsia* spp.), June grasses (*Koeleria* spp.), and fescues (*Festuca* spp.) (Lamson-Scribner and Merrill 1900). Narrow manna grass would have been one of the few and brightest green sights during a long, hot summer.

¹Jeffery is Managing Ecologist at the Sonoma Mountain Ranch Preservation Foundation and a member of the CNGA Board.

continued next page

Narrow Manna Grass *continued*

Davy may also have been drawn by familiarity when he discovered manna grass. The *Glyceria* genus is well-represented in Europe and Asia, and it is likely that Davy came to know it when he was employed at Kew Gardens early in his career (Gunn 1940). The seeds of several species of manna grass were harvested for food throughout Europe during the middle ages, but due to their small size and labor-intensive harvesting, they were never developed as commercial crops. Nevertheless, sweet manna grass (*Glyceria fluitans*) was so prized in Europe that it was still gathered and traded, or presented as tribute, until the early 20th century. Sweet manna — as in “manna from heaven” — grass seeds contain approximately 75% carbohydrates. They were typically served as a dessert (the groats boiled into a sweet gruel), often with milk and cinnamon added (Luczaj et al. 2012).

Narrow manna grass is a perennial that grows in or near coastal wetlands and waterways from Alaska to California (Darris 2008). It has erect to low-lying stems 60–110 cm tall, with flat leaf blades (3–7 mm wide) that roll slightly inward and are rough on both sides (Baldwin et al. 2012). The flowerhead (panicle) is open (Photo 1), 20–40 cm long, with a few branches pressed close to the main axis (Darris 2008). In moist soils around seeps and springs, individual plants often retain a typical bunchgrass appearance, but manna grass produces rhizomes and stolons that sprout roots and, when plants are submerged in ponds or streams, floating leaves (Calflora 2018).

Here on the Mitsui Ranch, in the Coast Range of Sonoma County and approximately 25 miles from Guerneville, summers are hot and dry once June has passed. Most remaining green vegetation is a suite of invasive weeds, along with rushes, sedges, and manna grass in the wet areas. Grazing animals are attracted to these wet areas not only for water, but also for the green vegetation. Even the genus and species names for narrow manna grass (*Glyceria*, meaning “new, sweet from the taste of grain,” and *leptostachya*, “thin ear of corn”) promise a reward beyond succulence. In the spring of 2013 on the Mitsui Ranch, we collected random grass samples from several locations in pasture adjacent to two water bodies, Turtle Pond and Copeland Creek. We then collected manna grass samples from the edges of the same two water bodies. The pasture samples were dominated by varying combinations of Italian rye grass (*Festuca perennis*), soft

chess, ripgut brome (*Bromus diandrus*), foxtail barley (*Hordeum murinum*), and seaside barley (*H. marinum*). In all nutritional categories except percent fiber, values for narrow manna grass collected in Turtle Pond and Copeland Creek were higher than those of traditional forage plants (Table 1).

Narrow manna grass, in addition to its nutritive and succulent value to a host of animals, provides another, less-considered benefit: an important structural element in the landscape for shelter, cover, thermoregulation, and attachment substrate for many living organisms (Photo 2). Consider Turtle Pond on the Mitsui Ranch: a small, deep, perennial pool that by July resembles an emerald ring floating amid a sea of dry grass (Photo 3). Much of the ring is composed of narrow manna grass, some growing on the bank, some rooted in the mud left after the water has receded. A night-time walk around the shoreline reveals a busy insect community. Stretch spiders (*Tetragnatha* spp.) anchor their webs between stalks and leaves of overhanging manna grass, extending their webs over the water to catch flying insects that hunt or feed at the surface or insects feeding directly on the manna grass, such as caterpillars and true bugs like leafhoppers. Lurking in the water below the overhanging manna grass, frogs await the same suite of insects — and often make a meal of the stretch spiders as well (Photo 4). When we examined the stomach contents of a bullfrog (*Lithobates catesbeianus*) that had been stationed under a ceiling of manna grass, it contained the remains of 13 stretch spiders (Alvarez and Wilcox, unpublished data).

continued next page



Photo 3. Narrow manna grass forms a ring of green around Turtle Pond, Mitsui Ranch, Sonoma County, California.

Table 1. Some standard nutritional values for narrow manna grass (*Glyceria leptostachya*); the mean values of eight (mixed) alien annual grass samples; Medusa head (*Elymus caput-medusae*); and yellow star thistle (*Centaurea solstitialis*). ENE (estimated net energy) is the energy leftover after metabolism and heat loss, and NEL (net energy for lactation) is the energy leftover after a cow's maintenance needs for supporting a fetus.

	Crude Protein	Fiber	Nitrogen	Phosphorus	Calcium	% Digestible Nutrients	NEL	ENE
Manna grass	14.69	31.26	2.35	0.45	0.37	67.53	0.7	57.6
Annual grasses	9.3	44.7	1.5	0.2	0.5	52.6	0.5	43.8
Medusa head	7.19	40.1	1.15	0.145	0.45	57.79	0.59	48.63
Yellow star thistle	8.88	40.43	1.42	0.2	1.36	57.33	0.58	48.21

Narrow Manna Grass *continued*

Islands of manna grass can form in a pond when rhizomes and stolons sprout roots offshore. These islands provide a different structural habitat altogether for pond-dwelling creatures. Under the water surface, amidst the stolons, microorganisms feed on spent plant parts and on algae that grows on the underside of the submerged plant. In turn, microorganisms provide food for scuds (Amphipoda family), small, shrimp-like creatures that forage among the stolons and lay eggs on the surface of submerged vegetation. Scuds are prey for larger aquatic insects, as well as for frogs and salamanders. In Turtle Pond, scuds are the primary food source for a robust population of rough-skinned newts (*Taricha granulosa*), and manna grass is the scud nursery.

Narrow manna grass is an important structural feature in streams as well. Copeland Creek is an intermittent creek that drains much of the

Mitsui Ranch property. Narrow manna grass overhangs the edges of runs and pools and even grows into the flowing water. Rhizomes that anchor between the cobbles of the streambed (Photo 5) provide a substrate in the current. Often the anchorage is so firm that rhizomes and stolons hold fast through the high flows of winter, even as the plants lose their leaves. These solid tangles in midstream in turn provide holdfasts for organisms to grasp — or anchor their eggs to — to avoid being swept away. One benefiter is the California red-legged frog (*Rana draytonii*), a native frog in decline throughout its historic range, and listed as “threatened” by the U.S. Fish and Wildlife Service. During their breeding period in late winter, California red-legged frogs attach their egg masses to aquatic vegetation to prevent them being swept away (Alvarez et al. 2013, Wilcox et al. 2017). Ponds are a recent geographic feature in California; most were constructed in the past century for flood control, recreation, or to water livestock and crops.

Prior to this, the frogs must have used streams for breeding (see Alvarez et al. 2013), but biologists have wondered how large egg masses could survive running water. This past winter provided a clue. For the first time in six years of annual surveys, we discovered a red-legged frog egg mass in a run in Copeland Creek, firmly attached in a tangle of stolons of narrow manna grass.

In our evolutionarily recent time on the planet, humans have counted on grasses for our very survival. Some provide us food (corn, rice, wheat, barley, etc.); some, shelter (thatched roofs, bamboo flooring); some, once we started raising food animals, livestock feed. The same is true for wild organisms that coevolved with uncultivated



Photo 4. A California red-legged frog (*Rana draytonii*) lies in ambush under the leaves of narrow manna grass at Turtle Pond, Mitsui Ranch, Sonoma County, California.

continued next page

Narrow Manna Grass *continued*

grasses. They use grass for food, for shelter, or simply for infrastructure to support critical behavior such as egg-laying. Narrow manna grass appears to have comprehensive value in its native range, well beyond being a rare green sight in the heat of summer.



Literature Cited

- Alvarez, J.A., D.G. Cook, J.L. Yee, M.G. van Hattem, D.R. Fong, and R.N. Fisher. 2013. "Comparative microhabitat characteristics at oviposition sites of the California red-legged frog (*Rana draytonii*).” *Herpetological Conservation and Biology* 8(3):539–551.
- Baldwin, B.G., D.H. Goldman, D.J. Keil, R. Patterson, T.J. Rosatti, and D.H. Wilken, eds. 2012. *The Jepson Manual: Vascular Plants of California*, 2nd ed. Berkeley: University of California Press.
- Calflora. 2018. "Information on California Plants for Education, Research and Conservation." The Calflora Database. Accessed August 18, 2018. www.calflora.org
- Gunn, M. 1940. "South Africa's debt to Joseph Burt Davy." *Journal of the South African Forestry Association* 5(1):10–11.
- Lamson-Scribner, F., and E.D. Merrill. 1900. "Studies on American grasses, the North American species of *Chaetochloa*," United States Department of Agriculture, Division of Agrostology, Grass and Forage Plant Investigations, Washington D.C. Bulletin No. 21. 67 pp.
- Luczaj, L.J., J. Dumanowski, P. Köhler, and A. Mueller-Bieniek. 2012. "The use and economic value of manna grass (*Glyceria*) in Poland from the middle ages to the twentieth century." *Human Ecology* 40:721–733.
- Wilcox, J.T., M.L. Davies, K.D. Wellstone, and M.F. Keller. 2017. "Traditional surveys may underestimate *Rana draytonii* egg-mass counts in perennial stock ponds." *California Fish and Game* 103(2):66–71.



Photo 5. Narrow manna grass stolons (center of channel), after high-velocity stream flows in Copeland Creek wash the leaves off. Individual plants on shore remain intact (center right). These tangles of stolons are sometimes attachments sites for the egg masses of California red-legged frogs.

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Figure 1. The bladderpod shrub, *Peritoma arborea* var. *globosa* on a hillside in Tejon Ranch. This image shows the observed dispersed spatial pattern of the shrub.

Explaining the Dispersed Spatial Pattern of *Peritoma arborea* var. *globosa*, a California Native and Endemic Shrub

by Mary E. McDonnell¹ Photos courtesy the author

Introduction

In California, conversions from shrubland to grassland and grassland to shrubland occur with unknown consequences to the many ecosystem services provided (Knapp et al. 2008, Wolkovich et al. 2010, Yu et al. 2016). For example, rangelands sequester carbon, host biodiversity, and provide cultural ecosystem services, all of which can be impacted by shifts in dominant vegetation, either for better or for worse (Schuman et al. 2002). Understanding ecological processes that influence distribution of vegetation in the landscape is an important first step in predicting the effects of shifts in dominant plant cover.

Shrub encroachment refers to the increase in cover of woody plants, mainly native shrubs (van Auken 2009). Encroaching shrubs have the ability to change the ecological processes of the landscape, including soil properties, inter-shrub plant species cover, and water availability, and often are able to persist in the landscape following disturbance (Schlesinger et al. 1996). The process of shrubs persisting after long disturbances of drought and wind erosion is often referred to as desertification and is considered a type of land degradation

(D’Odorico et al. 2013). However, in dryland ecosystems, the presence of shrubs or other woody species can have a positive influence on species richness and composition. Facilitation is the positive interaction between plants, and in water-depleted ecosystems such as drylands, shrubs offer shade and nutrient development in the soils under their canopy (Bertness and Callaway 1994, Brooker et al. 2008).

I investigated bladderpod (*Peritoma arborea* var. *globosa*) distribution and age on Tejon Ranch in southern California. At 109,000 hectares, Tejon Ranch (“Ranch”) is the largest contiguous land holding in California. Eighty-five percent (92,650 hectares) of the Ranch is protected from development under a conservation easement. Bladderpod is a member of the Cleomaceae, or “bee plant”, family and is native and endemic to southern California (Calflora 2018). It is drought tolerant and provides habitat for rangeland wildlife, such as sparrows, quails, finches, kangaroo rats, and ground squirrels (Smither-Kopperl 2012). The species is common on sloped terrain, desert washes, and disturbed areas, and resprouts after fire (Smither-Kopperl 2012). On the Ranch, bladderpod displays unexplained dispersed (i.e., even), spatial distribution and a uniform size class, as opposed to a more random spatial distribution and variation in size (Figure 1). This could suggest a disturbance event caused the shrub’s seeds to be dispersed or germinated within a narrow time period. The

¹Mary E. McDonnell is a recent graduate from College of Natural Resources at UC Berkeley with a BS in Conservation and Resource Studies. She conducted this research as a senior thesis with the UCB Range Ecology Lab.

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Dispersed Spatial Pattern of *Peritoma arborea* var. *globosa* *continued*

spatial pattern displayed by plants has implications for explaining resource use and interactions with neighboring flora and fauna (Turner 1989).

This study aims to describe the ecological processes driving the dispersed spatial pattern of bladderpod as observed on the Ranch. By examining several edaphic properties and shrub size and age, this study investigates the following questions: (1) Is there a relationship between shrub size and age? (2) Are the shrubs even-aged? (3) Is there a relationship between edaphic properties and the dispersed spatial distribution of bladderpods?

Methods

Tejon Ranch study site

The study took place in the San Joaquin Valley portion of the Ranch. There are three 5-m x 20-m established plots with bladderpod present. At sites where bladderpod occurs, no other shrub species were observed, and many grasses and forbs were present.

Soil and shrub field sampling

In October 2017, within the border of each shrubland plot, I collected three 0–15 cm deep soil samples: (1) directly underneath a randomly selected shrub, (2) at the shrub edge, and (3) 3-m away from the shrub. I collected these three samples at the three shrubland plots for a total of nine samples. These three soil collections are hereafter referred to as shrub, edge, and grass soil samples.

Then, within the border of each plot, I selected seven shrubs randomly for measurements of shrub height at center, maximum and minimum canopy diameter, and stem diameter, estimated using a caliper. In

addition, at each plot, I selected three shrubs near the plot border, but outside of the established plot to be measured for the same dimensions, and excavated plants to 15-cm deep (no shrubs within the plot border were excavated). I stored and weighed all excavated aboveground and belowground biomass in the field to attain wet weight. Shrub excavation took place three times at each plot, for a total of nine excavated shrubs.

Soil and shrub lab analysis

I ground the collected soil samples and passed them through a 2 mm sieve. For the properties Olsen-Phosphorus (Olsen-P), Sulfate Sulfur (SO₄-S), exchangeable Calcium (X-Ca), exchangeable Potassium (X-K), exchangeable Magnesium (X-Mg), and cation exchange capacity (CEC), I sent three 500-g samples of soil from each plot to the UC Davis Analytical Laboratory for analysis. I obtained bulk density, soil texture, pH, soil organic matter, and total C and N data from Lina Aoyama's research (personal communication 2018) on aboveground and belowground soil carbon stocks from the same plots at the Ranch, also collected in October 2017. For bulk density, I dried 5 g of each sample in an oven at 65°C for 24 hrs and reweighed the samples (Jones 2001). I then used the same five grams of soil to determine soil texture following the Bouyoucus Hydrometer Method (Jones 2001). From this method, I calculated percent sand, silt, and clay and further identified soil textural classes using the soil texture triangle (Jones 2001). I measured soil pH by adding distilled water to vials containing soil samples. I mixed the solution in the vial vigorously for 2 min. Then, using a pH monitor, I measured the pH of the solution every minute for 10 min, ultimately taking an average of the 10 measurements. I determined soil organic matter following the Loss-on-Ignition Method (Jones 2001). I placed a known amount of soil into a crucible that I then placed in a drying oven at 100°C for 24 hrs, then placed this in a furnace at 500°C for 4 hrs. I determined total carbon (C) and nitrogen (N) using a C/N elemental analyzer (JoVE 2018).

Dendrochronology

I dried aboveground and belowground biomass of the excavated shrubs at 65°C for 48 hours and reweighed to attain dry weight. I used the belowground primary stems for analyzing shrub age and ring growth measurements. Of the nine samples, only four remained intact following excavation and lab analysis. I sanded the intact primary stem samples plus one branch sample starting with 50 grit sandpaper, moving to 100, 200, 400, and finishing with 600 grit. I identified growth rings on three radii of the cross-section, taking measurements along the three radii at 100x (Figure 2). I attempted to crossdate the samples with a master chronology from nearby regions; however, due to the young age of the samples no such database currently exists. Instead, I crossdated the samples against each other using COFECHA, an analysis program for dating woody species and quality control (Holmes 2013). If I suspected false or partial growth rings to be present, such as cells appearing in the late wood but not forming a full ring or part of a growth ring pinching off and not forming a full ring, I entered a "0" for the growth measurement. I measured growth rings from the bark to the first ring on all samples since they were collected in October, near the end of the growing season.

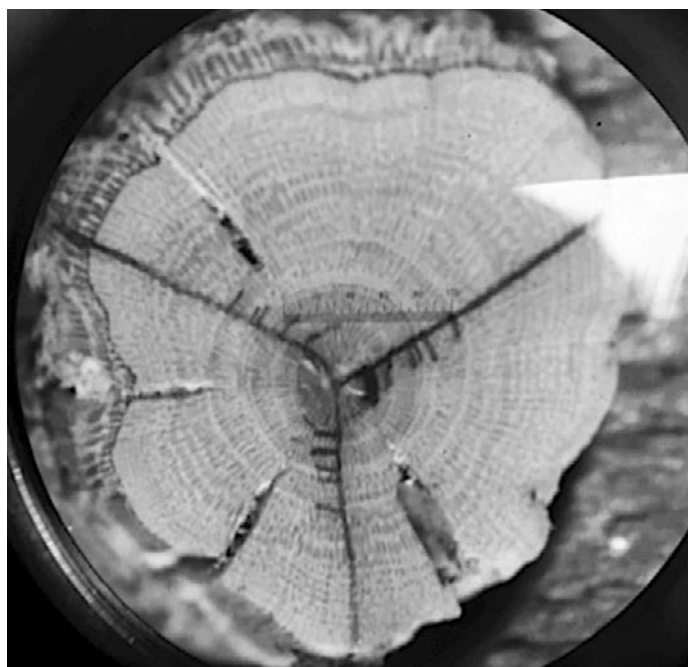
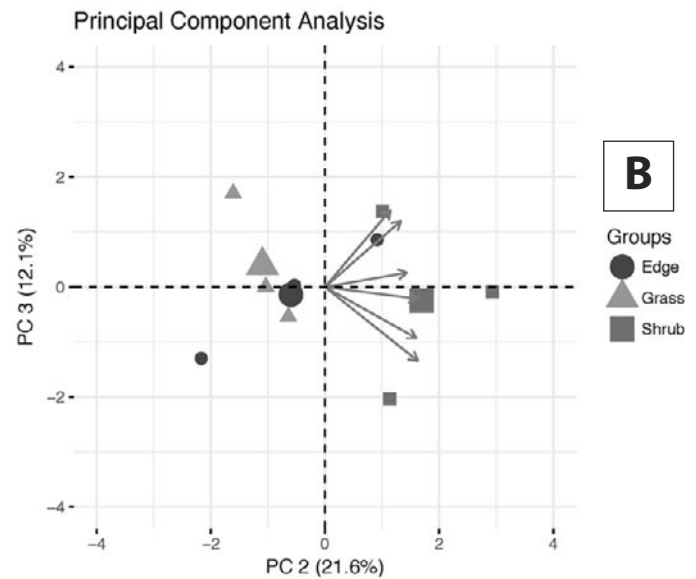
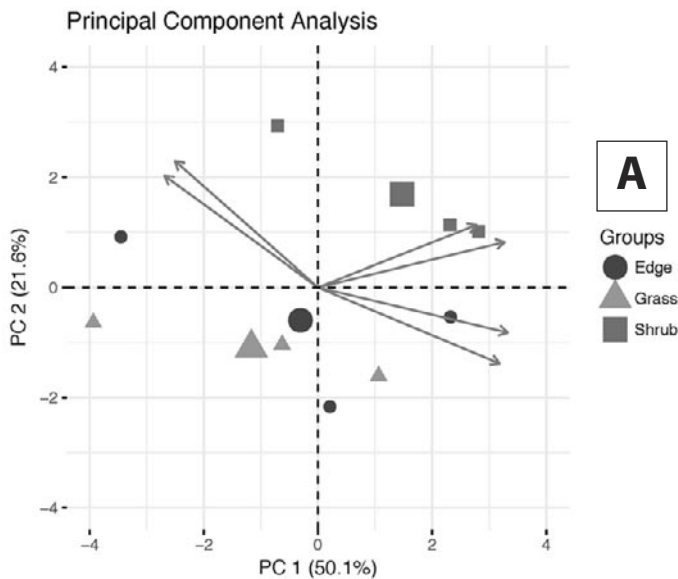


Figure 2. An example of a cross-section of *P. arborea* var. *globosa* under a compound microscope at 100x. Three radii on the cross-section were used to observe possible false or partial rings. Marks along the radii indicate a growth ring. This sample has 5 growth rings.

continued next page



Figures 3a-b. Principal component analysis of edaphic properties from shrub, edge, and grass soil samples. Edge samples represented by circles, grass samples represented by triangles, and shrub samples represented by squares. Shape size indicates relative mean values.

Dispersed Spatial Pattern of *Peritoma arborea* var. *globosa* *continued*

Statistical analysis

I conducted all statistical analyses and generated graphs in the computer program R (R Core Team 2018). Using the R package Rcmdr, I used linear regression to test for relationships between shrub age and size, as well as stem size and aboveground biomass (Fox 2017). Using the R package factoextra I used principal component analysis (PCA) to visualize soil property data using the package factoextra (Kassambara and Mundt 2017). Then, to test for mean differences between the shrub, edge, and grass soil, I conducted one-way ANOVA tests for each edaphic property in base R with an alpha level of 0.05 and calculated eta squared (η^2) as a measure of effect size with the package lsr (Navarro 2015, R Core Team 2018).

Results

Linear regression did not show a significant relationship between stem diameter and aboveground biomass ($p = 0.124$, $R^2 = 0.204$), stem diameter and estimated shrub canopy volume ($p = 0.065$, $R^2 = 0.103$), shrub age and shrub biomass ($p = 0.816$, $R^2 = -0.305$), or shrub age and stem diameter ($p = 0.457$, $R^2 = -0.074$). Crossdating showed that the shrubs were not even-aged, ranging from one to five years.

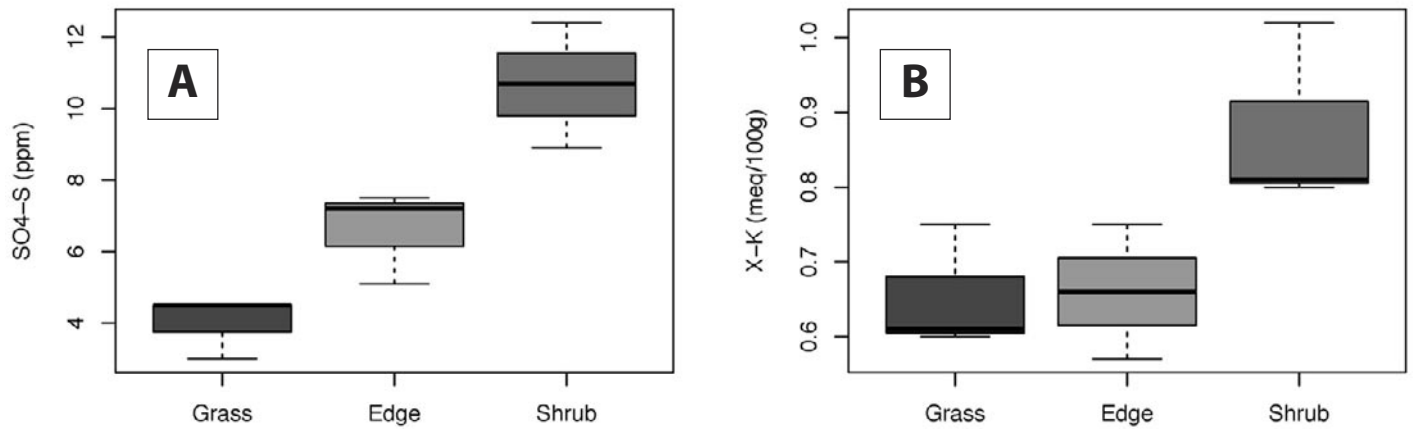
The PCA graphs (Figures 3a-b) visualizes the variation between the edaphic properties (Table 1) within each of the grass, edge, and shrub samples. The PCA graphs show a greater variation between shrub samples compared to grass and

edge samples by mapping the points representing shrub soil data away from the points representing grass and edge soil data. The axes of the PCA are principal components, which are the edaphic property data transformed into uncorrelated variables so that these data can be compared. Principal component (PC) 1 accounted for 50.1% of the variation in edaphic properties, PC 2 accounted for 21.6%, and PC 3 accounted for 12.1%. To further understand specific variables in

continued next page

Table 1. Summary of edaphic properties used in this study. Edaphic properties tested, along with function/quality in soil and plant relationships, the associated p-value results from one-way ANOVA, and the eta squared (η^2) as a measure of effect size.

Soil property	Quality	p-Value	η^2
SO4-S	Important for plant development	0.00276**	0.8597941
X-K	An essential plant nutrient	0.0579*	0.6130802
Total N	An essential plant nutrient	0.104	0.5292069
pH	Can affect plant nutrient take-up	1.88	0.4270087
Total C	Important for plant development and soil nutrient availability	2.1.8	0.39854
% Clay	Influences water infiltration rates	2.32	0.3856331
SOM	Improves water-holding capacity of soil	0.333	0.3068132
Olsen-P	Important for plant development	0.441	0.2387437
CEC (estimated)	Ability of soil to hold essential nutrients	0.812	0.06696921
% Silt	Influences water infiltration rates	0.812	0.06720618
X-Na	Small amount used in plant metabolism; can affect plant health	0.831	0.05984419
Bulk Density	Can affect root growth	0.869	0.04563
% Sand	Influences water infiltration rates	0.936	0.02165841
X-Ca	Important for plant development and soil health	0.962	0.0129986
X-Mg	An essential plant nutrient	0.969	0.0105245



Figures 4a-b. Boxplots of Sulfate-Sulfur and exchangeable-Potassium by soil sample type.

Dispersed Spatial Pattern of *Peritoma arborea* var. *globosa* *continued*

edaphic properties that explain differences between grass, edge, and shrub soil, I tested each property for mean differences with a one-way ANOVA.

The results from the one-way ANOVA tests showed only SO₄-S ($p = 0.002$, $\eta^2 = 0.860$) and X-K ($p = 0.058$, $\eta^2 = 0.613$) had significantly different means between grass, edge, and shrub soil samples, while other edaphic properties means were not significantly different from each other (Table 1, Figure 4). Although only SO₄-S and X-K were found to be significantly different, further investigation revealed that a similar pattern of low levels of nutrients in grass soil samples, intermediate levels at edge soil samples, and high levels at shrub soil samples was observed in most properties (Table 1).

Discussion

Shrub age-size relationship and shrub age

The relationship between shrub age and shrub size (both canopy volume, canopy biomass, and stem diameter as measurements of size),

as well as the relationship between stem diameter and shrub canopy volume and biomass, were not found to be significant. This result is different than what would be expected, since canopy and stem diameter typically increases with plant age (O'Brien et al. 1995, Genova et al. 2013). However, these relationships are also under the influences of abiotic stressors, such as drought, fire, or flooding. A larger sample size of successfully aged shrubs and a larger number of primary stem cross-sections may show a significant positive relationship between shrub canopy and stem size and shrub age as expected. In terms of age, the shrubs were found to be not even-aged. Since shrub age does not explain even size, an alternate explanation for size evenness should also be explored. For example, once the plant reaches a certain size, it may be more tolerant to abiotic stresses, such as drought, thus creating an even-size stand. From observations of the woody cells of bladderpod, the growth structure was non-porous with many rays present (Carlquist 2001). All cross-section samples displayed a significantly larger last growth ring. This is likely linked to

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Dispersed Spatial Pattern of *Peritoma arborea* var. *globosa* *continued*

increased precipitation in 2017. Comparing the ring growth data and annual precipitation data from PRISM dataset, there is a positive relationship (Figure 5) (PRISM Climate Group 2018). It should be noted that precipitation data refers to an annual average, whereas ring width growth in bladderpod is likely related to seasonal average precipitation. Seasonal precipitation data, as opposed to calendar year precipitation data, may show a more close relationship paired with more ring width data points as well as a possible lag in growth.

Edaphic properties

There is an apparent pattern of high levels of nutrients (e.g., $\text{SO}_4\text{-S}$, X-K) in the shrub soil samples, intermediate levels in the edge soil, and lowest levels in the grass soil. This pattern is similar to that what is observed in islands of fertility. The concept of islands of fertility refers to localized resource development directly underneath shrubs, commonly in dryland ecosystems (Schlesinger et al. 1996). Shrubs that form islands of fertility are more resistant to ecological disturbances, which also allow them to persist in the ecosystem when subject to disturbances (Schlesinger et al. 1996, Bond and Midgley 2001). Mesquite (*Prosopis glandulosa*), creosotebush (*Larrea tridentata*), and blue oak (*Quercus douglasii*) are examples of well-studied woody species that create islands of fertility in dryland ecosystems (Jackson et al. 1990, Reynolds et al. 1999). Our results indicate that bladderpod creates islands of fertility in the grassland matrix where they occur on the Ranch (Figure 3). The shrub drops its leaves, fruits, and flowering bodies, adding organic matter directly under the canopy, likely benefiting other adjacent plant species. Additionally, the shrub provides shade in an otherwise open grassland, likely increasing the number of wildlife species or individuals that visit the shrub and deposit nutrients.

Islands of fertility have implications for desertification and facilitation. Desertification is a socio-ecological term that is defined by “a change in soil properties, vegetation or climate, which results in a persistent loss of ecosystem services that are fundamental to sustaining life” and results in stress to human societies (D’Odorico et al. 2013). Operating under this definition, shrub encroachment is considered a desertification process, as it changes the dominant vegetation (D’Odorico et al. 2013). Facilitation is a non-trophic positive interaction between plants (Bertness and Callaway 1994, Brooker et al. 2008). In dryland ecosystems, plants that create islands of fertility can facilitate growth of other plants in areas where it would otherwise be more harsh. Oak species are well-studied examples of islands of fertility. Jackson et al. (1990) found that soil under blue oak canopy has higher plant-available inorganic N compared to the inter-tree spaces dominated by grassland. The higher nutrient availability positively affects plant species that grow under the oak canopy, at times increasing richness of native plant species, which can exclude exotic species (Roche et al. 2012). Given the dryland ecosystem habitat in which bladderpod exists, and the observed higher levels of nutrients in the soil directly under bladderpod, this shrub creates an island of fertility, which may have implications for desertification and/or facilitation.

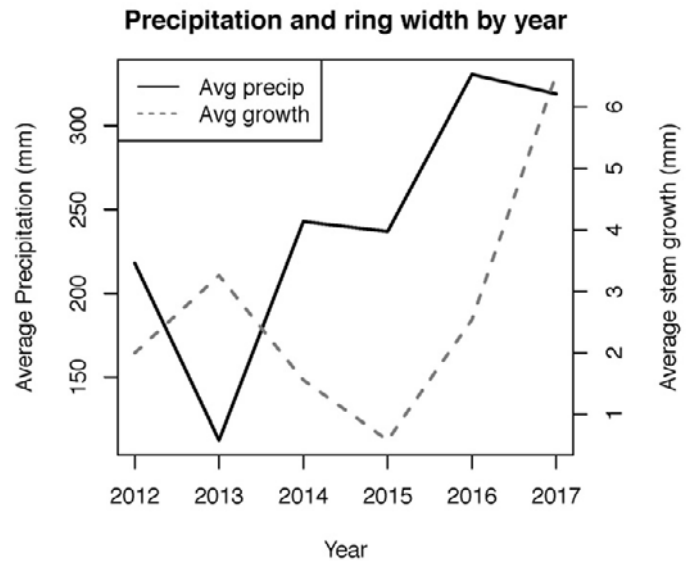


Figure 5. Average annual precipitation (solid line) and average ring width (dashed line) by year plotted on the same graph to show a relationship. No statistical analyses were completed on these data.

Although islands of fertility were found under bladderpod on the Ranch, this may not fully explain their dispersed spatial pattern. For example, the canopy may shade out other bladderpod, preventing clumped distribution. However, the structure of their root systems and the enriched soil fertility directly under the canopy makes it likely that bladderpod are not precluded from growing in a clumped distribution. This research should be used as a foundation for further investigations into abiotic and biotic ecological processes that drive the patterns observed, such as water availability or chemical inhibitions sourced from associated microbial communities, as well as the interactions occurring between the shrub and other plants, fauna, insects, and microbiota. Better understanding of ecological processes driving this observed pattern will allow for more informed management decisions in the face of landscape-scale vegetation shifts.

Acknowledgements

I extend gratitude to the UC Berkeley Range Ecology Lab for their encouragement and assistance. Thank you to James Bartolome, Lina Aoyama, John Sanders, and the Tejon Ranch Conservancy for their knowledge and time that made this project possible. I am thankful for the Sponsored Projects for Undergraduate Research program for funding, and friends and family for their support.



References

- Bertness, M.D., and R. Callaway. 1994. “Positive interactions in communities.” *Trends in Ecology & Evolution* 9(5):191–193.
- Bond, W.J., and J.J. Midgley. 2001. “Ecology of sprouting in woody plants: The persistence niche.” *Trends in Ecology & Evolution* 16(1):45–51.
- Brooker, R.W., et al. 2008. “Facilitation in plant communities: The past, the present, and the future.” *Journal of Ecology* 96(1):18–34.
- Calflora. 2018. “Information on California plants for education, research and conservation.” The Calflora Database. Accessed July 18, 2017.

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Dispersed Spatial Pattern of *Peritoma arborea* var. *globosa* continued

- http://www.calflora.org/cgi-bin/species_query.cgi?where-taxon=Peritoma+arborea+var.+globosa.
- Carlquist, S. 2001. *Comparative Wood Anatomy: Systematic, Ecological, and Evolutionary Aspects of Dicotyledon Wood*, 2nd ed. Heidelberg: Springer-Verlag.
- D'Odorico, P., A. Bhattachan, K.F. Davis, S. Ravi, and C.W. Runyan. 2013. "Global desertification: Drivers and feedbacks." *Advances in Water Resources* 51:326–344.
- Fox, J. 2017. *Using the R Commander: A Point-and-Click Interface for R*. Boca Raton: Chapman and Hall/CRC Press.
- Genova, M., J. Sanchez Espejo, F. Dominguez Lozano, and J.C. Moreno Saiz. 2013. "Dendrochronological study of the endangered shrub *Vella pseudocytisus* ssp. *pau* (Brassicaceae): Implications for its recovery and conservation." *Anales del Jardín Botánico de Madrid* 70(2):178–186.
- Holmes, R. 2013. COFECHA. University of Arizona Laboratory of Tree-Ring Research.
- Jackson, L.E., R.B. Strauss, M.K. Firestone, and J.W. Bartolome. 1990. "Influence of tree canopies on grassland productivity and nitrogen dynamics in deciduous oak savanna." *Agriculture, Ecosystems & Environment* 32(1):89–105.
- JoVE Science Education Database. 2018. "Carbon and nitrogen analysis of environmental samples." Accessed May 7, 2018. www.jove.com.
- Jones, B., Jr. 2001. *Laboratory Guide for Conducting Soil Tests and Plant Analysis*. Boca Raton: CRC Press.
- Kassambara, A., and F. Mundt. 2017. factoextra: Extract and Visualize the Results of Multivariate Data Analyses. R package version 1.3.
- Knapp, A.K., et al. 2008. "Shrub encroachment in North American grasslands: Shifts in growth form dominance rapidly alters control of ecosystem carbon inputs." *Global Change Biology* 14(3):615–623.
- Navarro, D.J. 2015. Learning Statistics with R: A Tutorial for Psychology Students and Other Beginners. Version 0.5. Adelaide: Lulu.com.
- O'Brien, S.T., S.P. Hubbell, P. Spiro, R. Condit, and R.B. Foster. 1995. "Diameter, height, crown, and age relationship in eight neotropical tree species." *Ecology* 76(6):1926–1939.
- PRISM Climate Group. 2018. PRISM. Northwest Alliance for Computational Science & Engineering, Oregon State University, Corvallis. Retrieved May 7, 2018. <http://prism.oregonstate.edu/recent/>.
- R Core Team. 2018. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.r-project.org/>.
- Reynolds, J.F., R.A. Virginia, P.R. Kemp, A.G. de Soyza, and D.C. Tremmel. 1999. "Impact of drought on desert shrubs: Effects of seasonality and degree of resource island development." *Ecological Monographs* 69(1):69–106.
- Roche, L.M., K.J. Rice, and K.W. Tate. 2012. "Oak conservation maintains native grass stands in an oak woodland-annual grassland system." *Biodiversity & Conservation* 21(10):2555–2568.
- Schlesinger, W.H., J.A. Raikes, A.E. Hartley, and A.F. Cross. 1996. "On the spatial pattern of soil nutrients in desert ecosystems." *Ecology* 77(2):364–374.
- Schuman, G.E., H.H. Janzen, and J.E. Herrick. 2002. "Soil carbon dynamics and potential carbon sequestration by rangelands." *Environmental Pollution* 116(3):391–396.
- Smither-Kopperl, M. 2012. "Plant guide for bladderpod (*Peritoma arborea*)."
Lockeford Plant Materials Center, Lockeford, CA, in collaboration with USDA-NRCS.
- Turner, M.G. 1989. "Landscape ecology: The effect of pattern on process." *Annual Review of Ecology and Systematics* 20(1):171–197.
- Van Auken, O.W. 2009. "Causes and consequences of woody plant encroachment into western North American grasslands." *Journal of Environmental Management* 90(10):2931–2942.
- Wolkovich, E.M., D.A. Lipson, R.A. Virginia, K.L. Cottingham, and D.T. Bolger. 2010. "Grass invasion causes rapid increases in ecosystem carbon and nitrogen storage in a semiarid shrubland." *Global Change Biology* 16(4):1351–1365.
- Yu, K., G.S. Okin, S. Ravi, and P. D'Odorico. 2016. "Potential of grass invasions in desert shrublands to create novel ecosystem states under variable climate." *Ecohydrology* 9(8):1496–1506.

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GETTING TO KNOW GRASSLAND RESEARCHERS

by Emily Allen, CNGA Board Member

Brianne Palmer

Brianne Palmer is in her second year as a PhD candidate in a joint doctoral program with San Diego State University and University of California Davis. She has been involved in grasslands research for three years.

What is your study system?

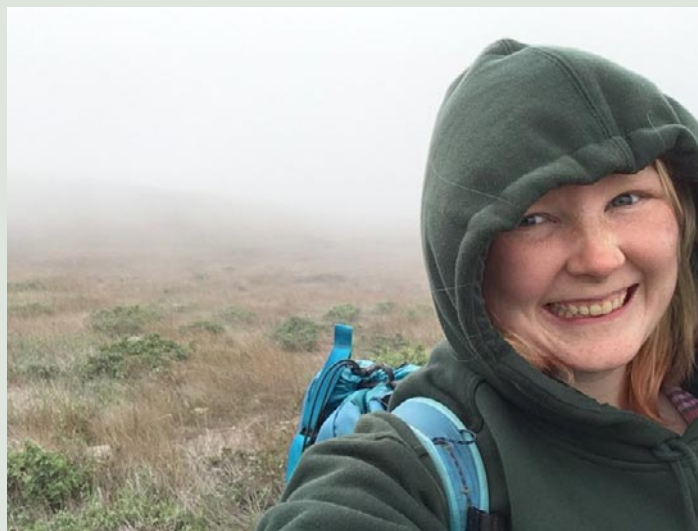
I study biological soil crusts (biocrusts) in California grasslands. My current plots are on San Clemente Island, though I am also looking at potential sites in central and northern California grasslands. When I moved to California in August 2017, with the intention of studying biocrusts, I didn't know they were even in grasslands. I had spent the previous few months in the Colorado Plateau region as a botany intern and didn't think about biocrusts existing outside deserts. When my advisor suggested a project studying biocrusts on an island and in a relatively understudied biocrust habitat, I was all in. The biocrusts on San Clemente are all over and so diverse! Unlike in the Colorado Plateau, these crusts are low statured and very cryptic. But once I am down on my hands and knees looking at them, there are so many different types: the black cyanobacteria, multicolored lichens, and bright green algae and moss. I think biocrusts appeal to me because I have a background in plant ecology and a growing interest in plant-soil interactions and biocrusts are the transition zone between plants and soils. The more I study biocrusts, the more I see them all around me. I found some outside my apartment while walking the dog and in a serpentine soil grassland. Once I notice them, it's hard not to make everything around me a potential study system, I just don't have that kind of time.

What are your primary research goals?

Broadly, I am interested in understanding how biocrusts alter the biogeochemistry, and consequently the plant communities, in varying successional states. I am primarily assessing nitrogen fixation and photosynthetic activity as well as overall biocrust cover. In a series of greenhouse experiments I am also testing how biocrusts inhibit successful native and non-native grass germination and how they alter the germination timing. One of the key aspects of my research that sets it apart from a lot of other biocrusts studies is the addition of fire response. An important aspect of California grasslands is the changing fire regime and we don't fully understand how biocrusts respond to fire. There have been prescribed burns for United States Geological Survey (USGS) research plots and naturally ignited fires on San Clemente island which makes it a good site to track biocrust succession after fire. I am using metagenomic techniques to look at the microbial community composition difference between burned and unburned plots and infer the ecosystem function.

Who is your audience?

In addition to the general research community who may be interested in the ecosystem function of biocrusts, I would also like to reach out



The photo was taken by me on in the early morning on San Clemente Island in April, 2017 during my first trip measuring biocrust cover at all my plots.

to land managers and agencies to share the importance of biocrusts in ecosystem assessments. I think biocrusts should be included in restoration plans and could possibly be used to aid restoration goals. I hope to share my findings with those doing restoration and fire management and hope biocrust management will make a notable difference in restoration ecology.

Who has inspired you, including your mentors?

I wouldn't be where I am today if it wasn't for notable mentors in my undergraduate, Utah State University, and joining the College of Natural Resources there was the best decision for my career. I gained valuable research experience working with Dr. Karen Mock for three years, studying aspen trees in northern Utah. That project got me out in the field and in the lab. Presenting that work allowed me to travel across the country and meet other scientists and reinforced my desire to go to graduate school. But the most influential mentor of my undergraduate is Dr. Fee Busby. He convinced me to join the plant identification team and without that I wouldn't be able to identify a single grass out there. He showed me that rangeland research can be fun and informative and can truly make a difference, all while being a friend. I don't know where I would be without his mentorship, guidance, and recommendations. In my year off before graduate school I worked as a rare plant botanist in Utah with a team of people so passionate about their job that it was fun to hike through record heat and monsoon storms to try to find a plant that may or may not exist anymore. I try to go into my work now with that same endurance and understanding that when working with cryptic organisms, failure is the default and that's okay.

My lab at San Diego State is also inspiring. I feel supported by Dr. David Lipson and the other students in our lab, and all the biology grad students in general! It's a great group of people to work with. I will be working at University of California Davis in Dr. Valerie Eviner's lab for the next year, and I expect I will find yet another supportive group of faculty and students.

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Brianne Palmer *continued*

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”?

With any luck, my research should improve our understanding of community interactions in grasslands. I presented my preliminary data at the California Society for Ecological Restoration Conference in May earlier this year and will be presenting my results at more conferences in the coming year with soil scientists, rangeland managers, and other professionals in the field. I will keep talking about how cool biocrusts are to anyone that will listen. The more people know about these complex communities, the more resources we can spend conserving our grasslands.

Why do you love grasslands?

I didn’t always love grasslands. Growing up in Colorado I associated grasslands with long and boring drives through the eastern half of the state. It wasn’t until I really got into botany that I realized the diversity and complexity of grasslands. I love that despite how widespread they are you can find something new anywhere you go. I love being able to get out of my car and just start walking into a grassland and where some people might just see a field of grass, there are so many cool species hiding in there just waiting to be appreciated. And there is something about the smell of grasslands after a good rain, when the grasses green up and the soil is moist, it just feels peaceful. On San Clemente, the island foxes hunt in the grasslands. I love just sitting on the ground and watching the foxes scurry around. Sometimes I miss the shade of the trees, but with a wide-brimmed hat and sunscreen, I’m ready to spend my day with the graminoids.



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Sciences
Hanford Applied
Restoration &
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Pacific Coast Seed

Poa secunda

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Ecological Concerns, Inc
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Grassroots Erosion Control
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Your membership directly supports CNGA workshops and educational projects, conservation and advocacy efforts, our quarterly *Grasslands* journal, and our new program, Grassland Research Awards for Student Scholarship (G.R.A.S.S.).

P.S. It's easy to renew online at cnga.org!

Thank you!

California Native Grasslands Provide Resilience in a Changing World.

...Essential services necessary to support life and provide benefits that extend to local, regional, and global communities.

CNGA is kicking off our end-of-year donation drive on Giving Tuesday, November 27th.

There are three ways to donate:

- 1. Donate Online:** Go to <https://cnga.org/GivingTuesday>
- 2. Donate by Mail:** Send your check or credit card information to: CNGA PO Box 72405, Davis CA 95617.
- 3. Donate by Phone:** Call us at 530.902.6009 with your credit card number and expiration date.

Any amount is welcome.

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**Grasslands provide resilience
in a changing world.**

**(see page 26 for details on how you
can make a difference)**

Front cover: 2014 super bloom of California poppies (*Eschscholzia californica*) in coastal prairies of the Marin Headlands, Golden Gate National Recreation Area. *Photo: Eric Wrubel*

Back cover: Coastal soap plant (*Chlorogalum pomeridianum* var. *divaricatum*), one of the many California native plant taxa found almost exclusively in coastal prairies, shown with the introduced annual rattlesnake grass (*Briza maxima*). *Photo: Eric Wrubel*

