California
Native
Grasslands
Association

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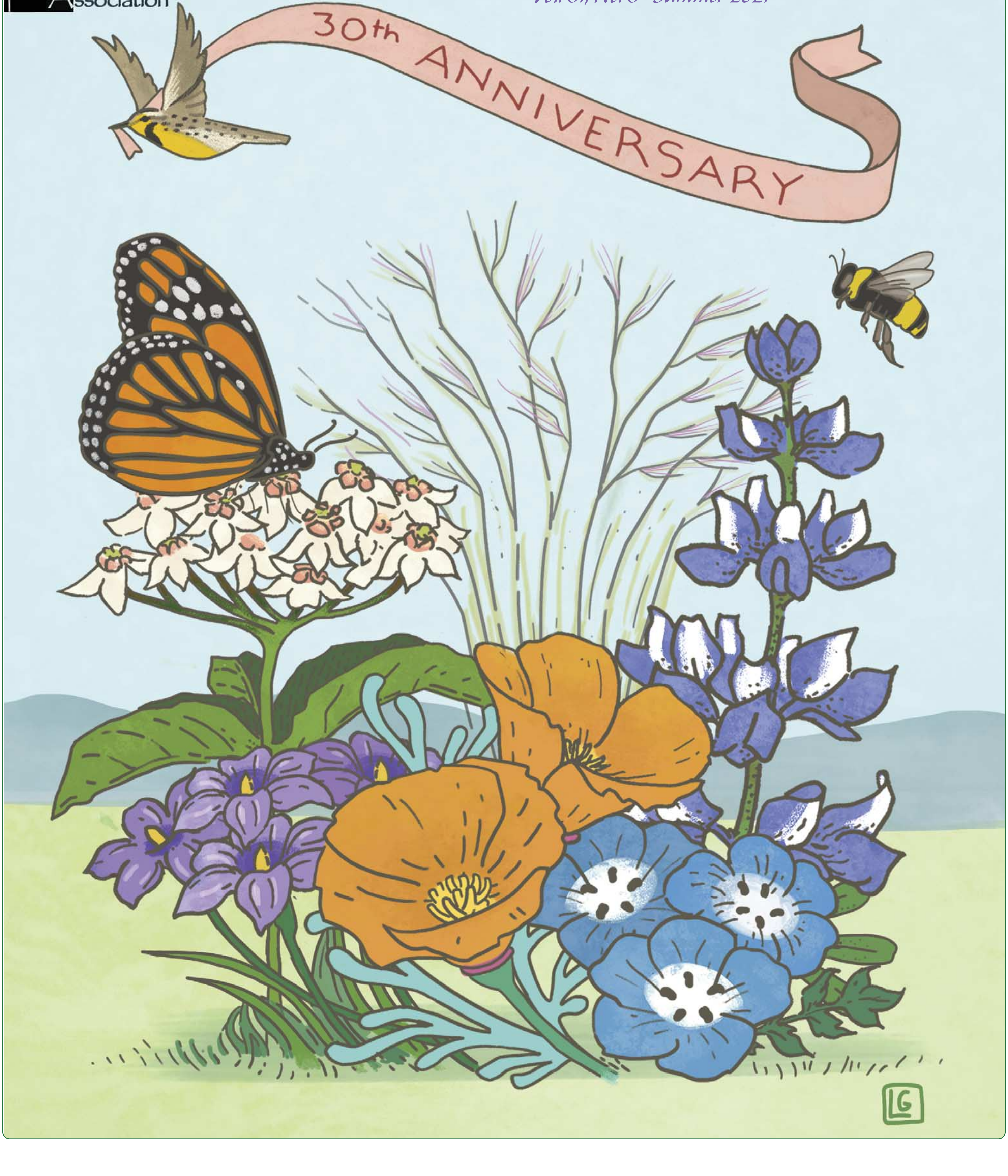

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Mission Statement

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

Dear CNGA members,

Following the special spring issue dedicated to John Anderson, it is my pleasure to present you this summer issue of *Grasslands* celebrating our 30th anniversary.

In this issue, we honor all of the CNGA founders, past and present directors, members, and supporters whose vision of a healthy future have brought the organization forward to this 30th anniversary as an intact and evolving organization dedicated to continuing our mission to promote, preserve, and restore the diversity of California's native grasses and grassland ecosystems through education, advocacy, research, and stewardship.

For the past 30 years, CNGA has been faithful to its original mission set by our founders, and you, the members and corporate sponsors, are the most important part of its success. Your feedback is important to us, and I want to thank all of you who participated in the membership survey (see page 28) that will assist us in serving you even better while continuing to follow the CNGA mission.

One word I have in mind as I am writing this note is resiliency. We are resilient, and while the coronavirus pandemic shut down the entire world, we adapted to the situation and were able to fulfill our mission thanks to our dedicated board members, supporters, and followers. Nature is also resilient, and while we are facing the impact of climate change and experiencing yet another record drought, I am confident that nature in general and especially native grassland ecosystems will adapt. Things might look different in the near future, but these systems have shown remarkable resiliency in the past.

Now more than ever, we need to protect the existing systems, and to that effect, CNGA is actively advocating for the protection of some existing grasslands to meet the "30 by 30" goal to protect 30% of the land by 2030. One example is the Tesla Park in Alameda County that is on its way up the legislature. I do hope you will continue to support us towards this global preservation goal.

Thank you for your continued support, and enjoy this 30th anniversary issue.

JP Marié

Field Day 2021 On-Demand

Don't worry if you missed Field Day on June 11th. We now offer all of the field tours and presentations as an on-demand video event with access to all of the Field Day materials we provided on the original date, including handouts and Q&A panel discussions. Three sessions take you through the restoration process — from wildland seed collection through farm production and tours of restored field sites throughout the state:

❊ Follow the life of a seed from wildland seed collection to farm production

❊ Seeds of restoration: Where are they now? Tour the state with virtual "show and tell" site visits and presentations

❊ The 30-year evolution of grassland restoration with short talks by CNGA leaders, past & present

Details and registration at cnga.org

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.

For 30 years, the California Native Grasslands Association has represented people concerned with the continued loss and degradation of California's grasslands, the most threatened ecosystem in California. Our dedicated Board of Directors volunteer their valuable time to educate and promote awareness of the beauty and importance of healthy grassland ecosystems.

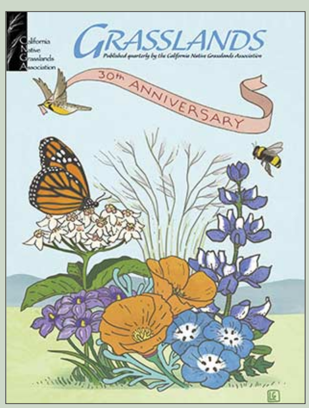
We invite you to support our mission with your donation or through CNGA membership.

Four ways to make your gift:

1. **Online** — cnga.org
2. **By Mail** — send your check or credit card information to: CNGA, PO Box 485, Davis CA 95617
3. **By Phone** — call us at (530) 902-6009 with your credit card info
4. **Donating your Time and Expertise** — join the CNGA Board of Directors! Contact admin@cnga.org for more information.

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 the Editor at **grasslands@cnga.org**. Include a caption and credited photographer's name.

Submission deadlines for articles:

❊ **Fall 2021**: 15 Aug 2021 ❊ **Winter 2022** 15 Nov 2021 ❊ **Spring 2022**: 15 Feb 2022 ❊ **Summer 2022**: 15 May 2022

In this issue

Thirty Years of Changes in How We Understand and Steward California's Grasslands

by Valerie Eviner[1] and Michelle Halbur[2]

The California Native Grassland Association's (CNGA's) leadership in the restoration of California grasslands has extended far beyond incorporating the latest science into restoration techniques, it's also pushed the frontiers of research—forging new directions and recruiting and collaborating with researchers to explore novel ways of understanding these grasslands, addressing critical knowledge gaps in our stewardship. This is a short review of some of the major changes in our understanding of California's grasslands in the last 30 years.

1. It's not just the grasses

Over the decades, we've progressed beyond a focus only on native grasses, and have expanded our efforts and attention to forbs—the non-grass herbaceous species, such as our wildflowers. There are four times more forb species than grass species in California's grasslands, and thus these wildflowers comprise the majority of our plant diversity. This diversity provides critical functions, with many of these forbs having traits that are tolerant of drought, fire, gopher activity, and other disturbances (Hallett et al. 2017). As a group, these forbs are the emergency first-responders to many types of grassland disturbances. For example, plots with more grasses and fewer forbs in the seedbank showed a large decrease in plant cover and biomass in response to drought. In contrast, those plots with a seedbank dominated by forbs sustained plant cover and biomass during drought, because the forbs had a higher diversity of stress-tolerant traits, and were able to fill in for the grasses that failed to establish during drought (Hallett et al. 2017). These wildflowers have a long-term seedbank that can remain dormant in the soil, often for decades, and emerge when there is "empty space", usually because grasses fail to establish. This may occur when fire kills much of the grass seed in the thatch layer (Cox and Allen 2008) (Photo 1), or when early-fall rains are followed by drought, leading to germination but then death of annual grasses. Rainfall timing also affects the balance between grasses and forbs. For example, when grasses are

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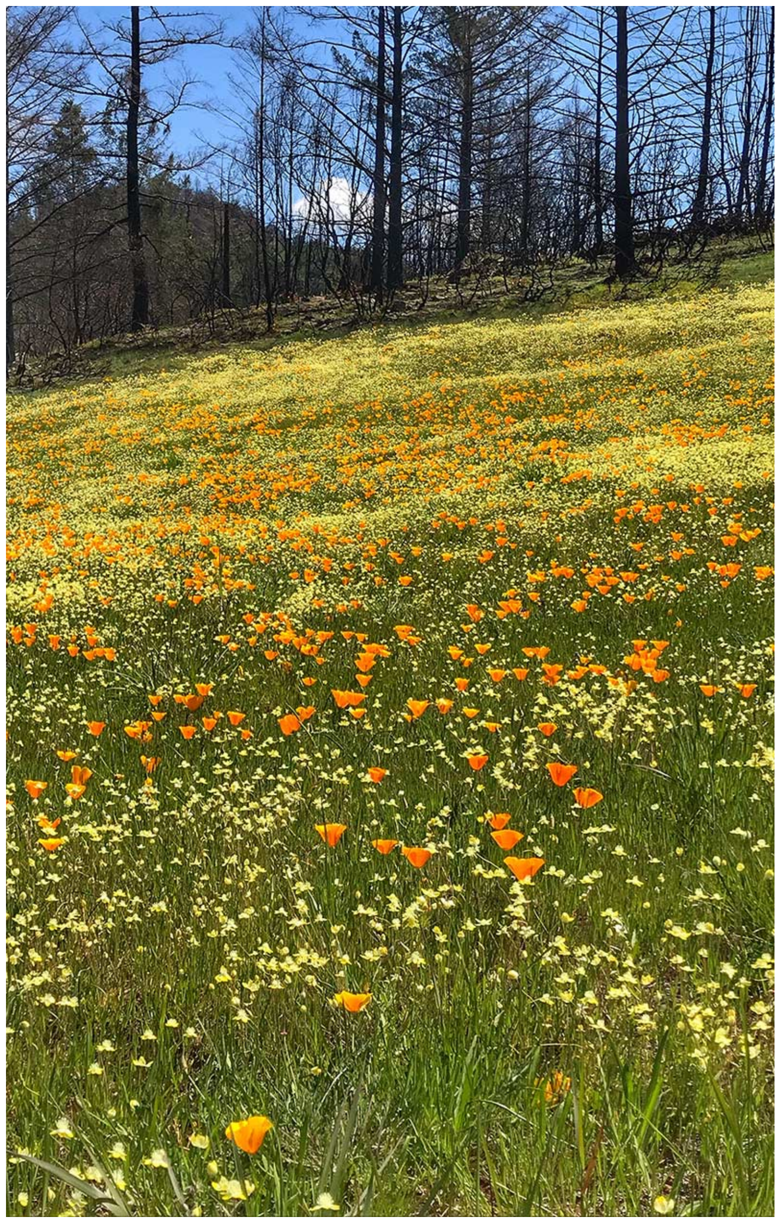

Photo 1. Creamcups (*Platystemon californicus*) and California poppies (*Eschscholzia californica*) dominate a meadow the spring following the October 2017 Tubbs Fire. *Photo by Gary Morgret at Pepperwood Preserve.*

[1]Professor, Dept. of Plant Sciences, University of California, Davis. *Eviner's research, outreach, and teaching focus on understanding how our ecosystems function, and then applying that knowledge to better understand and steward ecosystems under changing environmental conditions.* [2]Preserve Ecologist, Pepperwood Preserve, Santa Rosa. *Halbur conducts research at Pepperwood, a 3,200-acre nature preserve in eastern Sonoma County, that looks at how adaptive land stewardship practices impact upland terrestrial ecosystems in a changing climate.*

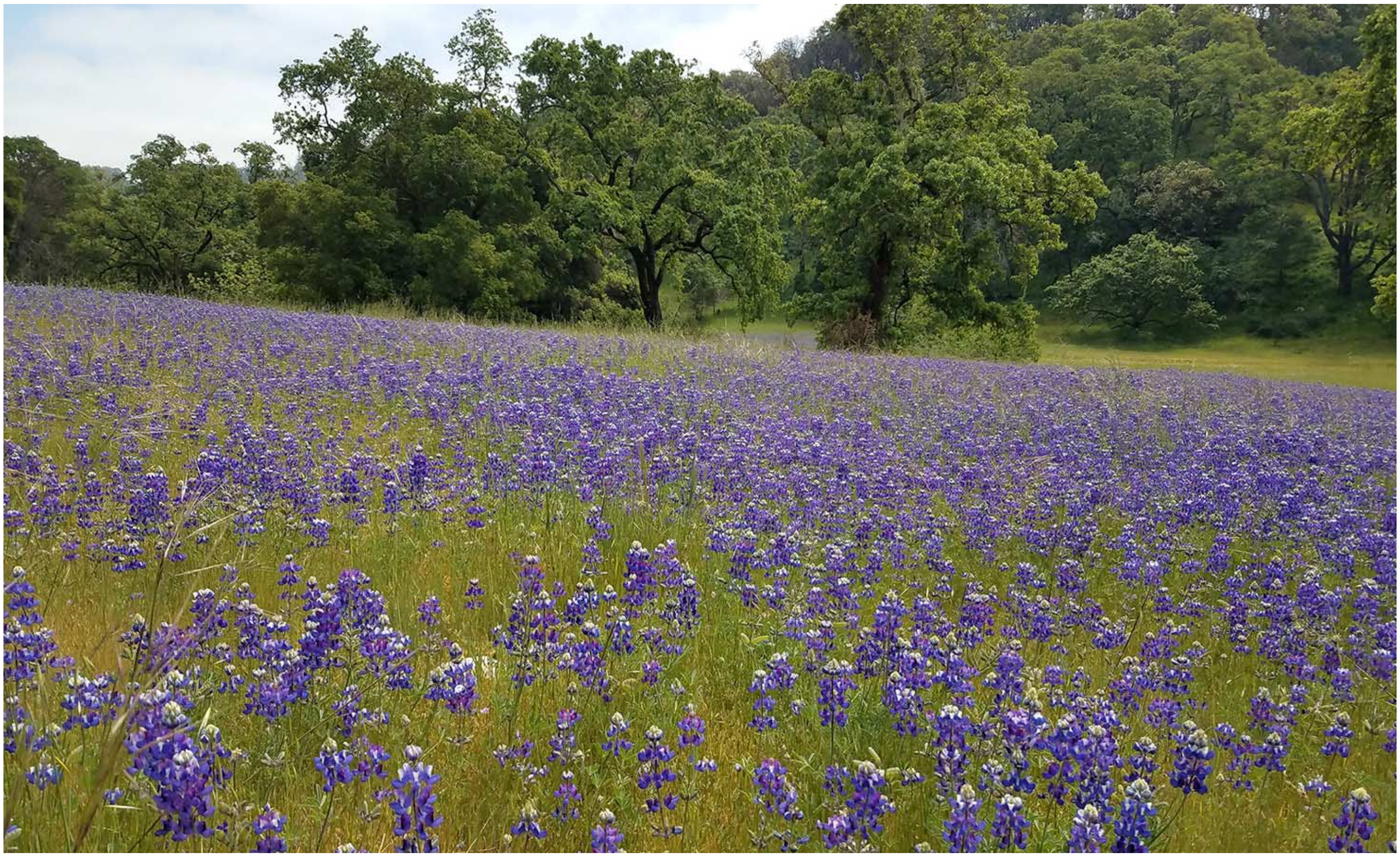

Photo 2. The dry 2020–2021 resulted in widespread domination of lupine across northern California. Pictured here, lupine in Spring 2021, following a 2019 wildfire. *Photo by Valerie Eviner, Pepperwood Preserve.*

Thirty Years of Changes in How We Understand and Steward California's Grasslands *continued*

sparse due to early-season drought, filaree (*Erodium* spp.) tends to dominate (Hallett et al. 2019), and when there is an extended drought in the winter or spring, clover and other legume species tend to be prevalent, filling in for the grasses (Pitt and Heady 1978) (Photo 2).

Forbs aren't consistently present in the standing vegetation—their presence blinks on and off, depending on environmental conditions and management. The California super blooms are a great example of this—they occur occasionally, and one shouldn't expect that non-bloom years indicate a decrease in diversity or function of the grasslands. This can be frustrating in restoration, when considerable time, funds, and energy can be invested in establishing forbs, without seeing immediate results. The success of forb restoration comes through establishing a seedbank, from which forbs can emerge episodically under the right conditions. Unfortunately, the resilience of our grasslands may be decreasing due to a decline in the diversity of forbs, specifically native annual forbs, most likely associated with lower mid-winter precipitation (Harrison et al. 2015).

There is evidence that maintaining a robust forb seedbank requires active management of grasses, especially as their thatch builds up. High thatch levels inhibit forbs, and their prevalence increases with thatch removal (Bartolome et al. 2007, LaForgia 2021). Removing thatch through prescribed or cultural burns, grazing, or mowing can be critical to allow forbs to emerge in the standing vegetation, thus replenishing their seedbank (D'Antonio et al. 2000, Hayes and Holl 2003). For example, moderate grazing (compared to low grazing) was shown to be a critical tool for enhancing forbs in the seedbank and increasing their prevalence during drought (Hallett et al. 2017). Grazing for maintenance of forbs can be particularly important in areas with high atmospheric nitrogen deposition, where this pollution fertilizes the soil and increases grass and grass thatch, leading to extensive forb decline (Hernandez et al. 2021). Wildfires (Hernandez et al. 2021) and drought (LaForgia et al. 2018) can also be important natural disturbances that increase forb prevalence and increase the seedbank.

2. It's not just the plants

An important justification for California grassland restoration and conservation is that these grasslands are a hotspot of diversity, providing critical habitat for nearly 90% of the state's rare and endangered plant and animal species (Skinner and Pavlick 1994). This

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Photo 3. Soap plant (*Chlorogalum pomeridianum*) is abundant in the small mammal exclosure (left), and much rarer in the plot with small mammal activity (right). *Photo by Valerie Eviner, at Hopland Research & Extension Center.*

Thirty Years of Changes in How We Understand and Steward California's Grasslands *continued*

broad diversity of organisms shapes California's grassland vegetation, and can even influence the balance between native and invasive plants. As indicated in the previous section, grazing can be a critical tool in the management of grassland vegetation, generally increasing the richness of forbs and cover of native grasses, although effects of course depend on site conditions, weather, and the intensity and duration of grazing (Stahlheber and D'Antonio 2013).

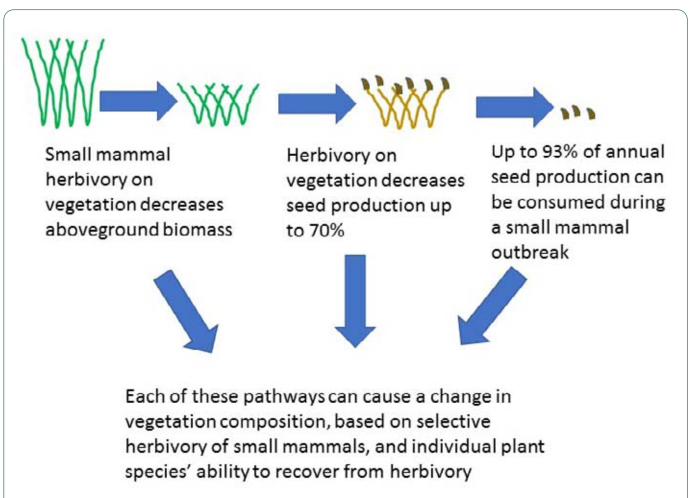

Figure 1. Small mammals impact grassland composition, productivity, seed production, and seed survival.

Small mammals, such as mice, ground squirrels, voles, moles, rabbits, and gophers, are abundant in California's grasslands and serve critical roles as herbivores, granivores, and seed dispersers (reviewed in Eviner 2016). Experimental removal of small mammals demonstrates the many impacts they have (Figure 1). Without small mammal herbivory on live vegetation, aboveground biomass increases by 40–87% (Peters 2007). This herbivory of live plants can decrease seed production by up to 70%. Small mammals also act as granivores, and during population peaks, can consume up to 93% of the annual seed production (Pearson 1964, Batzli and Pitelka 1970). These small mammals can have strong effects on plant community composition—decreasing the density of preferred seed species by 30–62% (Borchert and Jain 1978). For example, small mammals decrease cover of exotic plants, especially exotic forbs (Maron et al. 2014). Purple needlegrass (*Stipa pulchra*) density can decrease by 52% due to voles, mice, squirrels, and rabbits (Orrock et al. 2008). Small mammals particularly decrease plants with bulbs or tap roots (Maron et al. 2014) (Photo 3). Gophers, through their herbivory and disturbance, also can decrease perennial grasses, while increasing annual grasses and forbs (Bartolome et al. 2007, Tyler et al. 2007).

Insects and gastropods also have strong effects on native perennial grasses. Grasshoppers tend to mature in late spring and summer, so have little effect on annual grasses which have largely senesced by that time, but consume perennial grasses and late-season forbs (Porter and

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Photo 4. Post-fire, vegetation biomass is substantially higher on ant mounds (area surrounded by flags) than the surrounding landscape. *Photo by Valerie Eviner, at Hopland Research & Extension Center.*

Thirty Years of Changes in How We Understand and Steward California's Grasslands *continued*

Redak 1997). Slugs and snails (especially slugs) can consume high amounts of vegetation biomass, with their exclusion increasing aboveground biomass 28-71%. In a comparison of the effects of exclosures of small mammals vs. gastropods, snails and slugs decreased grassland seedling survival more than small mammals did—particularly decreasing seedling survival of forbs and legumes (Korell et al. 2016). The preferred food of gastropods may also change seasonally, with higher consumption of grasses in the fall, but higher forb consumption in the winter (Peters 2007). Ants also play an important role as seed consumers and dispersers and tend to increase legumes and non-native annual grasses, while decreasing forbs (Hobbs 1985, Peters et al. 2006). Their mounds are hotspots of soil organic matter and nutrient availability as well as soil microbial biomass (Beattie 1989, Boulton et al. 2003), and higher plant biomass on ant mounds is very noticeable post-fire (Photo 4).

Some of the greatest advances in enhancing our understanding of California's grasslands are related to the soil microbial community, with new technologies allowing us to measure their composition and activity. Microbial communities can strongly impact plant growth and the relative amount of growth in roots vs. shoots (Brandt et al. 2009). Different plant species can culture different microbes in the soil, which, in turn, can affect plant growth and competitive ability. For example, when soils are cultured by growing exotic annual grasses for five weeks, those exotic-cultured soils (even when exotic plants are then removed) decrease native grass biomass by 74% (Grman and Suding 2010) (the mechanism is unknown in this experiment). Similarly, exotic grasses change the composition of the soil arbuscular mycorrhizal community. Arbuscular mycorrhizae (AM) are fungi that are symbiotic with plants, exchanging plant carbon for soil resources, including nitrogen, phosphorus, and/or water. Most California grassland plants are reliant on these AM fungi, with growth, seed production, nutrient uptake, and drought stress tolerance being enhanced by this symbiosis (Harrison and Viers 2007). Native and exotic grasses culture different AM communities, and each plant group produces higher biomass and seeds when associated with their own AM community (Nelson and Allen 1993, Hausmann and Hawkes 2009, Vogelsang and Bever 2009, Haussman and Hawkes 2010). Exotic grasses have been shown to decrease AM in soil, decreasing native performance (Vogelsang and Bever 2009). This is particularly of concern because when plant communities consist of both native and exotic grasses, the effects of exotic grasses on AM are dominant (Vogelsang and Bever 2009, Haussmann and Hawkes 2009). These experiments largely have focused on the establishment phase of restoration—highlighting the importance of the soil microbial community to successful native restoration. Fortunately, there is one study that indicates that once native species establish, the AM community reverts to AM associated with native grasses (Nelson and Allen 1996), suggesting that soil microbial communities can be restored through plant restoration, over the long term.

Restoration efforts that use soil inoculation of AM from native soils can enhance native performance, but inoculation with commercial AM does not appear effective at enhancing natives (Emam 2015,

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Koziol et al 2018). In some cases, AM can help exotic plants become more competitive. AM form networks, plumbing into many individual plants simultaneously, moving nutrients such as phosphorus between plants (Chiariello et al. 1982). This network appears to help the non-native Napa starthistle (*Centaurea melitensis*) dominate over purple needlegrass presumably by parasitizing purple needlegrass through the AM (Callaway et al. 2003). Our best current understanding is that AM can play a critical role in native restoration, but we still have a lot to learn about how to manage the preferred types of AM, particularly in the presence of exotic annual grasses.

Another type of soil microbe also influences interactions between native and exotic grassland plants. Nitrifying bacteria convert plant-available nitrogen in soil from the ammonium to the nitrate form. As nitrate, this nitrogen can move more extensively through the soil, and is at greater risk for leaching losses. A series of studies at Hopland Research & Extension Center indicated that annual exotic grasses increase the population size of nitrifying bacteria and alter their community composition, doubling the rate of nitrification (Hawkes et al. 2005). In a greenhouse trial, nitrification inhibitors, commonly used in agriculture, were applied to soils cultured by exotic grasses, and resulted in nearly double native grass growth (Waitman 2019, Eviner et al. in prep.). This suggests that native restoration may benefit from reversing the soil changes that occur due to exotic grass invasion. A key challenge in understanding and managing soil nutrient cycling effects on plants, is that its effects vary from experiment to experiment. Native grasses have been shown to both increase and decrease nitrogen cycling, compared to exotic grasses, and more work needs to understand the site- and time-specific nature of these effects (Eviner and Firestone 2007, Eviner 2016, Carey et al. 2017).

Native grass establishment can also be limited by the pathogens they culture in their own soil, with their growth more than doubling with soil sterilization (Waitman 2019). Viruses are important pathogens that can limit native grass establishment. Barley yellow dwarf virus and cereal dwarf virus, spread by aphids, can decrease survivorship of native grasses by 50–80% (Malmstrom et al. 2006, Borer et al 2007), with effects increasing in the presence of annual grasses. These viruses have much more muted effects on annual grasses, since these grasses die each year and are not stressed long-term by the viruses.

3. Ecosystem services

Native grasslands are not just important for species conservation, but also provide many ecosystem services that benefit humans. As discussed previously, perennial grasses and native forbs are important for persistence of plant cover during drought, and rapid establishment following fires. Wildflowers in our grasslands are critical for supporting pollinators for California's agriculture (Kremen et al. 2004, Chaplin-Kramer et al. 2011). Carbon storage is important for mitigating climate change, and soil carbon can provide drought resilience by enhancing water infiltration and storage. The impacts of native grass restoration on soil carbon are mixed. A comparison of remnant stands of native grasses vs. invaded annual stands indicates that remnant perennial grasslands have higher soil carbon (Koteen et al. 2011). In studies of restored grassland sites, some show that planting perennial grasses does not change soil carbon (Potthof et al. 2005), while others show changes in the distribution of carbon, with deeper carbon that increases water holding capacity, providing deep-soil late-season water that extends the growing season for both native and exotic grasses (Eviner et al. in prep). Decisions of where to prioritize native restoration can be aided by a better understanding of which ecosystem services will be most enhanced by restoration, and how that varies by location across the landscape.

4. Future challenges and priorities

Conservation of remnant grasslands

Over the last few decades, there has been remarkable progress in techniques and resources to improve the restoration of California's native grasslands, as highlighted in every CNGA event and publication. While planting natives is critical for the restoration of our native grasslands (Seabloom et al. 2003), there is still high variability in the success of restoration projects, and high uncertainty in the best restoration approaches at a given site, and under a given set of weather conditions (Nolan et al. 2021). Given the importance of our grasslands in supporting diverse species and ecosystem services that Californians depend on, restoration efforts are critical. However, our top priority should be conserving remnant native grasslands. It is unrealistic to assume that we have the ability to replace grasslands that are being destroyed through land-use change—relying on mitigation is risky and expensive.

Landscape-scale approaches to conservation and restoration

Where grasslands occur and how they are managed across the landscape will strongly affect their regulation of ecosystem services, such as support of pollinators, water infiltration and storage, water purification, erosion control, fire control, and invasive species control. Regional planning across multiple partners and landowners is critical for managing these ecosystem services, and a landscape framework must be used to prioritize which grasslands will be conserved, where grasslands will be restored, and how grasslands will be managed and for what suite of goals. This landscape approach becomes more important under changing environmental conditions, where conservation of our grasslands will not just entail protecting them from development. Grassland distribution is projected to change with shifts in wildfire and climate, and changes in management such as grazing and prescribed fire (Eviner 2016). Coastal grasslands are likely

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Thirty Years of Changes in How We Understand and Steward California's Grasslands *continued*

to shift with sea-level rise, and riparian grasslands and wet meadows are changing due to hydrological shifts (from stream incision to changes in the timing and duration of flooding or inundation). Managing our grasslands under these complex changes requires extensive mapping of grasslands and their potential habitat and ecosystem service values, a better understanding of grassland community dynamics under a changing climate, and identifying how vulnerable each patch may be to current and future changes. Coordinated efforts between public land agencies, land trusts, conservation groups, and private landowners will be critical for achieving landscape-level conservation and restoration of grassland species and ecosystem services.

Changing resilience of grasslands

Numerous studies highlight the challenges of grassland stewardship and resilience in the future. News headlines describe unprecedented conditions in terms of warmer temperatures, droughts, changes in the timing of rainfall, and shifts in the frequency, intensity, and size of wildfires.

Restoration goals and approaches need to consider these changing conditions. Which species are most suited to the management and environmental conditions available? Which locations are most critical to restore? With fewer, and potentially larger, rainstorms with more dry periods between them, how do we successfully establish restoration sites (especially if we don't have access to irrigation)? Research in the last 30 years has highlighted the importance of selecting species based on their functions—which conditions they can tolerate (e.g. drought), and which conditions they can ameliorate (e.g. increasing soil water storage, increasing soil fertility). Plant traits can guide which species may be most tolerant or vulnerable to various challenges. Trait-based approaches have identified drought-adapted species, which include species that are highly plastic in their physiology and morphology (Luong et al. 2021, Funk et al. 2021). Relying on drought-adapted species can have tradeoffs, however, since these species tend to grow more slowly, and decrease plant production (Wolf et al. 2021).

There is increasing interest in restoration that proactively addresses climate change by sourcing species and genotypes from warmer, drier regions (e.g. Southern California), but this is highly contentious. Planting genotypes from other areas can provide plants adapted to novel environmental conditions, but can also cause unintended harm in numerous ways, including becoming invasive, disrupting existing local adaptations, disrupting the ability of the local community to respond to climate change, introducing pathogens, driving local species loss, altering community response to disturbance regimes, and disrupting the provisioning of ecosystem services (Hewitt et al. 2011, Alexander et al. 2015, Bucharova et al. 2018). Restoration has often focused on the importance of selecting local populations for restoration—those that are adapted to site-specific environmental conditions and community interactions, and that don't disrupt the evolutionary adaptations that local genotypes have developed (Knapp and Rice 1994). However, there is substantial debate about whether reliance on local genotypes is adequate for rapidly changing conditions. So far there is consensus that at least over the short term, reliance on local genotypes may be effective if it focuses on diverse local seed collections—including from diverse sites, especially including the poorest sites, and during the poorest years (Havens et al. 2015, Ramalho et al. 2017, Bucharova et al. 2018). For example, there can be substantial variability in plant traits (particularly phenology) across topographic positions within a landscape (Olliff-Yang and Ackerly 2020). It is also important to ensure that these restoration approaches extend beyond seed sourcing, with restoration plantings occurring across diverse sites within a region, creating refuges under variable conditions.

It is particularly critical to plant diverse species into restoration projects. When looking at native restored communities over time, the cover of natives as a group can be stable across disturbances and a variable environment, but different types of environmental changes lead to different individual species becoming more or less dominant (Seabloom 2007). For example, over 15 years post-restoration, native wildrye (*Elymus glaucus, Leymus triticoides*) dominated during the initial wetter years, while purple needlegrass became dominant during and after drought, and blue grass (*Poa secunda*) only had substantial cover during drought years (Eviner et al. in prep.). Diverse plant communities can have more reliable productivity year to year (Hallett et al. 2017) and can be critical in supporting pollinators by cumulatively providing flower resources over time, particularly under changing conditions (Olliff-Yang et al. 2020). Diverse native plantings are also critical for one of California restoration's greatest challenges-weed control. The most effective long-term weed control is achieved by suppressing exotic weeds with native plants with similar traits (e.g. similar seasonality, rooting depth, etc.) (Young et al. 2009), and a diversity of native perennial grasses can effectively suppress noxious weeds like goatgrass (*Aegilops* spp.) and medusahead (*Elymus caput-medusae*), even during their peak years (Eviner and Malmstrom 2018).

While warming, drought, and wildfires provide challenges to stewarding our grasslands, California's grasslands have experienced these conditions in the past and have evolved under these perturbations. We need to be vigilant against other environmental changes that may disrupt the evolved resilience of these grasslands. One example is nitrogen deposition—pollution from excess nitrogen in the atmosphere as a result of fossil fuel combustion, volatilization from agricultural systems, and fires. Nitrogen deposition changes plant

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Thirty Years of Changes in How We Understand and Steward California's Grasslands *continued*

species composition and favors plants that are weedier and more vulnerable to droughts (reviewed in Eviner et al. 2016). Similarly, as grasslands become more fragmented and managed by smaller landholders, there is less management (e.g. grazing, mowing, prescribed fires), which can lead to increased weeds, loss of resilience (e.g. loss of a robust wildflower seedbank), reductions in connectivity, and loss of many ecosystem services (Ferranto et al. 2011). While mitigation of climate change is difficult because it occurs at a global scale, changes in nitrogen deposition and land use are determined by regional-scale activities and policies, and California can take concrete steps to ensure these environmental changes don't limit our grasslands' resilience to climate change.

Meeting the challenges of restoring and conserving our grasslands under future conditions will require close collaboration between conservationists, managers, and researchers—and thus a continuation of the important leadership role that CNGA provides.

Acknowledgments

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CNGA's Origin and History in Three Brief yet Spectacular Articles

by Diana Jeffery, CNGA Administrative Director

For this 30th anniversary issue, we chose to reprint three seminal articles explaining the origins and history of CNGA.

The first article, by CNGA's first president Robert Delzell, describes how CNGA was "born with the dream to make native grasses available for restoration of natural plant communities."

In the second article, "Grass is the Forgiveness of Nature," author David Amme adds backstory details regarding the formation of CNGA.

The final article, "Note from a CNGA Founder" by John Anderson, explains how CNGA's promotion of the use of native grasses evolved over the years.

All three authors were leaders in launching and crafting CNGA. We salute and thank them and the many others who have contributed their time and expertise to CNGA.

CNGA's First Board of Directors, 1991

Elected officers

President: Robert Delzell
Vice-President: Chuck Goudy
Secretary: Bob Slayback
Treasurer: Charlotte Glenn

Directors

John Anderson
Dave Dyer
Mary Burke
Scott Stewart
Craig Thomsen
Gail Newton
Rich Reiner

CNGA Origin Story

[Reprint] Grasslands, Volume 1, Issue 1, April 1991

President's Message by Robert Delzell (1935–2009), CNGA President 1990–1991, State Resource Conservationist for Soil Conservation Service in Davis, California 1981–1990.

The Association was born with the dream to make native grasses available for restoration of natural plant communities. Land management agencies receive increasing public pressure to use native grasses for wildfire burns, roadside revegetation, and landscape plant material. Until recently, native grass plant material was unavailable to meet the increasing demand. Interest from agencies and others has sparked research efforts, public education, and the associated technology to select, produce, and promote native grasses.

On February 19, 1990, public and private organizations met at the Lockford SCS Plant Materials Center to explore opportunities and "figure out a way to meet challenges which the organizations faced." In the fall of 1991, we became the California Native Grass Association. The purposes of our organization are: (1) to promote native grass technology as needed to restore ecosystems (includes selection, evaluation, and establishment of California native grasses and associated plants), (2) to coordinate and support the production and marketing of commercial quantities of native grass seed and other plant materials (includes storage and preservation of these materials, and guidelines for marketing and using them, and (3) to educate our communities on the economic and environmental values of native grasses and associated species, (4) to endorse conservation efforts to preserve existing native grassland habitat. Individual participation in the association comes from more than 20 public and private organization.

"We promote the use of native grasses and associated plants with concern for genetic integrity and biodiversity within an end-use perspective. If ecosystem restoration is the goal, use of site-specific native species is essential. If a native plant is to be used for special purposes such as revegetating eroded soils along a highway, weed control, or urban landscaping, then selection and volume production of a variety within a species' population may be appropriate."

The CNGA will pursue a network approach to exchange information among its members through our newsletter, workshops, tours, and field trips. The ideas, experience, and enthusiasm of our membership points to a bright future for the revitalization of California's grassland ecosystems.

Grass is the Forgiveness of Nature

[Reprint] *Grasslands*, Volume 21, Number 1, Winter 2011

by David Amme, CNGA founding member and past-President. David taught CNGA's Grass Identification class across California, and has written many articles on California's coastal native grasses, as well as native grasslands in general.

The California Native Grass Association was founded in the fall of 1991. The stated purpose of CNGA was to:

1. Promote native grass technology as needed to restore ecosystems,
2. Coordinate and support the production and marketing of commercial quantities of native grass seed,
3. Educate our communities on the economic and environmental values of native grasses, and
4. Endorse conservation efforts to preserve existing native grassland habitat.

The road to founding CNGA stretched back to a series of meetings held between the winters of 1990 and 1991, led by Bob Delzell of the Soil Conservation Service (SCS), now the Natural Resources Conservation Service (NRCS). Our first issue of *Grasslands* was published in April 1991. But the road stretched even further back when I brought the first large bag of purple needlegrass to Stewart Brother's Farm in Rio Vista. At the time, Scott Stewart was successfully growing SCS-developed Zorro fescue and Blando brome, and Berber orchard grass. Scott was eager to find new grasses, especially native California grasses.

The first bag of purple needlegrass and Molate fescue was collected by me, Hunter Wallof, David Kaplow, and Denise Martinez. We were a ragtag nonprofit restoration organization called Design Associates Working with Nature (DAWN). We started out in 1985 with some funding from the City of Berkeley to transform the Berkeley dump landfill site into an open space park. We didn't exactly succeed in this transformation. Today much of the area is dominated by kikuyu grass. Along the way we got hooked on the idea of using native grasses to restore this open space. We couldn't find a grower who would produce native grasses. Bob Slayback, who worked for the SCS in Davis, suggested that I talk to Scott Stewart. You might say the rest is history. After some initial unsuccessful haggling in the Holland Ranch parking area, I slammed my tailgate and got ready to leave. Next thing I knew Scott cut a check, and I drove home along the levee roads with a shit-grinning smile that I just couldn't suppress.

Scott soon grew the "Big Three" (meadow barley, California brome, blue wildrye), purple needlegrass, and Molate red fescue. Scott had started ConservaSeed. By that time the SCS had developed the "Rio" form of creeping wildrye, and John Anderson developed the local valley form of slender wheatgrass.

What truly sparked CNGA were the open houses that Scott Stewart threw at the ConservaSeed Grass Farm at Holland Ranch near Rio Vista. He invited designers, landscape architects, planners, and

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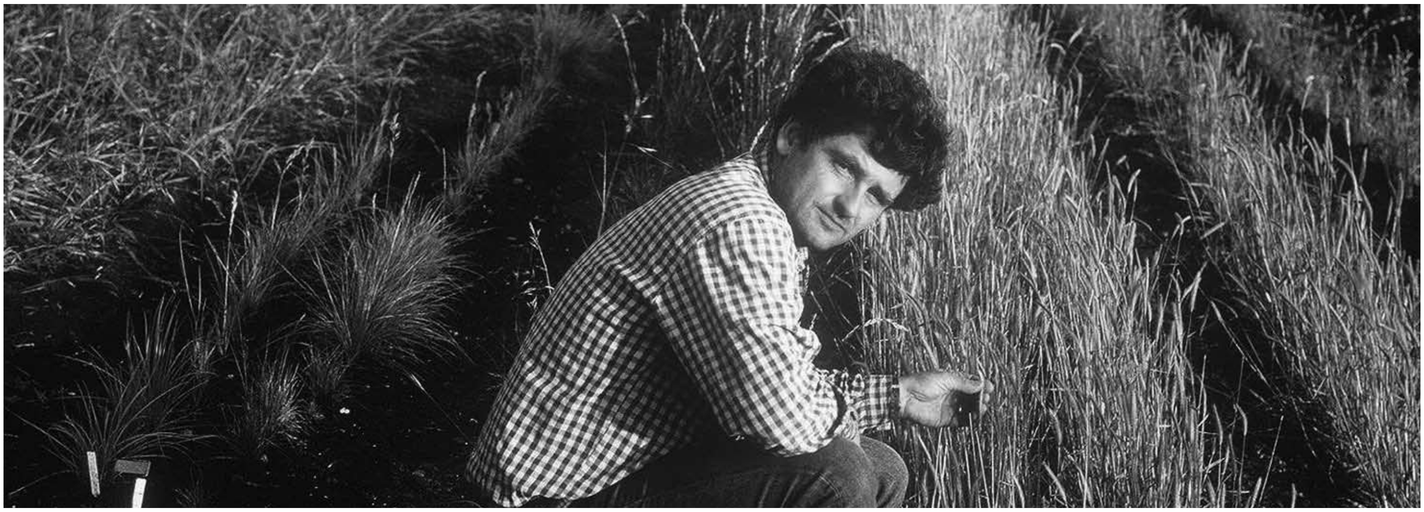


David Amme tending the first native grass R&D garden along the Big Sur coast near Gamboa Point, 1985. *Photo by Paul Kephart.*

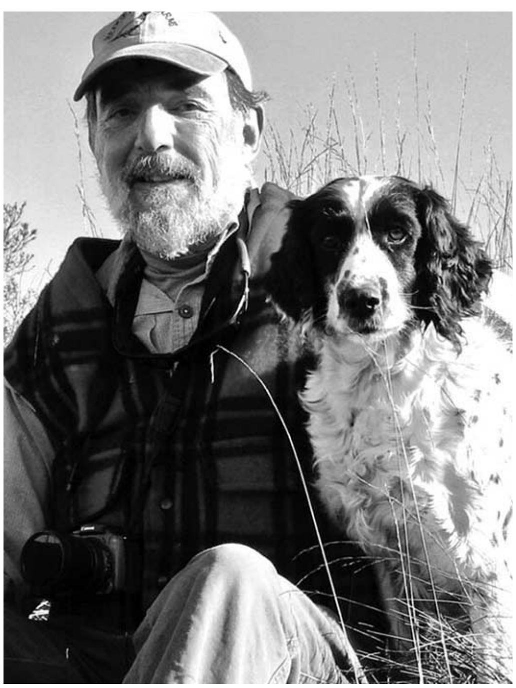
Grass is the Forgiveness of Nature continued

public agencies to see the native grass fields and have a free Bar-B-Q lunch. After the initial years of ever increasing attendance at the ConservaSeed open house, we were all looking around and saying: "We need to start an organization and get things going."

Around this same time, John Anderson, an activist conservationist and veterinarian-turned-farmer in Yolo County, founded Hedgerow Farms and began producing local central California native grass seed and developing sustainable native landscapes and hedgerows. Additionally, Victor Schaff at S&S Seeds began native grass production for Southern California ecotypes on his ranch in Los Alamos.

At first, the California Native Grass Association was focused on identifying, growing, and promoting native grasses. This has gradually expanded into conservation, restoration, management, and preservation of all the native grassland ecosystems of California. In the winter of 2005, CNGA was unanimously changed to the California Native Grasslands Association.

For me, it was an honor to be the catalyst, collector, and explorer for CNGA. It was nice reading what I wrote in April 20 years ago [referring to "Working with Native Perennial Grasses first published in *Grasslands* Vol. 1, Issue 1, April 1991]. We've all come a long way and there is still so much to do.



Note from a CNGA Founder

[Reprint] Grasslands, Volume 21, Number 1, Winter 2011

by John Anderson, CNGA founding member and past President; owner of Hedgerow Farms.

CNGA's contribution to ecosystem restoration and landscaping is real. In the early days when commercial quantities of native seeds were available, it was difficult to get buy-in by public agencies, park and refuge managers, the general public, landscape architects, etc. CNGA became and still is a major catalyst, teaching and promoting the importance and use of native grassland species. Almost all restoration projects now incorporate native grassland species as part of the plant palette. What was an initial vision and struggle has now become an accepted standard. CNGA has played a major role in making this happen. May the next 20 years continue to expand our influence.

A forb seed mix was drill seeded into an established native grass pasture in the fall of 2010. This photo is from a field trip in May of 2012 when the yarrow, California poppy (*Eschscholzia californica*), and purple needlegrass (*Stipa* spp.) were all in bloom. *Photo by Emily Allen.*

VISIT A NATIVE GRASSLAND: *by Sarah Gaffney*[1]

Russell Ranch, UC Davis

The Russell Ranch Grasslands of the UC Davis Putah Creek Riparian Reserve in Davis, CA, are a shining example of successful native grassland restoration. Previously orchards, pasture, and cropland, this 380-acre site was restored to a native grassland as a wildlife habitat mitigation requirement for UC Davis in 2003. The restoration and subsequent adaptive management of these grasslands are worthy of attention, as they exemplify how project success depends on both science and practitioner expertise. Now almost twenty years later, under the management of JP Marié (CNGA President) and Andrew Fulks, the grasslands are filled with native bunchgrasses and showy forbs. Located next to riparian and oak woodlands, these grasslands offer high-quality habitat for many animals, including sensitive wildlife species.

Restoration and Management

The main goal of the mitigation project was to create and maintain a healthy grassland that provides wildlife habitat, particularly for burrowing owl (*Athene cunicularia*), Swainson's hawk (*Buteo swainsoni*), and valley elderberry longhorn beetles (*Desmocerus californicus dimorphus*), all species of special status. The first step to reaching these goals was to prepare the various land types for planting native species. Orchard trees and resident vegetation were removed, and the residual seed bank of the pasture and crop fields were flushed and killed off with herbicide. Next, between 2003 and 2005, native grasses were drill

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[1]Sarah Gaffney is a Ph.D. candidate in Dr. Valerie Eviner's lab at UC Davis. Her research focuses on the role of temporal priority and plant-soil feedbacks in native grassland restoration. She is also a CNGA board member. If you are interested in further detail about management methods, feel free to contact JP Marié (**jpmarie@ucdavis.edu**).

seeded throughout the entire site, with different species mixes chosen for the various soil types. The following years demonstrate how continual weed management often needs to follow native seeding. The first spring, mustard took over and threatened the growth of the new natives. They were mowed down and sprayed with broadleaf herbicide, which allowed the native grasses to come up and get a fighting chance. However, keeping the annual exotic grasses at bay was a recurring challenge. Mowing was opportunely timed to cut off seed heads of annual grasses before the seed's milk stage but not too early that they could regrow more. But the bases of the perennial natives had to be protected, and so mowing had to be kept at a 6-inch cutoff. Another challenge arose with the attempted invasion of the noxious weed medusahead (*Elymus caput-medusae*), a late-season exotic annual grass that forms monocultures and large patches of thick thatch. Managers had to spray the medusahead with herbicide early in the growing season, which slightly affected the native perennial grasses but not enough to cause lasting damage. It took six years of overcoming new challenges and trying new methods to turn agricultural land into a well-established native grassland. The successful management of this native grassland is a testament to the attention and ability of its managers, who constantly spent time in the field observing what was going on in the plant community and adapting their management strategies.

However, grasses are not all that make up a grassland—forbs, or wildflowers, are also essential. Unfortunately, they are harder to restore due to so many species being shade-sensitive. Seeding forbs also means you can no longer use broadleaf herbicide. To increase the efficacy of the last stage of restoration, Marié and Fulks worked with UC Davis professor Truman Young and researcher Ayzik Solomeshch. They devised and implemented an experiment to determine a) which native forb species would establish most successfully, b) the ideal seeding rate, and c) the most effective seeding method (broadcasting; drill seeding after mowing, burning, or light disking). A nearby reference community helped to narrow down species choice for the seeding mixes. Experimental results determined the best seeding rate for the site and suggested that both burning and light disking before drill seeding were the better methods. Light disking is tilling to a depth of 2 inches, which turns under thatch to provide direct seed-to-soil contact but doesn't rip out the base or roots of established grasses. However, native forb seed is very expensive, and only 150 of the 380 acres could be seeded. The solution was to drill seed in large circles of approximately 6 acres, spaced out across the site, and hope that the forbs would naturally spread outwards. Both burning and light disking before drill seeding were implemented in different areas and produced equivalent forb establishment. Each year, the forbs crept further and further from their seeded areas, with yarrow, poppy, and lupine acting as the stars, and now in 2021, most of the grassland is filled with flowers.

Challenges remain, however, in maintaining the native dominance of the grassland. Now that native plant species have established, the goal is to manage biomass and keep the thatch down, while continuing to keep exotic species out. As the site is mandated for Swainson's Hawk forage, the grass needs to be kept at 6 inches. Keeping grass low also helps the forbs, as too much shade and thatch prevents seed germination and seedling success. Managers also found that the native grasses (in particular, creeping wildrye, *Elymus triticoides*) can be choked out by their own thatch if not managed. To manage biomass and thatch appropriately, managers employ a mix of mowing, grazing, and burning. Mowing early in the season is effective, but mowing the entire site is too costly and time-consuming to be the only action. Prescribed burns are also implemented with the help of local fire departments. Other fields are grazed by cattle, but they must be watched and rotated appropriately to ensure they don't graze the grass to the ground. Once that ideal 6-inch height is reached, they are moved from the pasture. The integrated management of these three techniques, which are rotated among fields each year, has proved successful in reaching the biomass management goals.

Plants & Wildlife

What do the grasslands look like now 18 years after the initial restoration? Closer to the riparian woodland, you'll see creeping wildrye (*Elymus triticoides*) in the wetter areas, bordered by a mix of blue wildrye (*Elymus glaucus*) and meadow barley (*Hordeum brachyantherum*). As you go into the center of the grasslands, you'll find purple needlegrass (*Stipa pulchra*) dominates, though nodding needlegrass (*S. cernua*), squirreltail (*E. multisetus*), California mellic (*Melica californica*), bluegrass (*Poa secunda*), and three-week fescue (*Festuca microstachys*) also dot the landscape. If you come in the spring and early summer, you'll see scattered among the grass abundant yarrow (*Achillea millefolium*), poppy (*Eschscholzia californica*), and lupine (*Lupinus bicolor, nanus, succulentus*). Though not as common, you can find redmaids, (*Calandrinia ciliata*), lotus (*Acmipson americanus*), gum plant (*Grindelia camporum*), common madia (*Madia elegans*), and clover (*Trifolium bifidum, gracilentum, microcephalum, willdenovii*).

These grasslands are now high-quality habitat for many animals. Elderberry shrubs, which are a necessary food source for the threatened valley elderberry longhorn beetle, are successfully established on the grassland borders. However, due to the beetle's elusive nature, they have not been confirmed on the site.

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While burrowing owls have not yet formed nesting colonies in the grasslands, they do visit the site occasionally. Interestingly, the burrowing owls avoid the man-made burrows and only use old ground squirrel tunnels. The ground squirrels were kept off the land prior to the restoration with poison, and so a key restoration act was to allow them to re-establish so they could provide habitat for the burrowing owl. Swainson's hawk is now a common sight, foraging extensively in the grasslands and nesting in the nearby riparian trees. Other raptors, such as northern harrier (*Circus hudsonius*), white-tailed kite (*Elanus leucurus*), and American kestrel (*Falco sparverius*) can also be seen. Meadowlarks (*Sturnella neglecta*), which are considered an excellent bioindicator of a healthy grassland, are often seen flying around as well. Perhaps the most exciting proof of the grassland's success is the return of the grasshopper sparrow (*Ammodramus savannarum*), which was previously made rare in Yolo County from habitat loss and land conversion.

Due to continuous and adaptive management and collaboration with local researchers, what used to be agricultural land is now a healthy native grassland teeming with wildlife. You can visit the grasslands along County Road 95A as you turn south off Russell Blvd (38.5433, -121.8539). There are several pullouts along the road to park. Due to its mitigation status, there is no trail system or public access, but roadside viewing still brings you close enough to see the grassland's beauty. The pullouts are also great for birding— come visit and you can join the many birders that frequent the site in the early morning.

Purple needlegrass (*Stipa pulchra*) dominates a corner of Russell Ranch that was restored to native perennials. May 2012.
Photo by Emily Allen.

Sacramento River NWR, La Barranca Unit, Tehama County: California poppy (*Eschscholzia californica*) , coastal tidytips (*Layia platyglossa*), and great valley gumweed (*Grindelia camporum*) seeds drilled with purple needlegrass (*Stipa pulchra*) seeds. April 2018. *Photo by Joe Silveira, USFWS.*

Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River National Wildlife Refuge

by Joe Silveira, U.S. Fish & Wildlife Service, Sacramento River National Wildlife Refuge, Wildlife Refuge Manager, retired

Abstract

Sacramento River National Wildlife Refuge (the refuge) was established to protect and restore riparian and floodplain habitats for endangered species, migratory birds, and to provide opportunities for wildlife-oriented public use. The Nature Conservancy and River Partners lead habitat restoration efforts converting flood-damaged agricultural lands to riparian and floodplain habitats. They provide cuttings and seeds of only local ecotypes to Floral Native Plant Nursery and Hedgerow Farms for commercial production and use at the refuge. The initial focus on restoring woody plant taxa resulted in documented successes measured by plant survival and wildlife use. We use local ecotypes for native grass and wildflower restoration, but due to a lack of source plant species and expense, some non-local ecotypes are also used, and concerning wildflowers, only for species that do not occur on the Sacramento River floodplain. Due to the simplicity of weed control, pure patches of native grass are relatively easy to restore. Native spring and summer wildflowers present challenges to habitat restoration because we often seed them with native grass, which limits broadleaf weed control. The greatest challenge with native wildflower restoration is long-term survival. Initial germination and first-year survival of non-local spring wildflowers, such as California poppy (*Eschscholzia californica*) and coastal tidytips (*Layia platyglossa*), often appear as super-blooms but shrink to small, scattered patches after a few years. The Yolo Bypass Ecotype of great valley gumweed (*Grindelia camporum*) was seeded at two restoration sites and has since disappeared, while the Sacramento River La Barranca Ecotype shows long-term survival and patch size increases at nearly all refuge floodplain restoration sites. Possible explanations for poor survival of non-local ecotypes include unsuitable soil texture and chemistry, seed burial with flood deposits, inundation, and mismatched pollinator timing. Research is needed to address these questions. Local ecotypes are adapted to the restoration sites physical conditions enhancing germination and survival, while flower phenology matches pollinator timing, which is necessary for long-term recruitment. The use of local ecotypes ensures conservation of undiscovered cryptic diversity and preserves native plant evolutionary lineages. The very nature of these lineages, surviving through time, is an indication of the potential for adaptations to climate change. For these reasons, we continue to use local ecotypes, to the fullest extent possible, at refuge restoration sites.

Keywords: *Sacramento River National Wildlife Refuge, middle Sacramento River riparian and floodplain habitat restoration, California native perennial grasses, California spring and summer wildflowers, local ecotypes, cryptic native plant diversity, evolutionary lineages, climate change.*

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

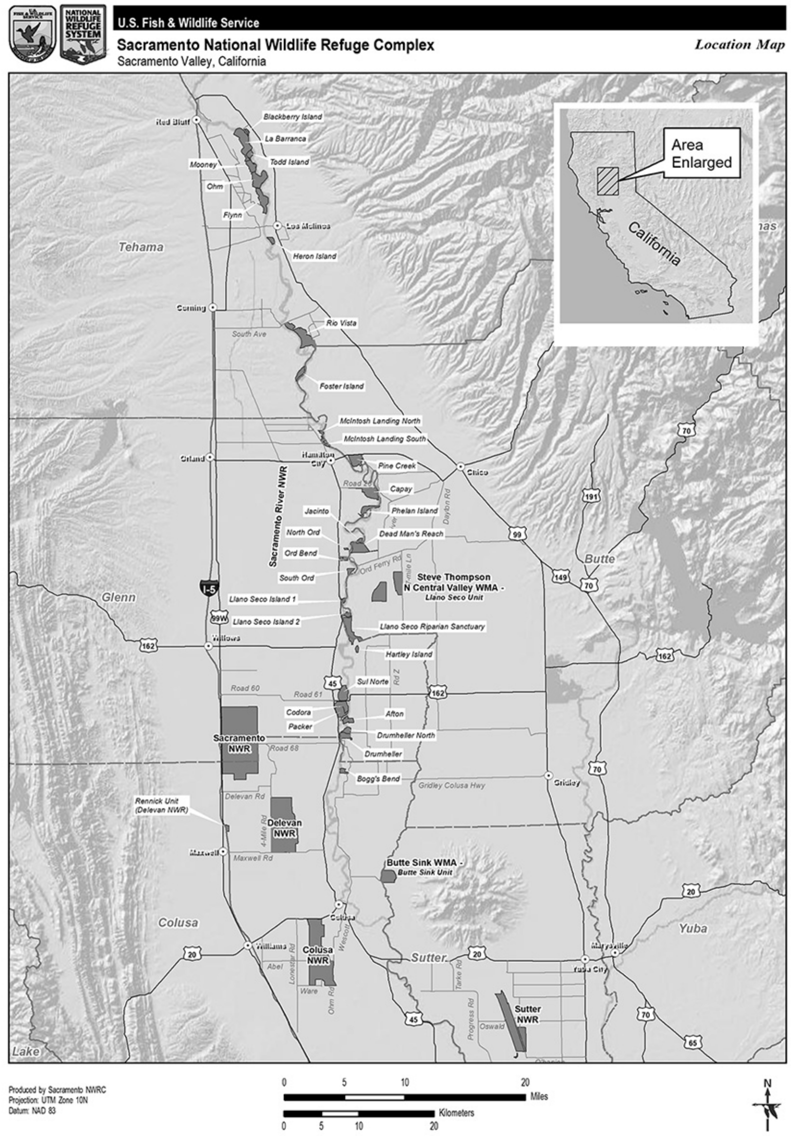

Figure 1. Sacramento National Wildlife Refuge Complex and vicinity.

Sacramento River National Wildlife Refuge background

Sacramento River National Wildlife Refuge (the refuge) was established in 1989 to protect and restore habitats for endangered and threatened species, migratory birds, and other native wildlife, and to restore floodplain wetlands. This 10,353–acre refuge occurs in the 100–year floodplain, along 81 river miles, from Red Bluff to Princeton, within the 100-mile "middle Sacramento River reach," Hwy 36, Red Bluff to Hwy 20, Colusa, (Figure 1). Fluvial geomorphic processes—overbank flooding, erosion, sediment deposition, and lateral bank movement—that are necessary for long-term ecosystem health, including native plant succession, characterize this reach. Unfortunately, federal and State flood agencies and private landowners have installed over 50 miles of revetment, or rock and rubble armored banks. This part of the floodplain is prone to frequent flooding, bank collapse, and river channel meander, which hinders commercial orchard operations, but has been heavily cultivated to walnut, prune, and almond orchards during dry periods in the 1970s and beyond.

The Sacramento River National Wildlife Refuge Comprehensive Conservation Plan (CCP) was completed in 2005. It identified Goals for Wildlife and Habitat, Public Use, Resource Protection, and Partnerships (USFWS 2005). Each goal has multiple objectives and includes measurable strategies for its implementation. Habitat restoration is accomplished with considerations, through surveys and investigations, for regional and site landscape ecology including hydrology, topography, geology, soils, and local native plant materials (Silveira et al. 2003, USFWS 2005). Ultimately, the Wildlife and Habitat Goal aims to restore functional habitat to aid in the recovery of threatened and endangered species and to provide an abundance of migratory and resident wildlife and native plants. Proximally, this was going to be a horticultural enterprise, of trial and error, using monitoring and research to inform and guide biologists and managers to adapt restoration strategies and techniques to the dynamic floodplain ecosystem.

Riparian and floodplain vegetation and habitat restoration overview

Woody plants

The refuge began collaborating with The Nature Conservancy (TNC) in 1989 and River Partners in 1999 to acquire and remove flood-prone orchards for floodplain restoration. We (the refuge, TNC, River Partners) immediately began developing partnerships for funding acquisition, restoration, monitoring, research, and public outreach. Restoration of trees, shrubs, and vines (woody plants) began in 1989. At this time, there were no useful guides on how to proceed, so regional and site elements of landscape ecology were identified through surveys, resulting in the use of local ecotypes of native woody species.

TNC and River Partners collect cuttings, seeds, and acorns primarily for Floral Native Plant Nursery in Chico and the California State University (CSU), Chico Farm, to propagate for use at the refuge. We develop plant communities for restoration based on those described by Holland (1986) because we find the list of species and associated physical site descriptions for plant communities a useful guide for the remnant natural vegetation, topography, and hydrology we observe adjacent to our restoration sites. We were not sure how the restoration would perform when we began in 1989, but by using local ecotypes we assumed that the restoration stock that survived was appropriate for the local site and for natural diversity conservation.

All seedlings are irrigated using drip tape for three years. Complete weed control is done for three or four years. This includes herbicide

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

weed suppression on the berms the seedlings, protected by milk cartons, are planted in, and the large 18– to 36–foot wide strips separating the berms, where native grasses and wildflowers will be drilled, typically in the fall of the third or fourth growing season.

Native grasses and wildflowers

We began planting native grasses in the understory, and within large openings and light-gaps in 1999. The primary objectives were to improve native plant species composition and vegetation structure, to displace invasive non-native plants, and to provide wildlife with breeding and concealment habitats. It was also important for our planting designs to allow flood flows to pass without impacting State planned flood control levees and other flood conveyance structures. Two-dimensional flow modeling is used to strategically locate areas for grasslands within the forests to decrease roughness so that flood neutrality (i.e., flood elevations relative to levee height) is maintained with our restoration planting designs.

Wildflower restoration began in earnest in 2009. The objectives were to increase native plant diversity and ecosystem functions, including providing breeding habitat and nectar sources for the monarch butterfly and other flower visitors. This seemed especially important in light of declining bee and butterfly populations, necessary to sustain the unique and vast natural diversity of the California Floristic Province.

Local ecotypes of native grasses and wildflowers

We were very interested in using local ecotypes of native perennial grasses and spring and summer active wildflowers because of the success we experienced using local ecotypes of woody species. However, extensive seed sources for local ecotypes did not exist when we began restoring native grasses in 1999 and wildflowers in 2009, and are yet to be commercially available. The costs for an extensive seed collection for a narrow range of target restoration locations would be very high. We were fortunate to work with John Anderson at Hedgerow Farms who was willing to contract to grow ¼-acre (or less) sized plots to satisfy some of our needs of producing highly localized seed stock. Ideally, this stock would come from various locations at the refuge.

The CCP includes native plant conservation strategies aimed at conserving naturally occurring populations of local wildflowers. Accordingly, we identified native plant reference sites and set targets for restoration using these native plant taxa. These sites serve as source populations for seed collection and wildflower propagation at Hedgerow Farms, and TNC and River Partners facilities. Most of the wildflower reference sites at the refuge are located where gravel is at or near the surface and where grasses and non-native weeds grow very poorly, or not at all. We also identified reference sites of native grasses and sedges, some near seasonally flowing sloughs, and also on coarse-textured soil mounds. We located two "Great Valley Floodplain Meadow" sites, one at the Steve Thompson North Central Valley Wildlife Management Area, the other located at Colusa NWR (Figure 1); the only other is located at San Joaquin River NWR. TNC, River Partners, and refuge biologists and field crews collect seeds of local wildflowers to provide Hedgerow Farms stock seeds for their seed production fields and nursery stock, which we can later purchase when restoration projects arise. TNC and River Partners also collect, clean, and store seeds for direct seeding at the refuge restoration projects.

We still need to augment our truly local seeds sources with non-local sources. However, in all cases concerning spring and summer wildflowers, the use of non-local taxa is now limited to species that either do not occur or no longer occur, on the middle Sacramento River floodplain. This is done to prevent genetic seed contamination to local ecotypes.

Native sedge and grass restoration and management

Taxa and strategies

Hedgerow Farms provides the grass species (and at one time, but no longer, the sedge species) we use for floodplain grassland restoration at Sacramento River NWR. These species are indigenous to the middle

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Table 1. Selected native perennial grass and sedge taxa used for seedling plugs (plug transplant or plug plant) at Sacramento River National Wildlife Refuge.

Species	*Common name*	*Ecotype Location*
Carex barbarae	Santa Barbara sedge, basket sedge, white root sedge	Yolo County (Yolo Bypass)
Carex praegracilis	Clustered field sedge	Yolo County (Yolo Bypass)
Elymus triticoides	Beardless ryegrass, creeping rye-grass, alkali rye-grass	Yolo County (Yolo Bypass)

Table 2. Native perennial grass taxa used for seed drilling at Sacramento River National Wildlife Refuge.

Species	*Common name*	*Ecotype Location*
Elymus glaucus	Blue wildrye	Butte County (Parrott=Llano Seco)
Elymus triticoides	Beardless ryegrass, creeping ryegrass, alkali ryegrass	Yolo County (Yolo Bypass)
Hordeum brachyantherum	Meadow barley	Solano County (Yolo Bypass, Glide Ranch)
Stipa pulchra	Purple needlegrass	Butte County (Llano Seco-Angle Slough)

Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

Sacramento River, but no local sources have become commercially available since we began grass restoration in 1999, so we use "downstream" non-local ecotypes of rhizomatous graminoids (Table 1). Seedlings are plugged in rows alongside woody plants where drip tape is used for irrigation. The rows are spaced 18–ft to 36–ft apart—these gaps will become the forest floor.

Hedgerow Farms also provides the native grass seed we use for seed drilling in the large row gaps, floodplain grasslands, and light gaps. These plants are also indigenous to the Sacramento River floodplain and some local sources are available and used for restoration projects (Table 2). Plugging beardless ryegrass (*Elymus triticoides*) seedlings was abandoned once we began large-scale seed drilling on the floodplain.

Restoration weed control and seeding strategies

Before planting, soils are prepared and weeds are controlled for a minimum of two years, more typically three years and up to four years if necessary. After orchard trees are removed, the ground is very uneven, so the surface is smoothed using a float (a small implement pulled by a tractor). We do not alter the grade of the topography to make it more level, as is the case with landplaning. We only need to remove the bumps and fill the holes to accommodate restoration activities, such as ATV boom spray herbicide applications and Truax Range Drill seeding. Afterward, herbicides are applied to remove any invasive plant species which germinate at the site. Most importantly, once herbicide weed control begins, we do not disturb the soil surface with tillage or floating because this would bring invasive plant seeds up from the soil seed bank into their germination zone. The golden rule for a successful native grass restoration: remove invasive plant seeds from above and below! The most important herbicide treatments occur just prior to native grass seed drilling in early fall, and as soon as possible after broadleaf weed germination in late winter, when agricultural regulations, native grass seedling stature, and field conditions are favorable. This strategy maximizes seedling growth and survival by reducing that first season's non-native plant competition.

The seeding rate we use is variable (10 to 20 lbs/ac), higher for purple needlegrass (*Stipa pulchra*) and blue wildrye (*Elymus glaucus*), lower for beardless ryegrass (*Elymus triticoides*) (mostly due to seed costs), and lower still for meadow barley (*Hordeum brachyantherum*), which disappears on the summer dry floodplain, but is a vital plant, key to seed-production-field-like results because it germinates early enough to outgrow any non-native annual grasses that remain at the site. Then, as the meadow barley goes into dormancy, blue wildrye fills in the restoration site, further suppressing the nonnative annual grasses.

Long-term management strategies

Because the Sacramento River is located in the lower portion of the floodplain, flooding is frequent, in normal to wet years, resulting in strong growth, especially for beardless ryegrass. Therefore, without management after planting, perennial grasses become dominated by standing dead material and build dense thatch, with the exception of purple needlegrass.

Prescribed grazing is the preferred option for controlling thatch in floodplain forests, which are often dominated by non-fire adapted trees, shrubs, and vines. Few woody plants, other than valley oak (*Quercus lobata*) and blue elderberry (*Sambucus nigra* ssp. *caerulea*), recover from moderate, non-crowning fires. Cattle are the preferred livestock at the refuge because they remove both annual nonnative grasses and native perennial grass thatch. They graze annual grasses down to a height of 4–cm to 8–cm, and perennial grasses as low as 20–cm, including the standing dead blades. Cattle are also heavy enough to trample dense thatch buildup and their manure, with the aid of soil biota, helps incorporate organic material into the soil. We also use sheep and goats, which are preferred livestock to remove non-native broadleaf weeds at any height. They are not as effective as cattle in removing standing dead material and thatch from native perennial grasses. Sheep require broadleaf plants to maintain nutrition and blood protein, so we discontinued their use in areas dominated by native grasses. We found the best use of goats to be for constructing firebreaks in the Wildland Urban Interface. Goats are also useful for controlling tough, coarse, woody, and spiny broadleaf weeds. Sheep and goats must be used with extra caution and care because they devour native wildflowers.

Prescribed burning is used in floodplain grasslands and in large native grass openings where fire-sensitive woody species can be protected with firebreaks. Burning is also done in valley oak woodland and savanna. Like grazing, burning is used to remove dead growth and restore vigor and vertical stature.

Spot herbicide treatments can be accomplished in areas where established tall perennial grasses are reduced in height by grazing or burning, giving access to the broadleaf weeds typically concealed by tall grasses. The abundant thatch generated by beardless ryegrass will eventually lie flat, forming dense mats, which tend to open in seams where weeds germinate and then invade the restoration site. If this occurs, the remedy we use is a prescribed fire to remove all of the thatch, followed by spot herbicide treatments where the broadleaf weeds remain or recover.

Native wildflower restoration and management

Taxa and strategies

Wildflower seeds used for plugging are collected and cleaned by TNC and River Partners staff and sent to Floral Native Plant Nursery in Chico where the seedlings are grown. All plant species are local ecotypes collected from Sacramento River NWR (Table 3).

Hedgerow Farms provides native wildflower seeds for Sacramento River NWR wildflower restoration projects. Spring wildflowers are rare on the Sacramento River floodplain, due to the commercial orchard conversions, within the 100-year floodplain from the late

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

1960s into the 1970s. Therefore, for a few species, we have opted for using non-local source species, which are also available from Hedgerow Farms (Table 4). Most importantly, they will not cross-pollinate and contaminate any local sources.

Summer wildflowers do occur on the Sacramento River floodplain, including the refuge, and field staff from TNC and River Partners collect and clean seeds for our own restoration needs, as well as for Hedgerow Farms to use for seed production (Table 4).

Restoration weed control and seeding strategies

The restoration site must be as free of broadleaf weeds as possible. There are limited options for widespread herbicide weed control after wildflower germination. As with the native perennial grasses, weeds are controlled for two to three or four years prior to seeding. To prevent weed seeds from entering the germination zone from the soil seed bank, the ground is not tilled, floated, or disturbed once herbicide weed control begins.

The seeding rate we use is variable (1½ to 6 lbs/ac). Low rates for coastal tidytips (*Layia platyglossa*) and slightly higher rates for California poppy (*Eschscholzia californica*) result in super-blooms in the first two years after seed drilling. Higher rates are used for great valley gumweed (*Grindelia camporum*) mainly due to its relatively low cost.

We have used various strategies for drilling native wildflower seeds in several field settings. These include (1) drilling wildflower seeds over recent and just-established native grasses, which have been mowed very short; (2) drilling into areas prepared for native wildflowers only, most often in areas with gravel at or near the surface where annual grass and broadleaf weeds are absent or sparse; and (3) drilling native wildflower seed along with purple needlegrass seed, but in separate drill bays. Overall, purple needlegrass seems the most suitable perennial grass to include with wildflowers because it grows in bunches, leaving spaces for the wildflowers to grow. Compare this growth habit with the rhizomatous growth habit of beardless ryegrass, which after flooding and sedimentation will dominate the site. However, this dense growing behavior provides excellent weed control, since few and small spaces are available for invasions.

Long-term management strategies

Without management, weedy annual grasses and invasive broadleaf weeds can invade a wildflower restoration site. Because the Sacramento River is located in the lower portion of the floodplain, flooding is frequent, especially in normal to wet years. Flooding can bring in non-native weed seeds.

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Table 3. Selected native summer wildflower taxa used for seedling plugs (plug transplant or plug plant) at Sacramento River National Wildlife Refuge.

Species	*Common name*	*Ecotype Location*
Artemisia douglasiana	Mugwort	Sacramento River
Euthamia occidentalis	Western goldenrod	Sacramento River
Oenothera elata ssp. *hirsutissima*	Hairy evening primrose	Tehama County (Sacramento River-Flynn)
Urtica dioica	Stinging nettle	Sacramento River

Table 4. Selected native wildflower taxa used for seed drilling at Sacramento River National Wildlife Refuge.

Species	*Common name*	*Ecotype Location*
SPRING ACTIVE WILDFLOWERS		
Eschscholzia californica	California poppy	Colusa County (Lodoga Hills)
Layia platyglossa	Coastal tidytips	Colusa County (Bear Valley Road)
Lupinus nanus	Sky lupine	Butte County (Sacramento River-Pine Creek)
Lupinus succulentus	Succulent lupine	Butte County (Llano Seco-Vermet)
SUMMER ACTIVE WILDFLOWERS		
Asclepias speciosa	Showy milkweed	Butte County (Llano Seco)
Centromadia fitchii	Fitch's spikeweed	Tehama County (Sacramento River-La Barranca, Ohm)
Eriogonum nudum	Naked buckwheat	Tehama County (Sacramento River-La Barranca)
Eriogonum wrightii	Wright's buckwheat	Tehama County (Sacramento River-La Barranca)
Grindelia camporum	Great Valley gumweed	Tehama County (Sacramento River-La Barranca)
Heterotheca grandiflora	Telegraphweed	Tehama County (Sacramento River-La Barranca, Ohm); Butte County (Sacramento River-Pine Creek)
Heterotheca oregona	Oregon golden aster	Tehama County (Sacramento River-La Barranca, Ohm)
Oenothera elata ssp. *hirsutissima*	Hairy evening primrose	Tehama County (Sacramento River-Flynn)
Madia elegans	Elegant tarweed	Tehama County (Sacramento River-Rio Vista)
Trichostema lanceolatum	Vinegarweed	Glenn County (Stony Creek near confluence with Sacramento River)

Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

Flooding also deposits sediments forming layers composed mostly of silts, sands, and gravels, and aggregations of these. With repeated flooding, gravel is buried deeper in the soil-forming strata, which alters conditions for plant survival and colonization. Sediments bury seeds of native wildflowers and increase the soil strata over gravel, with few exceptions, improving conditions for nonnative invasive plants. Gravel, sand, or silt deposits at the surface can also improve conditions for native plants— sky lupine (*Lupinus nanus*) often colonizes fresh sandy hillock-forming deposits. Telegraph weed (*Heterotheca grandiflora*) also spreads into sandy flood deposits, while mugwort (*Artemisia douglasiana*) often colonizes deposits with silty components.

Prescribed cattle grazing is the best tool to enhance wildflower habitat by reducing non-native annual grasses and the stature of native perennial grasses. This is not surprising, since some of the best places to visit California Great Valley spring wildflowers and summer tarweeds are cattle-grazed annual grasslands.

Prescribed burning is used in floodplain grasslands and in large native grass openings where wildflowers have been planted. However, wildflowers eventually become crowded by the native perennial grasses, especially beardless ryegrass, which grows vigorously after a burn (and flooding).

Spot herbicide treatments are not practical where weeds mix with wildflowers, which is most often the case. Small areas completely invaded by dense, tall weeds can be mowed, spot-treated with herbicide, and reseeded.

Monitoring and research results for woody and herbaceous seedlings planted on berms and under irrigation.

We monitor all species planted as seedlings under irrigation at restoration sites by conducting a complete census of surviving plants. Though survival often exceeds 90 percent, dead plants are replaced until a minimum of 80 percent survival is met after three years of restoration management. Furthermore, with interest from many individuals and various universities, federal and State government agencies, and private nonprofit organizations, multiple abiotic and biotic monitoring and research projects were conducted at refuge restoration sites and adjacent remnant habitat patches (~ 81 projects in 25 years). The science provided a convincing story of "build it and they will come." Wildlife diversity quickly increased at our floodplain restoration sites matching that of the adjacent remnant habitats, and also showing a spillover synergistic effect of increasing diversity at the remnant sites (Golet et al 2008). Increasing habitat patch size and connectivity through re-vegetation was highly successful. We learned that after three years of irrigation and intensive weed control, where the soil profile allows roots access to the river-flow-influenced water table, these woody transplants flourished on their own! We learned that floodplain elevation and location of gravel lenses in the mixed alluvium are key for the various woody plant species, each with specific root depth to water requirements, and gravel preventing root penetration to water (depth to gravel here is referred to as the depth to refusal). Restoring physical processes is necessary for the long-term health of the middle Sacramento River alluvial ecosystem, yet this is greatly lacking and will require federal and State flood agency policy development and local project approval (see Golet et al 2013).

Observations of long-term survival of native sedge and grass restoration

Meadow barley is used to outcompete any residual annual grasses that germinate at the site in the first season after drilling. It grows as fast as non-native annuals and overtops them. It goes dormant earlier than other native perennial grasses, then rapidly decreases and eventually

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

disappears on the summer dry floodplain, unless growing next to summer-wet areas.

Blue wildrye dominates later in the first season after meadow barley begins dormancy. Blue wildrye can dominate restoration sites for several years, often giving way to beardless ryegrass. It does not tolerate disturbance (i.e., fire, grazing, flooding) unlike beardless ryegrass and purple needlegrass.

Beardless ryegrass dominates at floodplain restoration sites after a major flood event. It also responds well to prescribed grazing and fire, even producing green shoots in July after early summer burns. In the absence of burning or grazing, the hydraulic forces of flooding remove heavy thatch buildup.

Purple needlegrass responds well with annual prescribed grazing and periodic prescribed burns. Early fall through late winter grazing shows great results for increasing vigor in purple needlegrass and beardless ryegrass because the grasses recover vertical structure with new growth just after winter and spring rains, going into the summer dry season with a robust stature that reduces spaces for summer active invasive plant species to germinate and grow while enhancing wildlife nesting structure and concealment cover.

Observations of long-term survival of native wildflower restoration

Great valley gumweed

Collections of great valley gumweed for seed production at Hedgerow Farms have occurred in two distinct regions of the Northern Sacramento Valley at Sacramento NWR Complex: the Sacramento River floodplain in mixed alluvium in mostly sandy soils with silt and gravel at Sacramento River NWR La Barranca Unit (Figure 1); and, the Colusa Basin in mostly saline-alkali clay soils at Sacramento NWR (SAC), Delevan NWR (DEL), and Colusa NWR (COL) (Figure 1). It is important to note that the southwest corner of COL is located on the Stony Creek Fan, so the soils are not saline-alkali as in the Colusa Basin. Interestingly, John Anderson noticed two phenotypic expressions of size and color at Hedgerow Farms seed production plots comprising the aggregated SAC-DEL-COL collections.

We use the La Barranca Ecotype for Sacramento River floodplain restoration projects and the aggregated SAC-DEL-COL Ecotype for projects in the Colusa Basin. However, before the La Barranca Ecotype became available from Hedgerow Farms, we tried their Yolo Bypass Ecotype at Sacramento River NWR Rio Vista Unit and Drumheller Unit (Figure 1). We exclusively used the La Barranca Ecotype for subsequent restoration projects at various units of Sacramento River NWR (La Barranca, Rio Vista, McIntosh Landing South, Pine Creek, Capay, Ord Bend, Deadman's Reach, Sul Norte, Codura, and Llano Seco) along 81 river miles (Figure 1).

Sacramento River NWR, Rio Vista Unit, Tehama County: California poppy (*Eschscholzia californica*), sky lupine (*Lupinus nanus*) , coastal tidytips (*Layia platyglossa*), and great valley gumweed (*Grindelia camporum*) seeds drilled with purple needlegrass (*Stipa pulchra*) seeds over buried gravel. April 2018. *Photo by Luis Ojeda, TNC.*

Over a period of eight years, the Yolo Bypass Ecotype completely disappeared from Rio Vista Unit and Drumheller Unit locations. Over this same period, the La Barranca Ecotype has steadily increased, dominating several sites at these refuge units. All sites, except Ord Bend Unit, have flooded twice during that period. Is the great valley gumweed La Barranca Ecotype adapted to middle Sacramento River flooding and sedimentation? This is an intriguing research question—a seemingly drought-tolerant plant adapted to periodic flooding and sedimentation.

River Partners used San Joaquin River Ecotype of great valley gumweed at two contrasting restoration sites. The source for this ecotype grows in mixed alluvium—protected from flooding by levees—and, when planted at San Joaquin River NWR in the same mixed alluvium, grows densely, covering that refuge with plants nearly 2-m tall. The Barney Flynn Del Rio Preserve occurs next to and just east of the Sacramento River, on an uplifted feature of the upper Butte Basin characterized by clay loam soils, which only rarely floods at the low eastern margin near Angel Slough. After seeding with the San Joaquin Ecotype (except at the low eastern margin), dense, but shorter 0.6-m to 0.8-m plants covered the preserve. However, the great valley gumweed did not survive at the preserve. Flooding and sedimentation are not issues at San Joaquin River NWR or the Del Rio Preserve. Does soil texture and chemistry, and landscape position proximity to the water table affect long-term survival? What about pollinator mismatches with ecotype flowering periods? These observations of restoration site natural history raise important research questions.

California poppy

We use the California poppy Colusa County Lodago Hills Ecotype because the Sacramento River floodplain lacks spring annual wildflowers and this species is absent. In the first two springs after seed drilling, these sites appear as super-blooms that cover the restoration site in a dense orange flowery carpet. The plants appear to do well but have decreased to small patches over time. Is this a result of seed burial

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

from overbank flooding and sediment deposition? Is there a problem with pollination? California poppy seems to have a long flowering period, some individuals flowering into fall, yet this is not adaptive if pollinators are scarce.

Coastal tidytips

We also use the coastal tidytips Colusa County Bear Valley Road Ecotype. Very low seeding rates produce amazing super-blooms. However, at most sites, they decline every year, until only a few individuals persist. The same questions arise, as with the great valley gumweed, of seed burial from sediment deposition and pollinator mismatch.

Benefits of using local ecotypes for habitat restoration

There are many practical and far-reaching benefits to using local ecotypes for habitat restoration aiming to increase habitat patch size and connectivity for native plant and wildlife population increases. These include:

Restoration Success—Local plant taxa are adapted to the restoration site soils, topography, hydrology, and climate; their use in restoration is the best approach for successful plant germination and survival.

Pollinator Timing Matchup—Flowering phenology is matched with that of the pollinators, further increasing chances for long-term recruitment and survival.

Adaptations of Edaphic Ecotypes—Edaphic ecotypes show great affinities for soil, topography, and hydrology; as such, they are great indicators and are highly valued for use in plant and wildlife habitat restoration, especially important in California with its highly diverse, locally variable, and often site-specific physical geography.

Conservation of Natural Cryptic Diversity & Native Plant Evolutionary Lineages—Preserving irreplaceable undiscovered natural diversity and evolutionary processes, which have developed over unimaginable periods, from genetic contamination and swamping allows for scientific investigations of cryptic taxa, which will ultimately inform and enhance habitat restoration and other conservation efforts.

Climate Change Adaptations—Current plant taxa have survived the last mega drought, sometimes referred to as the Medieval Warming Period; climate change is inevitable and ever occurring, so today's adaptations may be valuable for future climates. We must imagine and develop extremely long-term conservation priorities, a difficult task for most human societies.

For the reasons noted above, local ecotypes increase Ecosystem Health and enhance Biological Integrity at all scales—the landscape, ecosystem, and community; the population; the evolutionary unit.

Should we try smooth tidytips (*Layia chrysanthemoides*), which are noted as occurring on stream floodplains? The Colusa County Bear Valley Ecotype may be available from Hedgerow Farms. However, Bear Valley soils are unique and much different than the Sacramento River fluvial geomorphic-derived mixed alluvium. Bear Valley geology is tectonic with serpentine parent material.

An interesting observation about the elegant tarweed (*Madia elegans*) source population at Sacramento River NWR Rio Vista Unit follows. I recall taking John Anderson to the site, which I had just discovered in 2013. It was just above the river cut-bank, with plants growing on each side of a frequently traveled gravel service road. There were around 10 plants present in an isolated population. I wondered out loud how the plants colonized the site. Then, John commented on how finches eat and spread *Madia* seeds. That tarweed is happy at the Rio Vista site, and the population is growing healthy plants. A concept in plant ecology applies here: by chance and with the right conditions, plant life will colonize and flourish. The lesson here is to protect and conserve these important natural native plant nurseries.

Why use local ecotypes

Restoration success is critical to achieving the objectives of the Wildlife and Habitat Goal of the Sacramento River NWR CCP (USFWS 2005). Objectives for floodplain vegetation restoration have been achieved by predominantly using cuttings, acorns, and seeds of local ecotypes of native trees, shrubs, vines, perennial grasses, and spring and summer active wildflowers. Plantlife is flourishing, creating plant communities with vegetative structures, which support an abundance of migratory and resident wildlife. Visitation has also increased steadily since opening the refuge for wildlife-oriented, or Big 6 public uses (hunting, fishing, wildlife photography, wildlife observation, environmental education, and interpretation) and it often tops all other refuges of the Sacramento National Wildlife Refuge Complex (Figure 1).

We use local ecotypes to achieve restoration success; of course, long-term vegetation management plays a critical role. Local ecotypes have adapted to local abiotic conditions, including soil texture and chemistry; topography and hydrology (inundation period, frequency, and intensity); and hydrogeology. They include edaphic endemics, which show good stress tolerance for hydrology and soil chemistry, making great indicators, for example, of topographic position and salinity and alkalinity. Palmate-bracted bird's-beak (*Cordylanthus palmatus* = *Chloropyron palmatum*) is a federal and state endangered species known only from saline/alkali clay soils and is extant at five geographic areas: Delevan NWR (east of Maxwell), Colusa NWR (west of Colusa), Woodland Regional Park (southeast of Woodland), Alkali Sink Ecological Reserve and Mendota Wildlife Area (southeast of Mendota), and Springtown alkali sink and Alkali Wetlands Preserve (near Livermore). Molecular research splits the Delevan NWR and Colusa NWR geographic populations into two subpopulations for

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

each refuge. Topography may define these subpopulations as subtle topographic differences across these alkali meadows and flats that influence hydrology and salinity/alkalinity. Conducting stressor trials for these variables on palmate-bracted bird's-beak would determine this and provide invaluable data and information for reintroductions at Sacramento NWR, Delevan NWR, and Colusa NWR.

Local ecotypes may have specific narrow biotic affinities and connections for mycorrhizal fungi, maybe plant parasites (e.g., palmate-bracted bird's-beak is a hemiparasite), or stage vital plant-animal interactions. For example, we use only local blue elderberry (*Sambucus nigra* ssp. *caerulea*) because it is the host plant for valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), a federal and state endangered species and Central Valley endemic. Valley elderberry longhorn beetle has colonized our floodplain restoration sites, thus we are assisting with the recovery of this species. Nearly all our local blue elderberry populations are subjected to periodic flooding, while other Central Valley populations occur in areas of different geology and soils, at drier locations, or locations with cooler or warmer temperatures.

Local ecotypes may have special pollination requirements, such as pollinator timing and specific species. Accordingly, local ecotypes may also be important for the long-term conservation of bees, butterflies, and other flower visitors, many of which are suffering population declines, such as the much-admired monarch butterfly.

Ultimately, we use local ecotypes for the conservation of natural cryptic diversity and native plant evolutionary lineages. If local endemic taxa are genetically swamped by hybridization with non-local taxa, these endemic lineages are lost and there is no going back. We must keep our restoration projects in perspective. As land stewards, we charge ourselves with the protection and conservation of California's otherworldly natural diversity, fantastic in scope and wonderful to experience.

Thinking of ecotypes?

Using local native plant ecotypes for various types of vegetation and habitat restoration has many benefits, as noted above. The natural diversity found in the California Floristic Province is second to none in the North American continent, and with the persistent threat of habitat loss and invasions by non-native plants, it's more important than ever to conserve this spectacular flora at all scales of natural history, especially the unique evolutionary lineages within plant taxa that have also persisted through time, shaped in part by the dynamic patterns of climate. Habitat fragmentation combined with climate change complicates all land-based conservation efforts. However, all federal land management agencies have native plant conservation policies and the California Native Plant Society is developing policy guidelines on the use of local ecotypes for habitat restoration projects.

Habitat restoration efforts at Sacramento River NWR involved the work and dedication of many individuals representing over 50 agencies, organizations, businesses, and universities. Over 81 surveys, monitoring projects, and research investigations went into the development of this refuge. With congressional authorization for 18,000 acres, the refuge is almost 60 percent of the way to completion, so this work will continue in order to achieve the target acquired and restored acres.

Climate change will also change the timing, duration, frequency, and intensity of flooding on the middle Sacramento River, this will affect restored and remnant habitats, with mortality likely for some woody and herbaceous species due to summer or growing season extreme water stress—too dry, too wet, or even inundated. Then, after nonnative plant seeds are deposited with flooding, weeds will dominate the once native plant community. This has already occurred at the South Ord Unit swale restoration, where prolonged flooding into June 2017 killed most of the native grasses. Prolonged periods of

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Evolutionary Lineages, Unrecognized Local Plant Endemism, and Conservation of Cryptic California Native Plant Diversity

by Bruce Baldwin, UC Berkeley, Professor, Integrative Biology; Curator, Jepson Herbarium

Molecular phylogenetic studies of Californian native plants have increasingly revealed examples of evolutionary lineages warranting taxonomic recognition that have been overlooked, even within species that were subjects of experimental biosystematic studies in the past (see Baldwin 2019). Much of this cryptic (or semi-cryptic) diversity shows evidence of being ecologically distinct, edaphically or climatically, and represents unrecognized local endemism. Too few of such studies to date have included sufficient sampling across the geographic, ecological, and morphological axes of variation within recognized Californian plant species to survey our flora for cryptic diversity at the scale necessary to inform conservation planning at the landscape level. In lieu of such data, available evidence warrants local sourcing of any plant materials used for ecological restoration to avoid unintentional and irreversible loss of irreplaceable biodiversity, as discussed by Joe Silveira in this article.

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Observations of Ecotypes Used for Native Grassland Restoration at Sacramento River NWR *continued*

reduced flows will likely result in the mortality of certain trees and shrubs, creating openings in the forest for which to plan native grass and wildflower restoration projects. Purple needlegrass and great valley gumweed are among the most drought-tolerant plants we currently use, but opportunities to use other species of local ecotypes will arise. Conditions may change to the point of requiring the use of entirely different native species than we currently use, for example, local floodplain ecotypes from cattails (*Typha* sp.) for really wet conditions to Jimsonweed (*Datura wrightii*) for really dry conditions. The challenge will be how to plan and develop strategies for using current and new local plant taxa in a warming climate of extreme annual and seasonal weather conditions, which will also cause changes in hydrology, and strain societal water allocations. These conditions may become highly unstable and unpredictable, further complicating the challenges for riparian and habitat floodplain restoration and natural resources conservation.

John Anderson and his dedicated staff at Hedgerow Farms provided one-of-a-kind knowledge, skills, and hard-earned expertise and passion to the refuge grassland restoration program. John's willingness to grow local ecotypes was both helpful and inspirational. I recall sitting next to John at the 2010 Northern California Botanists Banquet at CSU Chico, where Bruce Baldwin was giving the Keynote Address about California native plant diversity, endemism, and cryptic taxa. When we started to realize that local ecotypes likely have adaptive advantages in a changing climate, John looked at me and said something simple, yet profound, "I'm going to have to grow more plant ecotypes…"

Acknowledgments

I recognize the following individuals and their organizations for the tremendous commitment, work, collaboration, and passion they brought to the habitat restoration program at Sacramento River National Wildlife Refuge: Kelly Moroney (Oregon Coast National Wildlife Refuge Complex and former Sacramento River National Wildlife Refuge) and Jennifer Isola (Sacramento National Wildlife Refuge Complex); Tom Griggs (River Partners, retired and former TNC); Dawit Zeleke, Luis Ojeda, Ryan Luster, Adrian Frediani, and Greg Golet, (TNC); Michael Rogner and Helen Swagerty (River Partners), Dan Efseaff (former River Partners), and John Carlon (River Partners, retired); Germain Boivin (Floral Native Plant Nursery, retired) and Zeb Putterbaugh (Floral Native Plant Nursery); Emily Allen (former Hedgerow Farms); Geoff Geupel and Tom Gardali (Point Blue Conservation Science); Bruce Baldwin (University of California, Berkeley); and, last but most respectively, John Anderson, deceased, founder of Hedgerow Farms and creative, energetic and passionate leader of native grassland restoration in California.

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30th Anniversary Membership Interest Survey

by Sarah Gaffney[1]

Thank you to everyone who completed our membership interest survey! We had a total of 132 responses and greatly appreciate everyone who participated – your feedback is invaluable to us. With these results, CNGA will be better able to serve you, our members, by providing the information you seek most from us. Your generous donations will go towards further addressing these needs and developing informational support!

Membership demographics

We wanted to know the roles of people coming to us for information about California grasslands. Many members identified with more than one role, so the total percentages add up to over 100. The top three roles were restoration practitioner (39%), land manager (30%), and homeowner (30%), but our membership also includes consultants, academic researchers, agency scientists, and landscape planners (Figure 1).

Our membership base has widened over the last 10 years! In 2011, 90% of our members worked professionally with grasslands; in 2021, that number drops to 77%, showing we are gaining interest from homeowners and others interested in native grasslands. We have already begun supporting this new audience with workshops such as our popular "Landscaping with Nature" series.

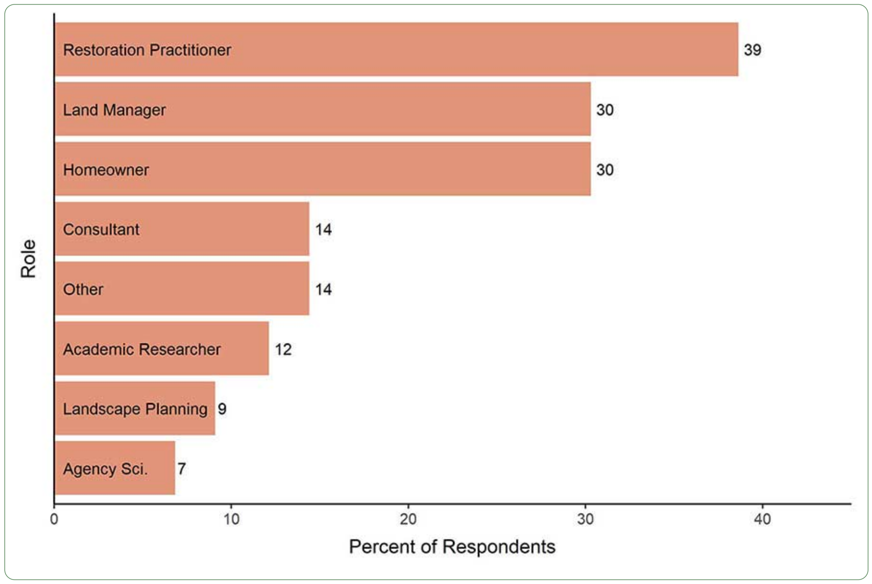

Figure 1. Who are our members? The most common roles among our responding members include restoration practitioners, land managers, and homeowners. The 'Other' grouping is composed of various members who are interested and enthusiastic about native plants; community activists, volunteer weeders, ranchers/shepherds, etc.

Main topics of interest

We asked members to choose the top five topics they wanted to learn more about from CNGA so we could better tailor the content we provide. More than two-thirds of our responding members included restoration, ecology, and management in their top five, with climate change, landscaping & gardening, and oaks the next highly rated (Figure 2). Our membership had similar interests in 2011, with restoration methods, long-term management, and ecology ranked as topics of highest priority.

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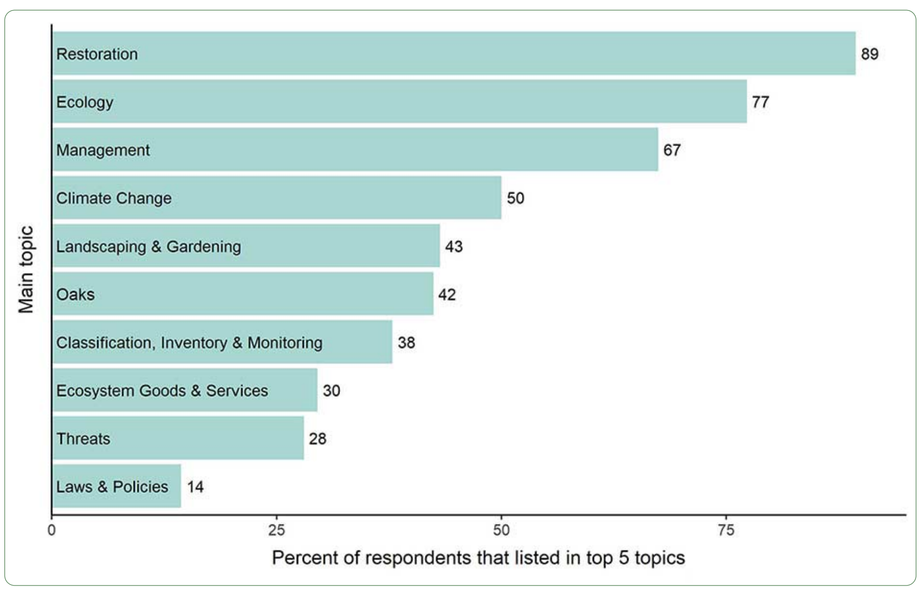

Figure 2. What main topics are our members most interested in learning about? Highest-priority topics include restoration, ecology, and management; these topics were also the top three of our 2011 survey.

[1]Sarah Gaffney is a PhD Candidate in the Graduate Group in Ecology at the University of California, Davis, and is a CNGA board member.

30th Anniversary Membership Interest Survey *continued*

Subtopics of interest

We also wanted to know what members hoped to learn within each larger topic. We asked members to rate their interest level among subtopics, regardless of how they ranked the main topics. For the top three main topics, restoration, ecology, and management, approximately 50% of our members expressed they were 'very interested' in all of the listed subtopics (Figures 3, 4, and 5).

Thank you again to all who took the survey! The Board of Directors will use these results to guide future planning and ensure CNGA is addressing the needs and interests of its members.

CNGA relies on its membership and donations to continue promoting, preserving, and restoring the diversity of California's native grasses and grassland ecosystems through our education, advocacy, research, and stewardship endeavors. To further support us in addressing your priorities, a gift of just $25 will help us provide more informative workshops, online materials, and student scholarships!

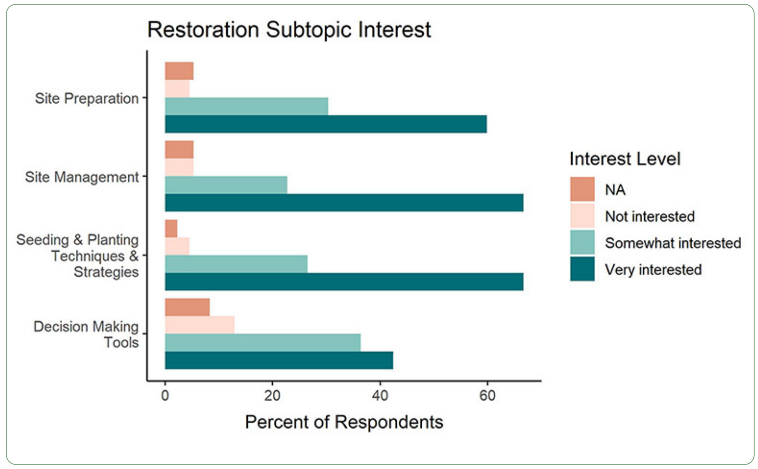

Figure 3. How interested are our members in different restoration subtopics? From 40 to 65% of respondents expressed that they were very interested in all restoration subtopics, and for each subtopic. Site management and seeding & planting techniques and strategies were the subtopics of greatest interest.

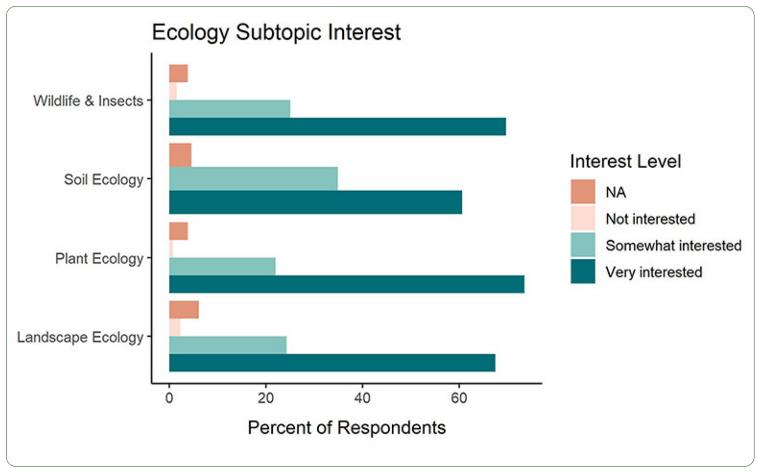

Figure 4. How interested are our members in different ecology subtopics? Over 60% of all responding members were very interested in all listed subtopics of ecology; plant ecology was the subtopic with the highest interest.

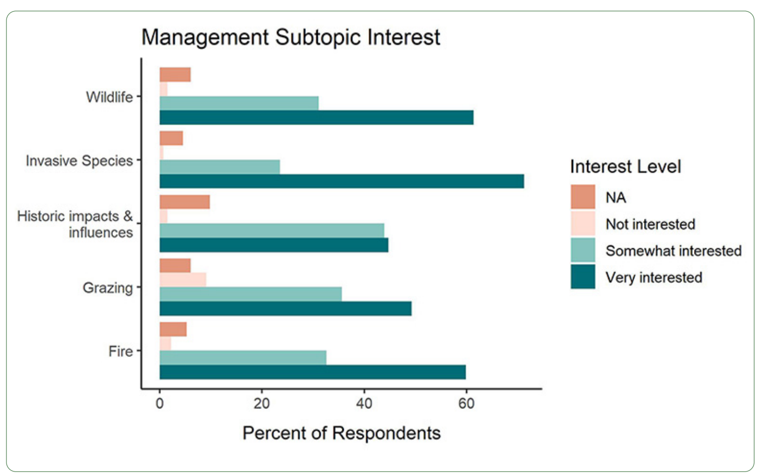

Figure 5. How interested are our members in different management subtopics? From 40 to 70% of respondents were very interested in all the listed management subtopics. Invasive species topped the interest list.

Meet the Class of 2021: Grassland Research Awards for Student Scholarship (GRASS) Recipients

One of CNGA's most important tasks is to enable the future of grassland conservation by training future generations of grassland managers and researchers. Since 2019, CNGA has offered competitive research funds to promote undergraduate and graduate student research focused on understanding, preserving, and restoring California's native grassland ecosystems in accordance with our mission and goals.

This year, twelve students, both graduate and undergraduate, qualified for funding. Thanks to the generous support of our members and donors, we were able to fund all twelve students. We congratulate and thank the GRASS Class of 2021 for their important work.

Gregory Arena, UC Berkeley. Advisor: Todd E. Dawson, Department of Integrative Biology. Project Title: *Impacts of shade on the reproductive success and vigor of* Stipa pulchra.

I'm a first-year Ph.D. student studying plant physiological ecology at UC Berkeley. Having grown up in rural Humboldt County, a primary focus of my research are those questions that can inspire solutions for the challenges facing our environment as well as agrarian spaces. After graduating with a major in Biology from UC Berkeley in 2016 I spent four years working in vegetation ecology at Golden Gate National Recreation Area and Point Reyes National Seashore. Whether pulling weeds or mending fences, I spent much of those days witnessing the subtle dynamics of the coastal prairies and pasturelands that span Marin County. Immersion in these systems and employment in land management led to my investigation of the relationships between encroaching woody plants and native and introduced grasses in the North Bay. Spurring further questions about community interactions, succession, and the physiological underpinnings that define these coastal grasslands, my experiences and interests in coastal grasslands have inspired my pursuit of a graduate degree.

CNGA 2021 GRASS Award Recipients, from top: Gregory Arena, Nora Bales, and Ernesto Chavez-Velasco.

Nora Bales, Cal Poly San Luis Obispo. Advisor: Dr. Yamina Pressler, Soil Ecologist, Natural Resources Management and Environmental Sciences. Project Title: *Investigating restoration potential of grassland habitat associated with* Chlorogalum purpureum *var* purpureum*, a threatened plant on California's Central Coast.*

I am a first-year Master of Science student at Cal Poly, San Luis Obispo, researching the specific biotic and abiotic habitat requirements of *Chlorogalum purpurea* var. *purpurea* (purple amole), a rare grassland plant found on California's Central Coast. In particular, I am investigating the link between purple amole and biological soil crusts. With my research, I hope to better inform purple amole management and conservation practices. In addition to my master's studies, I am a botanist with the California Military Department and manage purple amole in the largest of its four populations.

Ernesto Chavez-Velasco, UC Santa Cruz. Advisors: Justin Luong, Karen Holl, and Michael Loik, Environmental Studies Department. Project Title: *Does coastal fog interact with drought to affect plant water use and endophytic symbioses in California's coastal prairies?*

I'm a 4th-year undergraduate student in Environmental Studies, with a concentration in Conservation Science and Public Policy at UC Santa Cruz. I am interested in the conservation and restoration of California grassland ecosystems. I am especially passionate about land management and creative approaches to work with complex systems.

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Meet the Class of 2021: Grassland Research Awards for Student Scholarship (GRASS) Recipients *continued*

Roisin Deák, Cal Poly San Luis Obispo. Advisor: Dr. Nishi Rajakaruna, Geoecology Lab. Project Title: *Meadow vegetation trends in relation to fire.*

I am a second-year graduate student interested in the maintenance of plant diversity and how that diversity scales to ecosystem services. I am investigating the effects of wildfire on meadow composition, which captured my interest while working for the US Forest Service Range Monitoring program. I observed the conversion of a dry, weedy meadow being encroached upon by forest into a veritable wetland after a severe fire swept through the area. I hope that by examining long-term data from burned meadows, I can discern under what circumstances fire promotes the growth of obligate wetland species. I am interested in obligate wetland species in particular because they have been shown to contribute to watershed resilience. I intend to share my findings with land managers to refine decisions on control burn tactics or restoration efforts. I have worked as a field botanist for the last seven years and am thrilled to return to the meadows this summer!

This is Roisin's second GRASS award.

Madison Fedor, UC Los Angeles undergraduate. Advisor: Elihu Gevirtz, Channel Islands Restoration. Project Title: *A comparative study of western meadowlark songs on the Channel Islands and Mainland of Southern California and implications for prioritization of grassland conservation and management.*

I'm Maddie, a second-year undergraduate at UCLA pursuing a B.S. in Environmental Science with a minor in Conservation Biology. I am very excited to begin my first ecological research project this summer with Elihu Gevirtz and Channel Islands Restoration, comparing western meadowlark songs between the Channel Islands and the Santa Barbara County mainland populations. Through this opportunity I will be gaining valuable experience with ecological fieldwork methods, providing me with a strong foundation to pursue graduate education in conservation and restoration of biodiversity.

Robert Fitch, UC Santa Barbara. Advisor: Carla D'Antonio, Department of Ecology, Evolution, and Marine Biology. Project Title: *The effects of fuel manipulation and prescribed fire temperature on seed banks in a California grassland.*

I am Robert Fitch, a third-year Ph.D. student studying how native plants can be used to meet wildfire management goals and promote native ecosystem services. I work directly with the US Forest Service and I hope to continue to make similar partnerships throughout my career linking the applied world with academia. My interests span restoration, invasive species management, and fire ecology. I have had the privilege of studying plant ecology across Southern California and have worked in Hawaiian dry forests restoring rare and endangered plant species. I decided to pursue my doctorate in ecology because I am passionate about applying scientific theory and principles to solve real-world problems. My goal is to have my own restoration ecology lab at a California state university where I can engage with research and teach undergraduates.

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CNGA 2021 GRASS Award Recipients, from top: Roisin Deák, Madison Fedor, and Robert Fitch.

Meet the Class of 2021: Grassland Research Awards for Student Scholarship (GRASS) Recipients *continued*

Raphaela Elise Floreani Buzbee, UC Berkeley. Advisor: Dr. David Ackerly, Dean of Rausser College of Natural Resources. Project Title: *Exploring species distribution models for biodiversity conservation in California coastal prairies.*

I am a first-year Ph.D. student in the Department of Environmental Science, Policy, and Management at the University of California, Berkeley. Prior to my graduate studies, I spent the past decade working as a professional botanist and vegetation ecologist for various land management and conservation agencies including the National Park Service and the California Native Plant Society. During this time, I've surveyed and explored the vast variety of grasslands across the state. I am broadly interested in the intersections of people, plants, and places, and am always excited to share my botanical knowledge with others. My research is centered on climate change impacts on biodiversity in California—especially in unique ecosystems like coastal prairies, vernal pools, and montane meadows. When I'm not busy appreciating grasslands and geophytes, I enjoy watercolor painting, roller skating, and looking at plants. My favorite native grass is *Danthonia californica.*

Rebecca Ann Nelson, UC Davis. Advisor: Susan P. Harrison, Environmental Science and Policy. Project Title: *The effects of invasion and restoration on pollinator visitation for California native grassland plants.*

I am a first-year Ph.D. student in Professor Susan Harrison's lab in the Graduate Group in Ecology at UC Davis with an emphasis in integrative ecology. I am studying how invasive species and restoration strategies affect the structure and dynamics of plant-pollinator mutualisms in California grasslands. My project examines the extent to which hairy vetch (*Vicia villosa*), an invasive legume, competes with native California wildflowers for pollinators. Through this research, I aim to inform the restoration of plant-pollinator interactions in northern California grasslands. I am broadly interested in researching what strategies are effective for restoring grassland plant-insect interactions in the context of anthropogenic global change. I hope to foster partnerships between the applied and academic spheres of restoration ecology. I enjoy birding, nature photography, and creative writing.

Landin Noland, UC Davis. Advisor: Valerie Eviner, Department of Plant Sciences. Project Title: *Chaparral decline with short fire return interval: Promising habitat for native grassland species?*

I am Landin, a graduating senior at UC Davis interested in contemporary land management challenges presented by fire in California's ecosystems. I am joining Valerie Eviner's lab to pursue an M.S. in Ecology at UC Davis. I am particularly interested in post-fire management and restoration opportunities to maintain healthy and resilient landscapes. I hope to improve our understanding of California's changing fire regime and its impacts on native ecosystems so that we make fire-informed management decisions on the landscape. I am now assessing an uncharacteristically short fire return interval in Northern California's chaparral system to understand the resiliency of chaparral systems to frequent fires, and the restoration opportunities for native grassland species within the frequently burned system.

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CNGA 2021 GRASS Award Recipients, from top: Raphaela Elisa Floreani Buzbee, Rebecca Ann Nelson, and Landin Noland.

Meet the Class of 2021: Grassland Research Awards for Student Scholarship (GRASS) Recipients *continued*

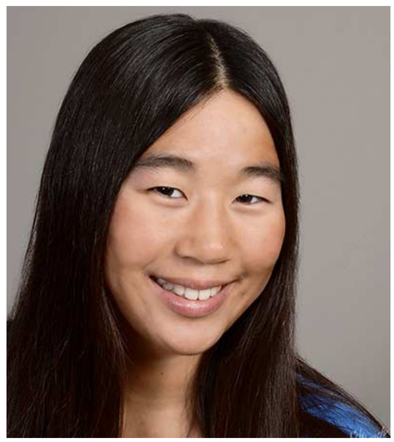
Suzanne Ou, Stanford. Advisor: Dr. Kabir Peay, Department of Biology. Project Title: *How do microbe-mediated plant-soil feedbacks affect turnover of California annuals?*

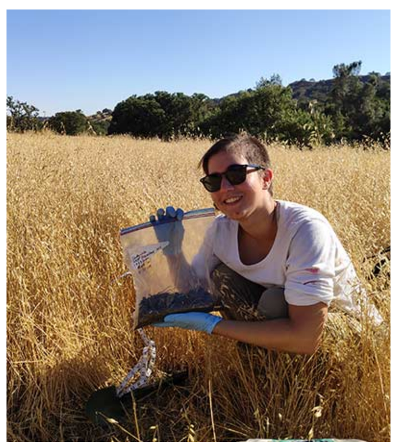
I am a Ph.D. Candidate studying the temporal dynamics of plant-soil feedbacks. Using a mix of fieldwork, greenhouse experiments, molecular sequencing techniques, and theoretical modeling, I am working to develop a better understanding of the ecology of native species on the unique serpentine grasslands of California.

Joanna Tang is a Ph.D. student, UC Santa Barbara. Advisor: Carla D'Antonio, Department of Ecology, Evolution, and Marine Biology. Project Title: *Ecotypic variation in Southern California grassland vernal pool communities.*

I am a Ph.D. student studying and researching long-term invasion dynamics in restored urban ecosystems, specifically, grassland vernal pools. As a born-and-bred Californian, I am committed to developing innovative, holistic restoration techniques that preserve and restore California's unique native communities in the face of widespread exotic invasion, for the benefit of Californians now and into the future.

This is Joanna's second GRASS award.





CNGA 2021 GRASS Award Recipients, from top: Suzanne Ou, Joanna Tang, and Leila Wahab.

Leila Wahab, UC Merced. Advisor: Dr. Asmeret Asefaw Berhe, Earth Sciences, Life, and Environmental Sciences Department. Project Title: *The role of organic nitrogen compounds in soil organic matter stability: Changes in soil chemistry and plant communities due to altered precipitation regimes in California grasslands*.

I am Leila, a third-year Ph.D. candidate at UC Merced who is passionate about understanding soils and plants and their responses to climate change. I specifically study California grasslands and study a precipitation gradient across the state to simulate how precipitation patterns might be altered by climate change. I am interested in both carbon and nitrogen dynamics and how these changes in chemistry in the soil will affect aboveground plant communities. Climate change will affect the sequestration potential of grasslands, and I am interested in understanding these multifaceted and complex problems in the beautiful native grasslands of California.

Students from any accredited college or university conducting research within California may apply for a CNGA student research scholarship (home institution may be outside California). The call for applications goes out November 1st each year with applications due by January 31st. For more information about the CNGA Graduate Research Awards for Student Research program, please visit **https://cnga.org/GRASSgrants/**.

CNGA's Bunchgrass Circle

A Special *Thank You* to our Bunchgrass Circle Members!

As a nonprofit organization, CNGA depends on the generous support of our Corporate and Associate members. Ads throughout the issue showcase levels of Corporate membership ($1,000, $500, $250). Associate members ($125) are listed below. Visit **www.cnga.org** for more information on joining at the Corporate or Associate level.

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Thirty Years of Changes in How We Understand and Steward California's Grasslands *(see page 3)*

CNGA 30th Anniversary Cover Artwork by Lesley Goren, **www.lesleygoren.com**. Counter-clockwise from left: Western Meadowlark (*Sturnella neglecta*), Monarch Butterfly (*Danaus plexippus*), Kotolo Milkweed (*Asclepias eriocarpa*), Western Blue-eyed Grass (*Sisyrinchium bellum*), California Poppy (*Eschscholzia californica*), Baby Blue-eyes (*Nemophila menziesii*), Sky Lupine (*Lupinus nanus*), Western Bumblebee (*Bombus occidentalis*), Purple Needlegrass (*Stipa pulchra*).

Back cover: *Asclepias speciosa* (showy milkweed) almost in bloom in Stoneman Meadow in Yosemite Valley with Half Dome in the distance. *Photo by Emily Allen, CNGA Board Member.*