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.

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From the President's Keyboard

Growing up in the San Francisco Bay Area, winter was my favorite season: the "heat" of fall relieved by rain, turning the bleached hills emerald; celebrations, vacation, and a new year to explore. Decades later, and I know the winter-green grasses are largely nonnative annuals crowding out local diversity, and the rain no longer a surety, but I still cherish this season as a time to celebrate what has been accomplished, to rest, and to look ahead to the coming year.

I am honored to start my term as president, and heartened by our board. We bring a great mix of backgrounds (ecologists and restorationists, grazers and landscape practitioners, researchers and advocates), skills, and terms of service (from over a decade, to new in 2018). We continued our great set of "standard" offerings such as Field Day and Grass ID, and will keep those coming; but we also debuted new workshops last year and have plans for more in 2018, including "Landscaping with Nature" and a refresher of our monitoring training. Our partnerships with other groups remain strong, with CNGA presenting sessions, workshops, or field trips at the California Invasive Plant Council, California Native Plant Society, and California Society for Ecological Restoration conferences, as well as working together on issues of conservation concern. I am thankful for our members, who support our mission to promote, preserve, and restore the diversity of California's native grasses and grassland ecosystems through education, advocacy, research, and stewardship.

California remains a resilient state, coming together after wildfire to support each other and our natural communities. CNGA and many of its sponsors worked to disseminate information on appropriate restoration options — often, fire- and drought-adapted natives can rebound on their own. Working together, we can channel our efforts and amplify our impact for greater grassland understanding, and better protection and management, in 2018 and beyond.

Andrea Williams, President

Meet the 2018 CNGA Board of Directors

CNGA members voted and we have 4 new Directors-at-Large.

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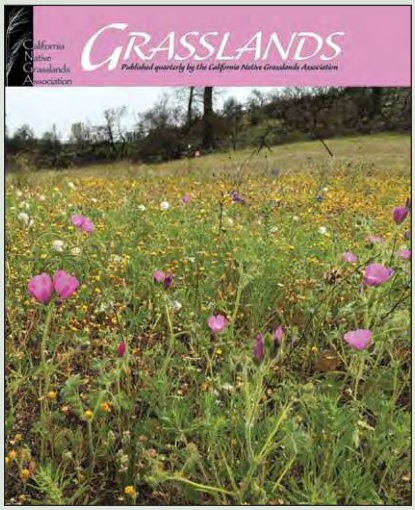
CNGA extends our thanks and appreciation to retiring Board Member, Cathy Little.

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:

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

2018 CNGA Workshops & Events

Registration Now Open:

April 20: 11th Annual Field Day at Hedgerow Farms

Maximizing Biodiversity and Pollinator Habitat in California Grasslands

Instructors: **Robbin Thorp**, Dept. of Entomology and Nematology, UC Davis; **Val Eviner**, Department of Plant Sciences, UC Davis; **Jessa Kay Cruz**, Senior Pollinator Conservation Specialist, Xerces Society; **Kimiora Ward**, Project Manager, Dept. of Entomology, UC Davis; **Billy Krimmel**, Owner, Restoration Landscaping Company, Sacramento; and others! Location: Winters, CA

$75/CNGA members | $90/Non-members | $45/Students

Register online at **cnga.org** or contact Diana Jeffery at admin@cnga.org or 530.902.6009

Upcoming:

May 9–11: SERCAL 25th Annual Conference

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

In San Diego — Register online at **sercal.org**

May 19: Identifying and Appreciating Native and Naturalized Grasses of California

Location: Marin TBD

June 2: Identifying and Appreciating Native and Naturalized Grasses of California

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

Register online at **www.cnga.org** or contact Diana Jeffery at **admin@cnga.org** or 530.902.6009

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From left: Figure 1. Noxious grass weeds, such as goatgrass and medusahead, can dominate grasslands and choke out most other species.

Figure 2: Delayed spring growth of noxious weeds, compared to naturalized annuals (late April of 2008). In the foreground: a plot of goatgrass and medusahead, which have low aboveground biomass during early to mid-spring; their peak aboveground growth tends to occur mid-May to early June. In the background: a plot of naturalized annuals dominated by wild oats; these naturalized annuals have an earlier growth spurt from late-February through mid-April, and thus much higher aboveground biomass for most of spring. *Photos: Valerie Eviner*

California's Native Perennial Grasses Provide Strong Suppression of Goatgrass and Medusahead

by Valerie Eviner[1] and Carolyn Malmstrom[2] Photos: Valerie Eviner

Background

There has been long-term interest in the competitive dynamics between native and exotic grassland species in California. While many species of native grasses and wildflowers are present in today's grasslands, in most sites their cover is as low as 1–10% (Bartolome et al. 2007). Starting 250–300 years ago, native grasslands became invaded by a suite of exotic grasses and forbs, which now dominate these systems, covering over 90% of the area in most sites (Bartolome et al. 2007). While non-native, these naturalized grasslands support a high diversity of plants, and nearly 90% of California's rare and endangered animal species. These ecosystems also provide 75% of the forage that supports the state's livestock industry (reviewed in Eviner 2007). In this article, we will refer to this suite of long-established exotic species as naturalized — species that maintain themselves over time in a non-native habitat (NRCS definition). These include species such as wild oats (*Avena* spp.), bromes (*Bromus* spp.), filaree (*Erodium* spp.), and ryegrass (*Festuca perennis).* In California's grasslands, these exotic naturalized species strongly suppress native grass growth and establishment at most sites (Bartolome and Gemmill 1981, Stromberg and Griffin 1996). However, in some cases, the restoration of native perennial grasses can decrease the prevalence of these naturalized species (Corbin and D'Antonio 2004).

A relatively new suite of noxious exotic grasses are invading California's grasslands, including barbed goatgrass (*Aegilops triuncialis*) and medusahead (*Elymus caput-medusae*). Areas invaded by these species show dramatic decreases in plant diversity (Figure 1) and experience a 50–75% decrease in livestock production (Peters et al. 1996) because these noxious grasses have lower biomass through much of the growing season (Figure 2), and once they increase their aboveground biomass, their forage quality is poor, leading to persistent thatch (Figure 1). Consistent

continued next page

[1]Valerie Eviner is an Associate Professor of Restoration and Ecosystem Management in the Department of Plant Sciences at University of California, Davis. Her research focuses on understanding how ecological interactions (plants, microbes, herbivores, environmental conditions, management) determine plant community dynamics and ecosystem processes.

[2]Carolyn Malmstrom is an Associate Professor in the Department of Plant Biology at Michigan State University. Her research focuses on plant, virus, and landscape ecology to address environmental challenges. Much of her California-based research focuses on how to preserve biodiversity and ecosystem services in working landscapes.

Native Perennial Grasses' Suppression of Goatgrass and Medusahead *continued*

management of these noxious weeds is challenging, particularly in our naturalized, annual-dominated grasslands, where competitive dynamics are reset each year as all plants emerge as seedlings (Eviner 2016).

While naturalized exotic species often suppress native grasses, native grasses could provide long-term suppression of the more recent noxious weed invaders, including goatgrass and medusahead. In general, control of weeds is most effective when they are suppressed by native species with similar traits (e.g., growth form, timing of growth, rooting depths, resource needs) (Funk et al. 2008). For example, in California grasslands, yellow star thistle (*Centaurea solstitialis*) was best controlled by native tarweed (*Hemizonia congesta* ssp. l*uzulifolia*), which is similar in phenology, rooting depth, and growth form (Dukes 2002). In grasslands throughout the Western U.S., restoration of native perennials can decrease noxious invaders such as cheatgrass (*Bromus tectorum*) (Blank and Morgan 2012). In California's grasslands, native grasses have the potential to compete with goatgrass and medusahead because these species are active in late spring (mid-May into June) (Peters et al. 1996) (Figure 3). In addition, the perennial nature of many native grasses can provide long-term suppression once they have been established (in contrast to competition resetting each year in annual-dominated grasslands, sensu Eviner 2016). This experiment was designed to test whether restoration of native perennial grasses can suppress invasion of the noxious weeds, goatgrass and medusahead, compared to when these noxious weeds are growing with the naturalized exotic annual grasses that dominate California's grasslands.

Figure 3. Stands of native grasses remain green into the late spring (here, June 2017), while most naturalized annuals have senesced.

Our study design

In Davis, California, during the fall of 2007, we established 18 replicate plots of two treatments (36 plots total), where **noxious invasive weeds** (*A. triuncialis, E. caput-medusae*) were planted with either **native species** (*Stipa pulchra, E.s glaucus, E. triticoides, Bromus carinatus, Poa secunda, Festuca microstachys, Lupinus bicolor,* and *Acmispon americanus*) or **naturalized exotic species** (*Avena fatua, Bromus hordeaceus, F. perennis,* and *Trifolium subterraneum).* Plots were 1.5 x 1.5 m, with a 1–m buffer between plots. Every spring, plots were assessed for percent cover of species at two time-points: mid-spring when most annual grasses were at their peak flowering (late March to April), and late spring, when perennial grasses and the noxious grasses were at peak flowering (mid-May to early June). These plots have been measured for 10 years, across various rainfall years, including the strong drought of 2012–2015 (Figure 4).

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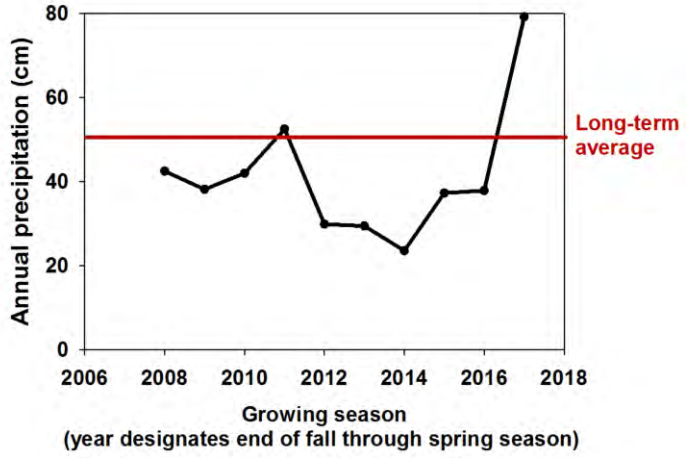

Figure 4: Annual precipitation for each growing season of the experiment. Each year on the graph denotes the end of a growing season (e.g., 2010 is the amount of rainfall that fell between August 1st 2009, and July 31st, 2010).

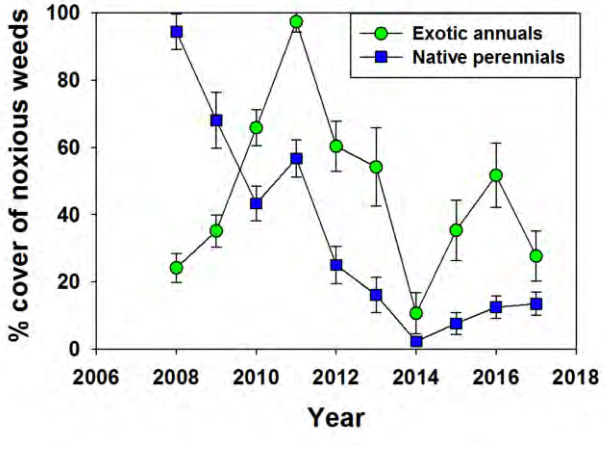

Figure 5. Percent cover of noxious grasses (goatgrass and medusahead) when grown with naturalized exotic grasses (green) vs. with native perennial grasses (blue).

Native Perennial Grasses' Suppression of Goatgrass and Medusahead *continued*

What we found:

Native grasses had a much stronger ability to suppress goatgrass and medusahead than naturalized grasses (Figure 4). When grown with naturalized annual grasses (dominated by *Avena fatua* and *Bromus hordeaceus)*, the cover of noxious grasses fluctuated greatly year to year, varying from 20% cover in the most intense drought year, to 100% cover in the relatively wet 2010–11 growing season (see green line in Figure 5). Most of this variation was due to medusahead, which ranged from 10% to 90% cover when grown with naturalized annuals. Goatgrass cover also varied year to year, but ranged from 10 to 30% cover.

In contrast, when grown with natives (dominated by *E. glaucus* and *E. triticoides*), cover of noxious weeds was initially high (90% in the first year), and greatly decreased over time (Figure 2, blue line). After 6 years, noxious weed cover was consistently less than 20% cover. The prevalence of noxious weeds did vary year to year (being relatively higher in wet years, and lower in dry years), but these variations were far more muted than those seen when grown with naturalized annuals. Natives suppressed both goatgrass and medusahead to the same extent. As in the native plots, annual variability in noxious weed cover in the native plots was largely due to fluctuations in medusahead cover.

While natives did suppress noxious weeds, they did not suppress the naturalized annuals. When grown with natives, naturalized annual cover varied greatly year to year, ranging from 5 to 100% cover. Over the course of this experiment, naturalized exotic cover steadily increased and became dominant over the natives (data not shown). This is consistent with the fact that the naturalized

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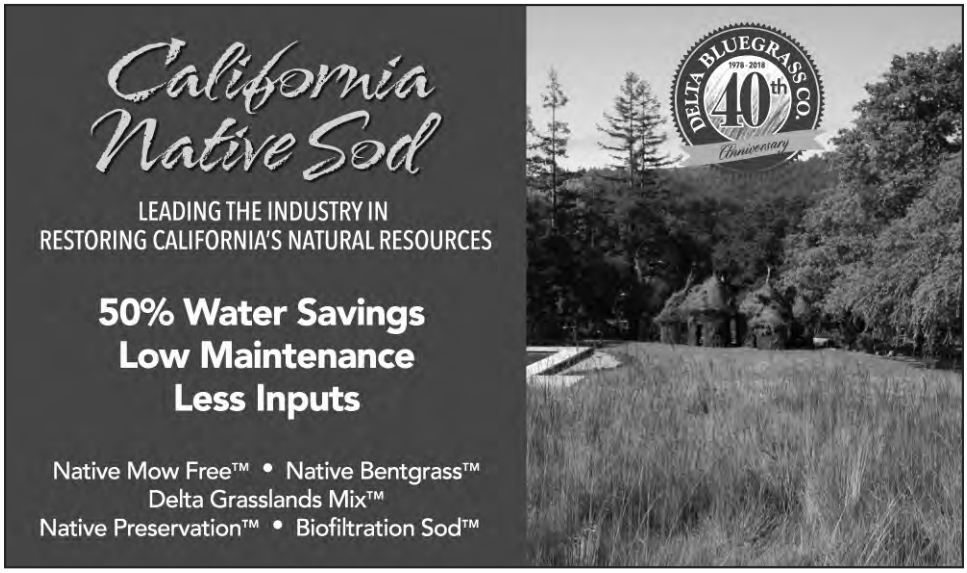

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Native Perennial Grasses' Suppression of Goatgrass and Medusahead *continued*

annuals dominate California grasslands, and often limit the success of native grass restoration.

Implications for management

As seen in many other studies, our experiment showed that California's native grasses were out-competed by the naturalized exotics which dominate our grasslands. In most sites, successful restoration projects require long-term, aggressive management of naturalized annual exotics (Bartolome et al. 2007, Malmstrom et al. 2009). What is unique about our study is that it suggests that the effort put into restoring native grasses can be an effective long-term control method for goatgrass and medusahead. While perennial grasses will not eliminate these noxious weeds, they will prevent them from dominating the grassland. The suppressive effect of natives on noxious weeds increased steadily over time, and took 5–6 years to fully kick in — the noxious annuals dominated over the natives for the first few years of the study. In our study, no weed control was done — we planted the mix of natives and noxious weeds and then simply monitored competitive dynamics. It is probable that the suppressive effect of natives on noxious weeds occurs more quickly in restoration projects that have aggressive weed management in the first few years after planting the natives. This will increase the speed of establishment and growth of natives. In our study, natives were able to "come from behind" and dominate the noxious weeds over time, but this may have only been possible due to the deep soils at our site. In other sites, intense weed management is likely to be critical for successful native establishment. It is also important to note that the plots in this study were not subjected to disturbances such as fire or grazing, which may alter the competitive balance between these species. On-going research is addressing these issues.

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Acknowledgements

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SPECIES SPOTLIGHT: *by Emily Allen[1], eallen624@gmail.com*

Dove weed (*Croton setiger*):

A unique plant with an interesting seed strategy

Dove weed (*Croton setiger*, previously *Eremocarpus setigerus*) is a native annual forb that is ubiquitous along dry roadside edges, gravely disturbed areas, and overgrazed pasture throughout the lower elevations of California and the United States, west of the Rocky Mountains (Baldwin et al. 2012). The two most frequently used common names are dove weed and turkey mullein, which is in reference to the birds that have been observed feeding heavily on its seeds. The scientific name is descriptive of its two most visible features: 1) *Croton* is derived from the Greek word for "a tick", which is roughly descriptive of the size and look of the seeds, and 2) *setiger* means "bearing bristles" (Smith. 2013). It forms distinctive, light green symmetrical mounds (almost topiary-like) that appear fuzzy because small hairs cover the entire plant.

Dove weed is a member of the spurge family which is a large and diverse family with unique traits. Like other members of this family, dove weed has several well-developed defense strategies to help it establish and persist in the open and harsh areas in which it thrives. Thick leaves and stems are covered in dense stellate hairs which successfully deter most grazing, although livestock will eat it if they have no other food sources, and dove weed hairs can cause a tangled mass that form in the stomach. These hairs can also cause extreme irritation to exposed skin, making seed collection difficult. Dove weed contains toxic diterpene compounds, including eremone, which were utilized by Native Americans, who broadcasted crushed leaves in waterways to stun fish, making them easier to catch (Burrows and Tyrl 2013).

Dove weed is monoecious; both male and female flowers are small and simplified with no true petals (Baldwin et al. 2012). Individual plants vary in size depending on the level of disturbance (being larger in more disturbed areas) and available nutrients. They can grow into mounds over 1 meter in diameter, sometimes with more than one individual forming a mound, but are typically much smaller. Populations tend to be spread out with several feet or meters between individuals. While seedlings can be numerous, only a small percentage survive the stiff competition between seedlings during establishment (Cook et al. 1971). The flowers are not very attractive to pollinators but bees can still be found foraging on them late in the season when resources are scarce. Some beneficial true bugs have been found on dove weed, including two species of big-eyed bugs, *Geocoris pallens* and *G. atricolor,* and minute pirate bugs in the *Anthocoridea* family (Krimmel 2017, email communication). These true bugs are predators that feed on aphids, small caterpillars, mites, whiteflies, and thrips (UC Regents, 2014), making them helpful in controlling insect pests in the vicinity of planted crops.

The seeds of dove weed are one of the more complex and interesting features of this plant. Dove weed produces several unique polymorphic seed forms. Seed coat coloring changes over the geographic range of dove weed, the time of year produced, and the lifecycle stage. Seeds produced early in the season tend to

continued next page

[1]Emily is the Sales Manager at Hedgerow Farms, a native seed production farm that specializes in locally sourced grasses, forbs, sedges, and rushes from Northern California. She earned her B.S. in Environmental Biology from Westmont College in Santa Barbara, served on the CNGA board from 2014–2016, and rejoined in January 2018

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From left: Small clumps of dove weed dot the disturbed landscape in a restoration project in Yolo County. *Photo: John Anderson*
Seeds with variability in coloring including striped, mottled, and solid grey, from a Central Valley seed source. *Photo: Michael Maccini*
Two closeups from a disturbed area in restoration project in Yolo County. *Photos: Emily Allen*

Dove weed *continued*

be more colorful and variable in pattern. For example, California coastal populations produce both mottled and striped seeds, while Central Valley populations produce mainly mottled seeds. Mottling on seeds, and to a lesser extent, stripes on seeds, act to camouflage the seeds on and in the soil from large populations of mourning doves (*Zenaida macroura*) that feed on dove weed. Mojave Desert populations produce conspicuous solid dark colored seeds, and it is thought that low mourning dove populations in that area have reduced the necessity for seed camouflage.

In addition to these diversely patterned seeds, all plants also produce some seeds that are light gray in color and are chemically different from other seeds. These light grey seeds are extremely unpalatable to the mourning dove, and tend to be produced later in the season when the plant is senescing (Cook et al. 1971, Cook 1972). Most seeds produced by dove weed do not travel more than 0.5 meters from the parent plant, and because they are often in open and sparsely vegetated areas, the seeds are vulnerable to predation by birds. The chemical protections in the later-produced grey seeds are key to future propagation. While grey seeds are unpalatable to birds, they also have other disadvantages, which includes low seedling vigor, higher susceptibility to fungal diseases, and shorter seed viability (Cook et a. 1971). These disadvantages make the continued production of both seed crops an advantageous strategy for the continued survival of this species.

Because of the high attraction of dove, turkey, and quail to the seeds, dove weed is very popular with hunters. Seeds can be planted in fall or spring to create foraging habitat for these game birds. If a population is already present onsite, it can be managed by creating soil disturbances and controlling early weeds that come in before it germinates. Dove weed seed can also be added to restoration seed mixes to provide diversity and increase resilience. It may not be seen in the first or second year, but seeds can survive long periods in the soil and take advantage of disturbances when they occur.

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[UC Regents] Regents of the University of California. 2014. "Minute pirate bugs." Natural Enemies Gallery. Verified February 6, 2017. **http://ipm.ucanr.edu/PMG/NE/minute_pirate_bug.html**

In light of the recent article in *California Agriculture,* "Forage seeding in rangelands increases production and prevents weed invasion" (October–December 2017), we felt a reprint of "Italian Ryegrass: A New Central California Dominant?" could be timely to provide additional perspective regarding the use of non-native plants in California landscapes. While not a rebuttal, this article may serve as a caution that some non-natives may be invasive and could cause future management problems given the right circumstance. Preservation of intact native grassland in California is known to be important for pollinators, wildlife habitat, biodiversity, and climate change resilience. Forage "improvement" projects, suggested by the CalAg article, that introduce non-native invasive annual and perennial grasses into the Sierra Nevada Foothills Valley Grassland must be planned and executed carefully, and ideally only in already disturbed areas with ruderal or highly non-native species composition.

Livestock grazing disturbance is a tool that can enhance and maintain the native forbs and grasses of California's grasslands, which may be especially important in light of increasing anthropogenic influences. The following reprint article highlights the advantage given to non-native grasses by air pollution, which essentially adds nitrogen fertilizer to grasslands in the Bay Area, and is an important consideration throughout California. Predictions of future warmer and wetter regional climates could also create a condition where a non-native perennial grass becomes the next invasive plant headache.

Ranching is an important part of preserving and managing large expanses of native grasslands throughout California both on private and public lands. — CNGA Board Members

Reprinted with permission. This article originally appeared in the Winter 2008 issue of *Fremontia*, the newsletter of the California Native Plant Society. The scientific names of plants have been updated by our editors.

Italian Ryegrass: A New Central California Dominant?

by Peter Hopkinson[1], Matt Stevenson[2], Michele Hammond[1], Sasha Gennet[3], Devii Rao[1], and James W. Bartolome[1] Photos: Range Ecology Lab, UC Berkeley

The non-native grass, Italian ryegrass (*Festuca perennis*), has long been characterized as a minor player in the Valley Grassland. While this may still be true in drier locations, in wetter areas of the state's annual grasslands, there is increasing evidence that Italian ryegrass is now a regional dominant, dethroning former champs such as wild oats (*Avena* spp.), soft chess (*Bromus hordeaceus*), and ripgut brome (*Bromus diandrus*).

From a cow's point-of-view, this newly emerging dominant is no bad thing because Italian ryegrass makes excellent forage. For a plant conservationist or those with hay fever however, the news is not so sunny. Italian ryegrass often forms dense stands that may crowd out native plants, the loss of which may affect other native species: Ryegrass has already been implicated in the demise of populations of the Bay checkerspot butterfly (*Euphydryas editha bayensis*; Weiss 1999). And as spring allergy sufferers know, when Italian ryegrass begins to release its pollen, several weeks of misery lie ahead!

Evidence for Widespread Italian Ryegrass Dominance in the Bay Area

Native to Europe, Italian ryegrass was probably introduced to California in the late 1700s (Hendry 1931). In most descriptions of the California annual grassland, Italian ryegrass is barely mentioned (e.g., Ornduff 1974, Heady 1977). A more recent review of California grassland states that Italian ryegrass sometimes dominates locally but is generally not as widespread in the grassland as the filarees (*Erodium* species) and bromes (Heady et al. 1991). Even *The Jepson Manual* limits ryegrass habitat to "disturbed sites, abandoned fields."

However, over the past decade, we have observed anecdotally how often Italian ryegrass is the dominant plant in many largely undisturbed grassland areas of the East Bay of the San Francisco Bay Area. Other researchers have made similar observations in the South Bay.

An ongoing study by the UC Berkeley Range Ecology Lab of 40 plots in six East Bay Regional Park District (EBRPD) properties spread over Alameda and Contra Costa counties has provided the data to show that our observations were in fact accurate. Between 2003 and 2007, from a pool of approximately 90 to 115 species, Italian ryegrass was the overall dominant species in our study every year. In the warm, rainy years of 2005 and 2006, ryegrass made up 23 percent and 32 percent,

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Determining species composition and cover at Vasco Caves Regional Preserve, near Livermore, California, April 2006. Annual ryegrass is the dominant at this site, with greater than 35 percent cover.

respectively, of the plant cover: One species contributing almost a third of the plant cover at our East Bay grassland sites. Even in the drought year of 2007, a tough year for grasses, Italian ryegrass remained dominant at 19 percent cover. Comparing five–year average cover values for the most common species, ryegrass had almost double the cover of the next nearest species, soft chess (Table 1).

Italian ryegrass was not the dominant species at every EBRPD site: Some parks had low levels of ryegrass for reasons that are not yet apparent. However, many of the areas with low levels of ryegrass or none at all in 2003 had substantial amounts by 2006, and the percentage of sites in which Italian ryegrass was the dominant increased from 28 percent in 2003 to 63 percent in 2006, falling back to 45 percent during the drought of 2007.

Moreover, ryegrass appears to have been on the increase for at least a decade. In a single East Bay Municipal Utilities District watershed in El Sobrante, a 9-year study by our lab from 1993 to 2001 showed that ryegrass rose steadily from under 10 percent plant cover in 1993 to dominance at 45–55 percent cover during 1997 to 2001.

These high levels of Italian ryegrass in the late 1990s and the 2000s contrast with the low levels found in a 5–year study from the early 1970s at another East Bay site. From 1969 to 1973 at the University of California Russell Reservation in Lafayette, ryegrass only rose above 8 percent plant cover once, when it reached 16 percent.

Elsewhere in the San Francisco Bay Area, similar trends are being observed. In the South Bay, at Stanford University's Jasper Ridge Biological Preserve and at Edgewood Natural Preserve in San Mateo County, Italian ryegrass also appears to have increased substantially during the 1990s (Weiss 1999, 2002). These sites have nutrient-poor, toxic serpentine soil, which until recently has prevented invasion by most annual grasses, but ryegrass is now able to dominate even there.

Four floras produced since the 1930s for Jasper Ridge indicate that ryegrass was not observed in serpentine areas through 1983. In the last few years however, at both Jasper Ridge and Edgewood, ryegrass was the dominant species, at 20–30 percent plant cover in 2001 and 2002 (Weiss 2002). In several other areas, both serpentine and non-serpentine, in south San Jose, Weiss (1999) reports increasing ryegrass plant cover and dominance since the mid-1980s or mid-1990s.

Impacts of Widespread Italian Ryegrass Dominance

If this apparent widespread dominance by Italian ryegrass is a long-lasting change, the ecological impacts may be significant. Economic and health impacts may also be appreciable.

The California Invasive Plant Council's (Cal-IPC) 2006 Invasive Plant Inventory (**cal-ipc.org**) categorizes Italian ryegrass as having a moderate negative ecological impact in California. Cal-IPC further describes ryegrass as having a significant effect on native grassland plant communities.

While the actual ecological impacts of ryegrass dominance in California's grasslands are largely unstudied, ryegrass competes strongly against other non-native grasses in California (McKell et al. 1969, Fehmi et al. 2001). In addition, ryegrass may increase mortality of the native bunchgrass purple needlegrass (*Stipa pulchra*) (Fehmi et al. 2004). Purple needlegrass is the most abundant native species in our East Bay Regional Park District study. It is also frequently used in grassland restoration projects.

In another highly invaded grassland, the pampas of Argentina, Italian ryegrass, which is non-native there too, rapidly out-competed other species, and within 3 years became the dominant grass in former agricultural fields (Facelli et al. 1987). The increase in ryegrass cover was correlated with an increase in local extinction of other plant species and with a reduction in plant species diversity. Whether Italian ryegrass has similar effects in California grasslands is not clear. For the EBRPD study, we could not find a strong relationship between Italian ryegrass cover and native plant cover or diversity.

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Table 1. Average percent cover for the top ten "species," including litter (previous year's dead plant material) and soil, 2003–2007

Species	Average percent cover, 2003–2007	Species	Average percent cover, 2003–2007
Festuca perennis	21.3	*Erodium botrys*	4.1
Bromus hordeaceus	11.9	*Avena barbata*	2.5
litter	10.4	*Stipa pulchra*	2.3
*Avena fatua**	9.5	*Trifolium hirtum*	2.1
Bromus diandrus	5.6	*Phalaris aquatica*	2.0
soil	4.6	*Vulpia bromoides*	1.9

* For 2007 only, *Avena* sp. included in *A. fatua*.

Italian Ryegrass *continued*

Italian ryegrass is known to suppress native plants in other California vegetation communities. Since the 1940s, ryegrass has been seeded in chaparral and forests after wildfires to reduce soil erosion caused by post-fire rainfall. Numerous follow-up studies of post-fire ryegrass seeding have shown that plant cover and diversity of native herbaceous species are reduced on sites with high ryegrass cover (reviewed in Beyers 2004).

One well-studied ecological result of Italian ryegrass dominance is unequivocally negative: The disappearance of threatened Bay checkerspot butterfly populations. Stuart Weiss has spent years studying the checkerspot in its South Bay serpentine habitat and has documented how the fairly recent invasion of ryegrass into serpentine sites has caused populations of California plantain (*Plantago erecta*) and other checkerspot larvae host plants to plummet (Weiss 1999). As go the host plants, so go the butterflies. Both the Jasper Ridge and the Edgewood butterfly populations have gone extinct, as have populations in south San Jose, with ryegrass the prime suspect (Weiss 2002). Other native plants are also declining as Italian ryegrass invades the serpentine grassland (U.S. Fish and Wildlife Service 1998).

And before you chuckle at the allergy problems that Italian ryegrass causes, a recent analysis estimates that allergy-related consequences of non-native grasses cost Californians between $400 million and $1 billion per year in missed work, medication, and Kleenex (Anderson 2005). Ryegrass pollen is an abundant and potent allergen (Pollart et al. 1988, Spangenberget al. 2000) and is likely to be responsible for a significant portion of the grass pollen allergies in California. At least three of this article's authors are highly allergic to ryegrass, one of whom had to go to the hospital due to a severe ryegrass reaction during the field season.

Why is Italian Ryegrass Increasing?

If the effects of Italian ryegrass dominance are undesirable, is there anything we can do to cut short its reign? To answer this question, it would be helpful to know why the widespread increase in ryegrass cover has occurred.

Several factors may underlie the change. Stuart Weiss has presented a strong case for air pollution being a primary cause. In addition, warmer and wetter weather may have given Italian ryegrass the boost it needed to become a common dominant.

Nitrogen "fertilization" of the soil by automobile air pollution is strongly implicated as the cause of ryegrass' invasion of serpentine soils in the South Bay and Peninsula. At Jasper Ridge, Edgewood, and sites in south San Jose, Weiss has shown that various forms of nitrogen are deposited on plants and soil at much higher levels in areas with bad air pollution problems (Weiss 1999, 2002). Experiments by other Stanford University researchers (reviewed in Weiss 1999) have demonstrated that nitrogen fertilization can rapidly turn a study plot from forb-dominated to grass-dominated, and that ryegrass, in particular, grows quickly and vigorously with nitrogen fertilization. It appears that over many years, air pollution has added enough nitrogen to the soil that a threshold has been crossed, allowing Italian ryegrass to flourish even in harsh soils.

In combination with nitrogen enrichment, warmer and wetter weather is likely to promote increases in Italian ryegrass cover. Weiss notes that ryegrass was rare at Jasper Ridge until 1998, a year of record El Niño rains. Experiments by Sherry Gulmon showed that ryegrass is favored in conditions with temperatures above 68°F and consistently available nitrogen and moisture (Gulmon 1979). When all three conditions were met, ryegrass was able to outcompete wild oats and soft chess.

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Italian Ryegrass *continued*

Gulmon's work suggests that if global climate change brings higher temperatures, especially during the growing season, California's climate may be even more suitable for Italian ryegrass domination. With continued nitrogen deposition from air pollution, increased temperatures due to global climate change, and periodic high rainfall events, such as El Niño years, Italian ryegrass may come to dominate large parts of California's central coast grasslands.

Ryegrass Control

There is not much we can do about warmer and wetter weather, and even reducing air pollution from cars requires large-scale societal changes. Drought years reduce Italian ryegrass cover somewhat (Weiss 1999), but it appears likely that a wet and warm year would allow ryegrass to reestablish dominance.

Livestock grazing may be one management action that can mitigate some of the deleterious effects of ryegrass dominance, at least on serpentine soil. At Weiss' serpentine sites in south San Jose, nearby areas that were grazed by cattle maintained large populations of plantain and checkerspot butterflies, and cover of Italian ryegrass was much lower. When grazing was reintroduced to one of the ungrazed sites, although the butterflies did not return, grass cover, dominated by ryegrass, fell from 75 percent to 45 percent, while forb cover increased from 10 percent to 30 percent (Weiss 1999).

The impacts of livestock grazing on Italian ryegrass and native plant cover were not so clearcut at our EBRPD study sites, which are not on serpentine soil. In three parks (only two in 2007), there are grazed and ungrazed sites. Ryegrass cover was higher on grazed sites in all years, but this difference was only statistically significant in 2004 and 2006. Native plant cover and diversity, however, did not differ between the grazed and ungrazed sites in any year.

Conclusion

Data from several studies suggest that, over the past decade, Italian ryegrass has emerged as a dominant species in the annual grassland

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Annual ryegrass-dominated site, early in the growing season, Vasco Caves Regional Preserve, near Livermore, California, April 2006. Ryegrass makes up over 80 percent of the plant cover here.

Annual ryegrass-dominated site, late in the growing season, Sycamore Valley Regional Open Space Preserve, near Danville, California, June 2006. Ryegrass makes up 55 percent of the plant cover at this site.

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of the San Francisco Bay Area. Although the ecological repercussions of ryegrass dominance are little studied, several lines of evidence suggest that native plants and animals could be negatively impacted. Increased ryegrass pollen may also cause higher levels of allergies and asthma in people. Consequently, research into the causes, ecological impacts, public health impacts, and control of Italian ryegrass dominance should be made a priority. Research priorities include:

- Collecting further evidence documenting the extent of Italian ryegrass dominance in the Bay Area and elsewhere in California.
- If long-term data sets are available, evaluating how much ryegrass abundance has changed over the past several decades.
- Analyzing the relationship between nitrogen deposition and Italian ryegrass dominance in the Bay Area with deposition models and field data.
- Conducting greenhouse and field experiments in serpentine and non-serpentine soils designed to investigate the effects of ryegrass on native grassland plant species richness and abundance.

Experiments should be conducted under several levels of nitrogen, moisture, and temperature, including at levels predicted by regional climate change models.

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California goldfields (*Lasthenia californica*) and arroyo lupine (*Lupinus succulentus*) bloom in this installed meadow in Loomis, CA, using the seed mixes on page 18. *Photo: Billy Krimmel*

SNAPSHOT: *by Billy Krimmel[1] and Haven Kiers[2]*

Creating Structured Native Meadows for Landscapes

Natural meadows are dynamic ecosystems where annual plants (such as wildflowers) change in relative abundance and location every year, blooming and waning within a season. For landscapers, recreating native meadows exemplifies the challenge of striking a proper balance between wild and organized aesthetics. From the perspective of habitat restoration, meadows provide immense value: they produce large amounts of biomass, are highly biodiverse, and are frequented by a diversity of animals, many of which are rare or threatened.

But from the perspective of those working in the landscaping industry, restoring meadows is far more challenging, logistically and aesthetically, than executing the conventional landscapes around which the industry is built. For example, annuals are beautiful when they are growing and blooming, but as the plants senesce and die they remain as dried, standing skeletons while other species begin to bolt and bloom. Large rain events following sowing of seeds can wash seeds out of areas, resulting in bare patches. Maintenance is complicated, and preparation, particularly in large areas, requires surveying, planning, and time.

Despite these challenges, we are hopeful that meadows will emerge as a widespread element in California landscapes. Recreating native meadows in large spaces — public and private — can be cost-efficient and the messiness of the *tangled bank* (see explanation next page) softens when seen from afar. Even in small residential settings, meadows can work well when homeowners embrace the complexity of their landscape (and the task of explaining to their neighbors, "*No, those are not weeds!")* Every meadow has different requirements depending on the project intentions and the constraints of scale, location, and budget. This can be intimidating, but should not deter people from attempting to create native meadows. For those who prefer self-help, Gornish and Shaw (2017) recently published a helpful manual on restoring native grasslands. Also, the California Native Grassland Association and its partners are great resources for working through the challenges of designing, creating and maintaining native meadows. If you are interested in creating a meadow but intimidated by the challenges, reach out to **admin@cnga.org** and we'll do our best to help you out or connect you with someone who can. Please also send pictures of your attempts — successful or not — in creating native meadows, and we'll publish them in subsequent *Grasslands* editions. We would also love to hear about your trials, tribulations and successes.

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Native Meadows *continued*

A Quick Guide for Creating Structured Meadows

Site preparation

Properly preparing an area for restoration is critical, and is probably the step that most often predicts success or failure. The key element to keep in mind is that once the area is seeded with native species, selective removal of weeds becomes extremely challenging. Differentiating between species before plants flower can be difficult for even an experienced ecologist or restoration practitioner. Therefore, the easiest time to remove weeds from your meadow is before you install the meadow.

Many methods of weed removal are available before the meadow is installed, including solarization, removal by hand, herbicide, mowing, torching, tilling, removing soil, and many more. The appropriate method depends on the species of weeds and the constraints of the project (in particular, scale, timeline, budget, and ability to use herbicides). The first step is figuring out what weeds are already present, and then determining how to control them. The University of California Statewide IPM program (**http://ipm.ucanr.edu/**) is a great resource for most relevant species in California. Regardless of the method, the goal is to create a low-competition environment for the meadow. This is particularly critical when seeds are to be sown in the first season.

On very small scales, another weed control method takes advantage of the fact that root hairs are tiny in comparison of cotyledons and true leaves. This method involves putting cardboard down and covering it with a few inches of soil, then sowing seeds upon the soil. When the seeds germinate, their microscopic root hairs can penetrate the cardboard, assuming it stays wet — this is important — if the cardboard dries, this method will not work. New leaves coming from below the cardboard, however, are unable to penetrate the cardboard and thus suppressed. This approach works well with some weeds but is not sufficient to suppress others such as Bermuda grass (*Cynodon dactylon*), nutsedge (*Cyperus* spp.) and *Oxalis* spp., which will eventually find a way to make it through or around the cardboard. It is important to have supplemental overhead irrigation available for this approach to keep the cardboard moist during dry and sunny periods of the winter.

For larger meadows, a staged preparation and installation is the most common practice. Weeds and thatch are removed as much as possible, and then foundational native plants are planted in the first fall, typically in small sizes such as liners or plugs for the sake of cost efficacy. For the foundational species (typically bunch grasses and some woody perennials) we like to use a matrix design, placing plants at a regular distance from one other. During the first year, weeds that come up can easily be killed because the area within the matrix is still relatively open and accessible (as opposed to filled with germinating wildflowers). If weed control is successful, native forb seeds can be sown the following fall to create a full grassland or meadow. Another advantage of this approach is that it allows the bunchgrasses and slower-growing perennials to establish before encountering competition from the seeded forbs.

Tangled bank is a term coined by Darwin in _On the Origin of Species._

He writes: "It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us".

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Native Meadows *continued*

Irrigation

Supplemental irrigation is a great tool for successfully establishing a meadow. In addition to supporting thirsty native transplants and seedlings in dry years, it also helps with weed control because supplemental water can stimulate germination and vegetative growth in weeds that can then be killed, especially during the preparation phase. Another advantage is that blooms of native wildflowers can be extended for desired species by supplementing water in the spring and summer.

The two most common setups for supplemental meadow irrigation are overhead sprinklers and a drip irrigation grid. Overhead sprinklers need to be tall enough to throw water over nearby plants, so they should either be attached to risers or on large pop-up bodies that allow them to get at least a few feet above ground level. A drip irrigation grid, on the other hand, involves setting up a grid of inline drip emitter tubing throughout the entire meadow area. With this system, irrigation water is dispersed slowly and relatively homogeneously throughout the entire area. Compared with drip irrigation setups where individual emitters are placed next to each individual plant, the grid setup allows plants to grow anywhere within the grid area, which is necessary for a meadow where seeds are to be dispersed irregularly. The spacing and flow rate depend primarily on the soil type and grade. Manufacturers of these products tend to have good information on recommended specifications based on site conditions. Resources and information for irrigation systems can also be found at CNGA native landscaping workshops.

Plant selection

As with all native landscaping, the starting point for thinking about which species to use should be the local conditions. Ask questions like: What other native plants (if any) grow here, or nearby, already? Is the soil sandy or heavy? What animals are present that might eat the plants? What animals do I want to create habitat for?

Another consideration is the origin (commonly referred to as ecotype) of the plant material to be used. When possible, it's best to use plants that are propagated from individuals collected nearby. Most nurseries and seed suppliers that specialize in native species for restoration purposes keep track of this information. To find the correct ecotype for a given species, we encourage a two-step process. First, use CalFlora (**calflora.org**) to determine the natural distribution of a given species. Next, check with your supplier on what ecotypes they have available and then try to use one from as close to the project site as possible. Hedgerow Farms and others have this information online: (**https://www.hedgerowfarms.com/species-database**).

A common goal for creating meadows is to create habitat for native animals. For best results, think beyond floral traits and pollinators. Having flowers that bloom throughout the season is important — it's just not the whole picture. Other plants traits, like oils and resins produced by plants, are also important pollinator resources (e.g., Rasmussen and Oleson 2000). Also, not all flowers are of equal value for a given pollinator—some pollinators are generalists and use a variety of easily-accessible flowers, while others are specialists and prefer less-accessible flowers to which they are uniquely adapted (e.g., Faegrin and Van Der Pijl 2013). Other elements of installed meadows also have habitat value. For example, dead plants and dry twigs can be important nesting sites for solitary bees, while rocks are important to reptiles for hiding and basking, and piles of wood are used as overwintering sites for beneficial insects. The most effective approach may be to strive for local plant species (with proximal origin locations) and high diversity. This approach is a simple and safe way to ensure you will be creating good habitat for a diversity of native animals.

Aesthetic considerations

No matter how weed-free or species-diverse your meadow, if it doesn't look good, no one is happy. So how do you create functional meadows that are also beautiful? The key is to take a cue from nature itself.

Have you ever sown a "wildflower seed mix" in your backyard and then studied the results? The landscape is evenly distributed with the same mixture of species in a riotous bloom of colors and textures. Although rife with color, the meadow is strangely uniform — one corner looks almost exactly like another. Now picture the wildflowers that bloom along the Coast Range in the spring — long ribbons of purple broken up by great swaths of yellow. There's no such thing as a perfectly randomized mix in nature. Annual wildflowers bloom and typically spread their seeds close by. If the seeds land in conditions conducive to growth, they will colonize and reseed extensively, out-competing other species. In areas where one flower fares poorly, another might thrive and multiply. The result will be a different trajectory of growth across the landscape, with plants settling into spots best suited to their ecological needs.

Aesthetically, our eyes are drawn to these patches and swaths of color — we find more beauty in a meadow made up of a series of discreet repeating modules than in an endless sea of uniformity, no matter how diverse the species mixture. One method we use in adding structure to seeded meadows is to make mixes comprised of a few species that are sown together. Each mix is comprised of species that bloom at different parts of the season, resulting in approximate monocultures at any given time, but changing with the changing seasons (see Mix ideas next page).

When designing your own meadow, consider using the hierarchy of planting created by garden designers Piet Oudolf and Noel Kingsbury (2016). The bulk of the meadow is made up of matrix planting — these are the foundational species — typically bunch grasses that are planted en masse and spread across the site, as described above. Mixed into the matrix in small groups and clumps are primary plants — select perennial forbs that stand out against the relatively neutral backdrop of the grasses and create seasonal interest.

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Sample species mixes for a 1.5-acre meadow in Loomis, CA — Each mix has a combination of species that will bloom from early spring through fall, with one predominant species blooming in each patch at any given time. Broadcast the mix into a distinct swath in the area to be seeded, to create structure reminiscent of natural blooms.

Mix 1 Elegant clarkia (*Clarkia unguiculata*) | Red ribbons (*Clarkia concinna*) | Sky lupine (*Lupinus nanus*) | Vinegarweed (*Trichostemma lanceolatum*) | Turkey mullein (*Croton setiger*)

Mix 2 California goldfields (*Lasthenia californica*) | California bluebell (*Phacelia campanularia*) | California poppy (*Eschscholzia californica*) | Spanish clover (*Lotus purshianus)*

Mix 3 Slender clarkia (*Clarkia gracilis*) | Common madia (*Madia elegans* var. *vernalis*) | Coastal tidytips (*Layia platyglossa*) | Common gumplant (*Grindelia camporum*)

Mix 4 Arroyo lupine (*Lupinus succulentus*) | Fort Miller Clarkia (*Clarkia williamsonii*) | Coastal tidytips (*Layia platyglossa*) | Common madia (*Madia elegans* var. *densiflora*)

Mix 5 California goldfields (*Lasthenia californica*) | Purple clarkia (*Clarkia purpurea*) | Evening primrose (*Oenothera californica*) | Turkey mullein (*Croton setiger*)

Mix 6 California goldfields (*Lasthenia californica*) | Redmaids (*Calandrinia menziesii*) | Woolly sunflower (*Eriophyllum lanatum*) | Summer lupine (*Lupinus formosus*) | Common madia (*Madia elegans* var. *densiflora*)

Native Meadows *continued*

Annual wildflowers can either fall into the primary plant category, in which case seeds are scattered in large monocultural groups (or mixes as described above) within a grassy matrix, or into another category called scatter plants. While matrix plants add consistency and primary plants add visual interest, scatter plants add spontaneity to a meadow. In this case, seeds of a single species or mix are scattered across the site in patches.

Another area to consider in your meadow design is the edge. This transitional zone between meadow and its neighboring habitat (be it urban infrastructure, commercial development, formal landscape, or a home) is typically an area of flux, with increased sunlight and higher biodiversity (e.g., Harris 1988). Edges create a dramatic foreground to your meadow beyond — use them to introduce seasonal plants, test new species, and highlight variety in color, form, or texture.

As with any garden, it's important to consider bloom time and seasonality of plants. California meadows tend to put on their biggest display in the spring and then fade into the background the rest of the year. That's OK — your meadow doesn't need fireworks for every season. But a little color can go a long way — adding patches of later-blooming *Epilobium* spp., *Solidago* spp., and *Aster* spp. can take a meadow from summer all the way through fall. And consider leaving seed heads and flower stalks for winter interest.

Monitoring and maintenance

Creating a meadow or grassland is not a one-step installation but should be a dynamic, ongoing process that requires attention and effort throughout. Following installation, it is critical that meadows and grasslands are monitored for weeds and that weeds are promptly removed to the extent possible. Hand removal, torching, and spot-spraying with herbicides are effective approaches when the spatial scale is manageable. In larger settings, well-timed mowing or grazing can also be highly effective. In most landscape settings, mowing is more accessible than grazing, and can be used to target problematic species of weeds.

In some instances where invasive weeds are abundant within an already-seeded meadow, it may be necessary to kill entire sections, including the desired plants. The sooner these patches can be identified in the rainy season and killed, the better, because desired seeds may still germinate afterward. This is another instance where having supplementary irrigation is beneficial — it can extend the 'rainy season' longer, allowing native seeds to germinate in areas where invasive species had to be removed early in the rainy season.

The extent to which weeds can be eliminated *prior* to seeds being sown will make the maintenance following seeding immensely easier. Patience pays off. *Now go make a meadow!*

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Front cover: *Sidalcea diploscypha* in a serpentine meadow at the McLaughlin Reserve in April 2016, showing the signs of having burned in the Rocky/Jerusalem Fires of summer 2015. *Photo: Susan Harrison*

Back cover: Purple needle grass (*Stipa pulchra*) in a home garden in Woodland. *Photo: Jennifer Hogan*