APPENDIX: Abstracts on Grasslands from CNPS Conference, February 2018 in Los Angeles

Selection of abstracts from 2018 CNPS Conservation Conference related directly or indirectly to grasslands, prairies, and meadows (blue titles summarized in accompanying CNPS Conference recap by Jim Hanson, starting on page 20 of the Spring 2018 issue of *Grasslands*)

Rare Plants

This session focuses on research, management, and conservation of California's rare plants. The session includes a panel discussion focused on conserving cryptic species in light of the increased recognition of plants that are difficult or impossible to identify solely on the basis of morphology. It also includes a sub-session on new rare plant discoveries in California.

There's no place like home: Five endemic plants from southern California and the soils they love

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The California Floristic Province is one of the most biodiverse regions in the world and home to a large number of endemic plant species. The high degree of endemism is attributable to a diversity of climatic, topographic, and edaphic conditions (i.e. relating to soil, especially as it affects living organisms, including drainage, texture, or chemical properties such as soil pH) creating unique microcosms for species specialization. Unfortunately, many of these microcosms have been lost to urbanization and populations of edaphic endemic plants have been isolated by habitat fragmentation and loss of pollinators. In addition, specialists are extinction-prone and vulnerable to climate change. Land managers need more specific information about habitat requirements to successfully conserve these species. This study focuses on soil chemistry and physical properties of five edaphic endemic plants in San Diego County including two clay-endemic species: *Deinandra conjugens* (Asteraceae) and *Brodiaea filifolia* (Themidaceae), two species restricted to gabbroic soils: *Nolina interrata* (Ruscaceae), and *Tetracoccus dioicus* (Picrodendraceae), and *Acanthomintha ilicifolia* (Lamiaceae), which occurs on clay and gabbroic soils. We used a spatially matched design to compare occupied and unoccupied soils. Results indicate that each species is associated with a unique suite of physical and chemical soil conditions that vary over a fine spatial scale. This information can help prioritize areas for management activities. It also improves our ability to identify suitable but unoccupied habitat for population expansion and translocation efforts within the species' current range and under shifting climactic conditions.

Introduction and reintroduction as an aid to species recovery

Carol W. Witham

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Members of the Orcuttieae tribe (Poaceae) are entirely endemic to vernal pools of the California Floristic Province. Both prior and subsequent to their listing under the California and federal Endangered Species Acts in the 1990s, numerous individual populations of these rare grasses have been extirpated through habitat conversion and other factors. As California continues to expand both its urban centers and its agricultural base, the vernal pool habitat that supports these and other species is becoming highly fragmented thereby reducing the chances of natural (re-)colonization. In 2014 and 2016, Sacramento Orcutt grass (*Orcuttia viscida*) was planted into unoccupied suitable habitat within its natural range. These out-plantings were intended to compensate for unregulated losses that occurred prior to listing. In 2015, Solano grass (*Tuctoria mucronata*) was replanted into Olcott Lake, its type locality. This population was probably extirpated due to stochastic (random) events following overzealous herbarium specimen collecting. The plantings consisted of simply scattering seed collected from nearby donor sites. Both the donor sites and the newly established populations are being monitored annually for special distribution, population size and plant vigor. Since the initial plantings, the rare grasses have occurred in the recipient vernal pools every year and the new populations appear to be relatively stable. For both species, these recently established populations will serve as a buffer against extinction. This research may also serve to illustrate possible conservation approaches for rare vernal pool plants in the face of both habitat fragmentation and climate change.

A dozen years of rare plant discoveries on Tejon Ranch

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Tejon Ranch, the state's largest contiguous piece of privately owned land, located primarily in the Tehachapi Mountains of Kern County, has long been recognized as a black hole by botanists. Until recently, a survey of records in the California Natural Diversity Database showed that the Tehachapi Mountains Ecoregion (as defined by the *Jepson Manual*, 2nd Edition) had the lowest number of rare plants and lowest density of rare plant occurrences in the state. Over the past 12 years, however, we have learned that the low numbers on

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Tejon Ranch and the Tehachapi Mountains, in general, resulted from a lack of botanical survey work. Prior to 2006 only 14 rare plant species had been documented on Tejon Ranch. Since then, because of surveys associated with proposed development projects, and more recently made possible by the Tejon Ranch Conservancy, this number has blossomed to 51. Some of these discoveries are exciting! Botanists discovered the rare Tejon Ranch endemic, *Eriogonum callistum* (Polygonaceae), in 2006. *Caulanthus californicus* (Brassicaceae), once thought to be extirpated in the San Joaquin Valley was found in large number in the Tejon Hills in 2016 and 2017, and in 2015, a large population of *Lupinus peirsonii* (Fabaceae), a species previously thought to be endemic to the San Gabriel Mountains, was discovered on Tejon Ranch. These discoveries, and many others, are proof that shining a light on botanical black holes can yield results that are not only scientifically interesting but also important for California rare plant conservation.

Approaches and methods for the quantification of soil seed banks: Overcoming seed blindness

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A plant is 'born' when a seed (dormant embryo) is produced and dispersed from the parent plant. Most dispersed seeds eventually become mixed into the soil as seed bank. Seeds mixed in soil are virtually invisible to the naked eye. Due to their invisibility, soil seed banks are a rarely monitored segment of the plant population. In many cases, however, the soil seed bank may represent the majority of the individuals in a plant population. Soil seed banks are the foundation of all plant species populations, buffering them from extirpation and extinction against unpredictable environmental conditions (e.g. drought, habitat disturbance). A plant species has either a transient (short lived; < one year) or persistent seed bank (long lived; >>one year). The specific approaches and methods used in the quantification of soil seed banks are dependent upon the specific life history and ecology of the species. This review will examine the approaches and methods to the quantification of persistent soil seed banks of several rare California endemic plant species with disparate life history and habitat characteristics. Rare plant population monitoring programs and California Rare Plant Rank (CRPR) assessments should include soil seed bank quantification, in addition to the traditional emergent plant census. Not including soil seed bank quantification in monitoring and CRPR assessment can lead to incorrect conclusions about the stability of populations and the overall rarity of a species, particularly for infrequently (erratically) emergent desert species and fire/disturbance-following species.

Grasslands and Prairies

California grasslands are among the most endangered ecosystems in the United States and are important subjects of ecological research and experimentation. This session focuses on native grassland research and management including invasive species, livestock grazing, and restoration within our unique California grassland/prairie ecosystems.

Updates to classification and ranking of California grasslands and prairies

Jennifer Buck-Diaz, Julie Evens

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Upland herbaceous vegetation in central California, such as annual grasslands and prairies, is difficult to quantify because of the variable and ephemeral nature of this distinctive system. The vegetation exhibits shifts in species composition and cover within different seasons of the same year, across different years, and along latitudinal and longitudinal gradients. California Native Plant Society's Vegetation Program uses quantitative definitions and tools to define, map and rank vegetation across the state. We have sampled and analyzed grasslands across 5+ years to track vegetation dynamics within two California ecoregions; the Great Valley and the Central California Coast Ranges. Species composition and abundance has fluctuated widely, primarily based on variation in temperature, the timing and amount of precipitation, plus other factors such as parent material and soils. California's episodic droughts create difficulty in recognizing semi-arid native types due to a lack of germination. Overall, grasslands that we studied appear to have cyclical dynamics with patchy spatiotemporal processes, which enable the coexistence of both native and non-native plant species. Establishing definitions of grassland vegetation must be based on a combination of indicator species presence, temporal persistence, and richness with less emphasis on the dominant cover of non-diagnostic, invasive plant genera such as *Bromus*, *Avena* and *Schismus* (Poaceae). A quantitative classification and a transparent and defensible rarity ranking system will ultimately aid in the continued conservation of this imperiled ecosystem.

Grasses versus forbs: What a long term, repeat study can tell us about California's native prairie landscapes

Paul Laris, Chelsea Seymour, Chrys Rodrigue

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Much of the foothill and valley areas of southern California are covered by stands of non-native grasses. Researchers have long hypothesized as to the original vegetation cover of these landscapes.

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For decades, the dominant view held that the original vegetation was native bunch grasses including *Stipa pulchra* (Poaceae). This so-called "bunchgrass hypothesis" put forth by Clements has been gradually overthrown through careful examination of historical records and critiques of Clements' methods. Today it is thought that forbs and not bunch grasses dominated some grasslands prior to European arrival. This study uses a long term, repeat study design to analyze and compare data from three surveys of 15 permanent quadrats in La Jolla Valley, California to determine changes in grassland cover over 35 years. A unique aspect of the study is that the original site was selected precisely because it contained excellent stands of *Stipa pulchra* and was conducted shortly after the area was released from grazing and placed under conservation management. We compared data on species frequency and percent cover collected using the same sampling routine for three time periods: 1979–81, 1993–95, and 2015 to document the shifts in vegetation. We found that native grass cover decreased dramatically, exotic grass cover fluctuated widely while both native and exotic forb cover increased greatly. The findings support the notion that forbs, and not bunch grasses, were historically the dominant vegetation cover in the area. The findings also suggest that grazing management practices caused the former stands of *Stipa pulchra*.

Livestock grazing as a tool for enhancing native grassland in the East Bay Regional Park District

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Looking at ongoing experimentation and vegetation management in the East Bay Regional Park District, this talk covers examples of using targeted livestock grazing to enhance native grassland and manage special status plant species. The Serpentine Prairie Restoration Project at Redwood Regional Park uses a combination of sheep and goat herd grazing experimentally to increase native cover in a serpentine grassland that includes the Presidio clarkia (*Clarkia franciscana* [Onagraceae]; Federally and State endangered, CRPR 1B.1). The Santa Cruz tarplant (*Holocarpha macradenia* [Asteraceae]; Federally threatened, State endangered, CRPR 1B.1) is managed with field rotation and grazing incentives as part of a native grassland enhancement management program with year-round cattle grazing in Wildcat Canyon Regional Park. Results from the *Clarkia* project show a decrease in non-native annual grasses, an increase in annual native forb cover, and an increase in total native species richness after three years of late summer grazing. Results from the *Holocarpha* project are mixed and appear to be more weather-dependent.

Livestock use has mixed effects on *Orcuttia tenuis* in northeastern California vernal pools

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Land managers often face the dilemma of balancing livestock use with conservation of sensitive species and ecosystems. For example, most of the remaining vernal pools in California are grazed by livestock. Vernal pools are a unique type of seasonal wetland that support many rare and endemic species, such as *Orcuttia tenuis* (Poaceae). Although there is evidence that livestock use may benefit some vernal pool specialists, grazing has been considered a threat to *Orcuttia tenuis* in northeastern California. We evaluated the effects of livestock use by comparing *Orcuttia tenuis* frequency, density, and cover in plots where livestock had been excluded with plots where grazing occurred. Livestock do not directly graze *Orcuttia tenuis*, so the effects of livestock use on this species are indirect. Year had the largest effect on *Orcuttia tenuis*, probably because of variation in annual precipitation patterns. Livestock use had no effect in some years; in other years *Orcuttia tenuis* was twice as abundant in unfenced than in fenced plots. Litter cover was also lower in unfenced plots in these years, suggesting that livestock use may benefit *Orcuttia tenuis* in some years by reducing litter accumulation. Conversely, livestock use negatively affected *Orcuttia tenuis* in pastures where livestock hoof print cover was high, including pastures that were grazed early in the season. Our results suggest that by considering environmental factors such as precipitation, site conditions, and season of grazing, land managers may be better able to balance the needs of sensitive vernal pool species with maintaining livestock utilization.

Novel fine-scale aerial mapping approach quantifies grassland weed cover dynamics and response to management

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Invasive weeds threaten the biodiversity and forage productivity of grasslands worldwide. However, management of these weeds is constrained by the practical difficulty of detecting small-scale infestations across large landscapes and by limits in understanding of landscape-scale invasion dynamics, including mechanisms that enable patches to expand, contract, or remain stable. While high-end hyperspectral remote sensing systems can effectively map vegetation cover, these systems are currently too costly and limited

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in availability for most land managers. We demonstrate application of a more accessible and cost-effective remote sensing approach, based on simple aerial imagery, for quantifying weed cover dynamics over time. In California annual grasslands, the target species include invasive weedy grasses (*Aegilops triuncialis* [Poaceae] and *Elymus caput-medusae* [Poaceae]) and desirable forage grass species. Detecting invasion of annual grasses into an annual-dominated community is particularly challenging, but we were able to consistently characterize these two communities based on their phenological differences in peak growth and senescence using maximum likelihood supervised classification of imagery acquired twice per year (in mid- and end-of season). This approach permitted us to map weed-dominated cover at a 1–m scale (correctly detecting 93% of weed patches) and to evaluate weed cover change over time. We found that weed cover was more pervasive and persistent in management units that had no significant grazing for several years than in those that were grazed, whereas forage cover was more abundant and stable in the grazed units. This application demonstrates the power of this method for assessing fine-scale vegetation transitions across heterogeneous landscapes.

California's Changing Climate: Translocation, transplantation, assisted migration

Transplantation, translocation, and assisted migration of plant populations are often considered when restoring, recovering, and conserving plant populations, whether rare or common. The choices one makes are now further complicated by projected changes in climate and how different populations, taxa, and interacting species might be affected. The purpose of this session is to explore when there may be a need for translocation, transplantation, and assisted migration to restore, recover, and conserve plant populations, how information about projected changes in climate might alter choices, how populations may be selected and deployed in a way that reduces risk, and to identify knowledge gaps and future research needs.

Population-level genetic variation and climate change in California plant species

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Estimated future climate scenarios can be used to predict where hotspots of endemism may occur over the next century, but species-specific traits will be important in informing the varying responses within myriad taxa. Essential to predicting the consequences of climate change to individual species will be an understanding of the factors that drive genetic structure within and among populations. I review the factors that influence the genetic structure of plant species in California. Persistence in the face of climate change is likely determined by: dispersal ability, generation time, reproductive ability, degree of habitat specialization, plant-insect interactions, existing genetic diversity and availability of habitat or migration corridors. Existing levels of genetic diversity in plant populations vary based on a number of evolutionary scenarios that include endemism, expansion since the last glacial maximum, breeding system and current range sizes. A number of well-documented examples are provided from the California Floristic Province. Some predictions can be made for the responses of plant taxa to rapid environmental changes based on geographic position, evolutionary history, existing genetic variation, and ecological amplitude. The prediction of how species will respond to climate change will require a synthesis drawing from population genetics, geography, paleontology and ecology. The important integration of the historical factors that have shaped the distribution and existing genetic structure of California's plant taxa will enable us to predict and prioritize the conservation of species and areas most likely to be impacted by rapid climate change, human disturbance and invasive species.

Climate change and open space conservation: Lessons from TBC3's researcher-land manager partnerships in the San Francisco Bay Area

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Translating climate change projections into informed conservation action is both an immediate priority and a 'wicked' problem given the inherent uncertainties about future impacts. In 2012, we created the Terrestrial Biodiversity Climate Change Collaborative (**tbc3.org**), a group of researchers and conservation planners dedicated to advancing climate change science to inform open space conservation in the San Francisco Bay Area and beyond. Our work includes development of high resolution climate and watershed hydrology layers under multiple future climate projections, modeling potential impacts on vegetation distributions, and evaluating the robustness of regional conservation priorities in relation to current and future climatic diversity. We strive to enhance understanding of how to appropriately apply climate change projections, co-produce applied tools for land and water managers, incorporate managers' feedback into long-term research priorities, and promote meaningful exchanges capable of generating new approaches to conservation in the face of inevitable rapid change in ecosystems. In a recent

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workshop, we engaged land managers in three narrative scenarios for climate change impacts on vegetation: extreme drought, catastrophic fire, and increased rainfall. Collectively, researchers and managers evaluated a range of strategies to promote specific management objectives — e.g., biodiversity conservation, reduced catastrophic fire risk — under different scenarios. Participants spoke to the value of having researchers help reframe "how to think about the problem" in a meaningful regional context, rather than dictating specific management recommendations. By incorporating managers' local knowledge, this approach empowers informed yet flexible site-specific solutions, while avoiding the pitfalls of overgeneralization in the face of uncertainty.

Fire management, managed relocation, and land conservation options for long-lived obligate seeding plants under global changes in climate, urbanization, and fire regime

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Few studies have quantified the potential value of multiple conservation interventions in light of multiple threats. We linked spatial distribution and population models to explore conservation interventions under projected climate change, urbanization, and changes in fire regime on a long-lived obligate seeding plant species, a dominant plant functional type in many fire-prone ecosystems, including the biodiversity hotspots of Mediterranean-type ecosystems. First, we investigated the relative risk of population decline for plant populations in landscapes with and without land protection under an existing habitat conservation plan. Second, we modeled the effectiveness of relocating seedlings and seeds from a large patch with predicted declines in habitat area to two unoccupied recipient patches with increasing habitat area under two projected climate change scenarios. Finally, we modeled eight fire return intervals (FRIs) approximating the outcomes of different management strategies that control fire frequency. Invariably, long-lived obligate seeding populations remained viable only when FRIs were maintained at or above a minimum level. Land conservation and seedling relocation efforts lessened the impact of climate change and land-use change on obligate seeding populations to differing degrees depending on the climate change scenario, but neither of these efforts was as generally effective as frequent translocation of seeds. While none of the modeled strategies fully compensated for the effects of land-use and climate change, an integrative approach managing multiple threats may diminish population declines for species in complex landscapes. Conservation plans designed to mitigate the impacts of a single threat are likely to fail if additional threats are ignored.

A decision tree for determining whether to re-introduce extirpated plants

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At least twelve taxa of native plants are presumed to have been extirpated from Santa Cruz Island (voucher specimens document past occurrences, but no detections in recent decades) and we faced questions about whether to re-introduce them. Finding inadequate guidance in the literature, we created a decision tree and are now using it to inform decisions about re-introductions proposed on the northern Channel Islands. The tree includes fourteen steps. Step 1 addresses the timespan under consideration, steps 2 and 3 the evidence the taxon in question was once present, steps 4–7 the evidence that it was extirpated, steps 8 and 9 whether threats deemed responsible for the extirpation have been abated, and steps 10–12 cover the suitability of prospective re-introduction sites. Step 13 requires evaluation of potential benefits and costs of a re-introduction, and step 14 of appropriate donor populations. To date, we have used the tree to evaluate proposed re-introductions for six extirpations (taxa x island). We have taken another nine extirpations partway though the tree and are gathering data necessary to complete remaining steps. We are now moving ahead with initial actions necessary to re-introduce one island-endemic taxon to two islands (total of two extirpations). The decision tree can be used for plants on mainland sites or other islands, and slight modifications will make it suitable for animal taxa. In addition, it may require few modifications to be useful for decisions about translocating taxa beyond their native ranges, decisions many will face as the climate changes.

Using provenance studies to develop guidelines for resource management and restoration plans: Valley oak as a case study

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Oak species represent a critical component of California ecosystems. Because their ability to respond to change climate will influence the fate of many ecosystems, forest management and restoration projects may need to consider assisted migration of seed sources to optimize adult survival under future climate conditions. Traditional provenance studies, which are comprised of individuals with seed

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sources collected from throughout the species range and grown in one or more gardens, provide valuable data on the genetic basis of phenotypic differences across provenances (e.g., source populations). In this talk, we will present findings of a large-scale provenance study of range-wide populations of valley oak (*Quercus lobata* [Fagaceae]), a keystone tree oak of California that is already in jeopardy due to landscape transformation. In 2011, we collected over 11,000 acorns that were germinated in greenhouses and eventually planted into two common gardens using progeny from 5–8 families per 95 provenances. Measurements of 6-year-old plants taken within each garden in Fall 2016 revealed differences in family growth rates among provenances and genetic differences in family leaf traits across provenances. In particular, we found a genetic basis for leaf traits, such as leaf thickness and trichome density, which are related to response to drought. Using these data, we explore different strategies that could be employed for management practices. We will also present a set of questions that could be considered before translating findings from provenance studies into resource management and restoration plans that may benefit from assisted migration.

Tools for seed sourcing decisions in a changing world: Using species distribution models with climate change projections and species traits to help inform restoration of southern California shrublands

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In ecological restoration, practitioners strive to give restored communities their best shot at long-term success in part by using plant material from appropriately adapted populations. Decision tree formats for sourcing native plants consider information about a species' geographic distribution, pattern and scale of genetic differences, dispersability, habitat connectivity, potential for adaptive evolution, and risk of maladaptation upon translocation. Understanding the planting site, its fragmentation history, and traits of plants appropriate for the site are important to navigating decision trees designed to minimize risks of translocation. Available decision frameworks now include pathways to evaluate if assisted migration, with its associated risks, should be considered to mitigate for habitat fragmentation and geographic shifts in expected future habitat suitability. Species distribution models (SDMs) can be used with future climate scenarios to provide estimates of climate exposure, measured in terms of projected change in suitable habitat. We explored geographic patterns of habitat suitability under baseline (1951–1980) climate and five mid-century (2040–2069) future climate scenarios, for 36 common taxa from coastal sage scrub, alluvial scrub, and chaparral plant communities of southern California, identifying areas of projected habitat stability, loss, and gain for each. The results are being paired with ecological and genetic information on each taxon — such as habitat heterogeneity, fragmentation, and variety of natural barriers, life history, mating system, and dispersal mechanisms — and collected into plant profiles. These species profiles provide land managers with the type of information needed to navigate modern decision tree frameworks designed to guide seed transfer decisions.

Managing Lands for Native Plant Conservation

Whether mandated by law, required by regulatory oversight, or simply done at the request of a private landowner, effective native plant conservation emerges from a common set of well-designed land management practices. This session presents examples of California plant conservation on federal, state, and local public lands; and on private lands. These examples both clarify the differences among laws and regulations pertaining to different land ownership categories, and highlight underlying themes common to successful land management in all.

Improving land management through native plant conservation

Frazier Haney, Madena Asbell, Peter Satin

Mojave Desert Land Trust, Joshua Tree, CA, USA

The Mojave Desert Land Trust (MDLT) has been acquiring and managing land throughout the Mojave Desert for over 10 years, protecting over 68,000 acres to date. Typical stewardship activities include preventing destructive incursions, conducting site clean-ups, and implementing passive restoration practices such as vertical mulching to promote native revegetation. In 2016, MDLT established a native plant restoration nursery and conservation seed bank to increase its conservation and restoration efforts. In order to make restoration plans as site-specific as possible, management activities now include collecting and storing native seed, collecting environmental data for spatial analyses, and documenting the location of both non-native and rare, threatened, or endangered native plant species. Since implementing these practices, MDLT staff and trained volunteers have identified several rare plant species on their properties, including a previously undocumented population of white-margined beardtongue (*Penstemon albomarginatus* [Plantaginaceae]), and have added records to the California Natural Diversity Database. MDLT restored hundreds of acres of degraded sites and is currently devising plans for two major revegetation projects, a former aggregate mine and an abandoned agricultural property. Both of these were previously beyond the abilities of MDLT to properly restore, prior expansion of the nursery and seed bank

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programs. In addition to restoration, the establishment of a conservation seed bank serves as an ex-situ conservation tool, that will continue to support post-disturbance re-seeding efforts in the face of future disturbances. These activities demonstrate the role land trusts can play in managing, monitoring, and restoring large scale landscapes.

Using locally sourced species in field-based seed production for regional restoration projects

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California native species can be found growing in a wide range of habitats throughout the state, e.g. *Baccharis pilularis* (Asteraceae), *Stipa pulchra* (Poaceae), while other species are found growing in a single habitat, e.g., *Arctostaphylos sp.* (Ericaceae), *Malacothamnus sp.* (Malvaceae). Morphologic and molecular data show that individuals selected at different locations within a range can vary significantly, and although abundant within that range, they can be genetically unique. In addressing the use of locally sourced vegetation in specific restoration work, the option to obtain high quality material, drawn on local, distinct populations, composed of multiple individuals is essential. This is especially important when much of the seed used in California restoration lacks adequate documentation and/or a diverse genetic basis. Using an agronomic approach and locally hand-collected species from known locations, twelve species commonly employed in restoration projects in San Luis Obispo County were sampled and grown using high-density plantings at Nipomo, CA in 2016–2017. Results indicate that such an approach works well despite the variable nature of these species. When grown in closely spaced field populations, high quality seed in ample quantities was obtained.

The influence of seed sourcing on the establishment and growth of *Stipa pulchra* (Poaceae) during an extreme drought

Madeline Nolan, Carla D'Antonio

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Perennial bunchgrasses, such as purple needle grass (*Stipa pulchra* [Poaceae], were likely an important source of structure in native California grasslands. Yet today, many grasslands are now dominated by exotic annuals and restoration to native grasses is challenging. Current restoration projects emphasize the use of locally sourced plant material, but this practice is criticized for not considering how climate change will impact this practice. For example, drought tolerance of *S. pulchra* populations could be important for restoration planning because drought is expected to become more common in California in the future. Because populations of *S. pulchra* adapt to local variation in water availability, we hypothesize that using seeds from a variety of local populations may be important to establishment success. We addressed this hypothesis through a field-based experiment. We had two seed source treatments, a local treatment sourced from two populations adjacent to the restoration site and a mixed treatment sourced from six local populations that occurred within 2km (1.25 mi) of the restoration site. These two population treatments were then crossed with a watering treatment to understand how a long-term drought would affect restoration success. We found that in ambient and drought conditions, the mixed treatment produced more biomass and seeds then the local populations over the first growing season. Additionally, when compared to the ambient watering treatment, populations in the mixed treatment had a smaller decrease in biomass and seed production. This study suggests that small differences in seed sources can influence the establishment and persistence of *S. pulchra* restoration projects.

Restoring prairie habitat quality for a federally endangered annual forb: A ten-year report on Presidio clarkia

Lech Naumovich

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Presidio clarkia, *Clarkia franciscana* [Onagraceae], is a federally endangered annual forb that is limited to serpentinite outcrops in Oakland and one population in San Francisco. The remnant habitat is predominantly classified as coastal prairie grassland and rock outcrops. Over the course of the past ten years, we have conducted extensive applied experiments including grazing, phenological mowing, scraping, habitat fencing, and raking to better understand the life history of this taxon and how to best restore and maintain habitat in Oakland. After numerous experiments, observations and even a few surprises, it became evident that well timed disturbance within a certain range of intensity proved to be highly beneficial for the taxon. A minimum of 5 years of monitoring data is necessary to capture variation in annual populations. Upon noting key differences in responses to management between the Oakland and San Francisco populations, our results full-heartedly reinforce that restoration and management must be site-specific.

Restoration techniques and planning for the rare, native annual grass *Dissanthelium californicum* (Poaceae), formerly considered extinct, on San Clemente Island, CA

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First described in 1847 from collections on Catalina and Guadalupe Islands, *Dissanthelium californicum* (Poaceae) was collected on San Clemente Island in 1903 and not recorded again

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for over 100 years. By 1963, it was considered potentially extinct throughout its range on the three islands. Its rediscovery on Catalina in 2005, and Clemente in 2010, is a testament to the recovery of native species following control/management of exotic herbivores. In 2014, the Navy and Soil Ecology and Restoration Group (SERG) initiated a multi-phased project to create additional populations outside of heavily used training areas on San Clemente in order to: preemptively prevent extirpation from the island, learn more about the habitat requirements of the species, and develop best restoration practices. The translocated reserve populations established in the first phase are now in their second and third years of recruitment without supplemental planting or seeding, irrigation, or maintenance weed control. These populations appear to be persisting in a variety of habitat types and through distinct precipitation regimes. This success heralds the initiation of the second phase of the project and allows for further focus on more efficient installation methods, overcoming monitoring challenges, and fostering population sustainability.

Preventing extinction of an endangered annual forb, San Mateo thornmint

Christal Niederer, Stuart B. Weiss

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San Mateo thornmint (*Acanthomintha duttonii* [Lamiaceae]) is a federal- and state-endangered annual forb known only from Edgewood Natural Preserve, San Mateo County, CA. The original population, occupying relatively bare patches within a < one hectare patch of serpentine vertisol soil, had been in decline for decades, from >50,000 plants in 1994, to 395 plants in 2009 (occupying 35 square meters (m2), to <30 plants in 2017 (occupying only 6 m2). In 2008, a restoration project began to census the population, increase seeds ex-situ, enhance existing habitat, find suitable introduction sites, and seed to augment the existing population and establish new populations. Seedling establishment rates have averaged 27 percent, and first-year survival to flowering 11 percent. Fecundity of individual plants is low, with most plants producing only one whorl (maximum 16 seeds). Unfortunately, abundance declined in subsequent years with few exceptions. In 2015 spring irrigation in seeded plots greatly increased fecundity, and numbers increased the following year. In 2016 and 2017 seeding included three additional serpentine vertisol sites within Edgewood, and produced a total of 7,549 plants occupying 237 m2 in 2017. In both seasons, the additional sites produced numbers similar to or better than the original site, producing cautious optimism. Challenges in the past decade include annual grass growth, drought (especially dry spring seasons), flooding rains post-seeding, dodder parasitism, deep cracks in the clay soils, and intermittent funding. In the long run, seeding multiple sites and creating opportunities for the thornmint to occupy suitable bare microsites will be necessary for self-sustaining populations.

The significance of functional diversity over percent cover: A call to use more native forbs in habitat restoration

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Native forbs are an important and essential component of California's varied ecosystems. Yet faced with the many challenges in ecological habitat restoration (including invasive plant competition, often high native cover performance criteria required, and expense), it remains relatively uncommon for restoration practitioners to include native forbs as significant components of restoration planting palettes. Aspects of the importance of the functional diversity provided by native forbs in California ecosystems are reviewed and discussed, including: functional diversity in below-ground root architecture and effects on soil shear strength, water infiltration, and soil biota; niche partitioning and competition with non-natives; provision of floral resources for native pollinators and other beneficial insects; and the important roles that forbs play in ecosystem food webs and wildlife habitat. The historical and current reasons for the relative lack of emphasis on forbs in habitat restoration will be explored, along with the challenges presented to establishing native forbs in large scale restoration projects, based on multiple case studies. Finally, practical recommendations will be provided to restoration practitioners motivated to include more native forb diversity and cover in habitat restoration projects.

Lessons learned from 20 years of habitat management for the federally listed mission blue butterfly

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The Bay Area endemic mission blue butterfly (*Icaricia icarioides missionensis* [Lycaenidae]) relies on certain species of lupine (*Lupinus albifrons*, *L. formosus*, and *L. variicolor* [Fabaceae]) growing in coastal grasslands to complete its life cycle. Despite 20 years of habitat restoration, mission blue butterflies (MBBs) have declined in many parts of the Golden Gate National Recreation Area. We will present our successes and challenges given limited resources, and how habitat management has adapted over time. Long-term vegetation monitoring shows success in controlling woody invasive plants that outcompete lupines, but that native scrub is encroaching into those same areas. Lupine cover has declined over this same period. Left unchecked the scrub could have a negative long term impact on lupine recruitment. Despite time spent on managing woody scrub, the data suggests that a fungal pathogen, *Colletotrichum lupini* (Glomerellaceae), that causes dieback in lupines is the main threat to MBBs. While we can't manage *Colletotrichum* itself, one host species of lupine, *L. formosus*, is

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known to be more resistant than other lupine species. In order to buffer against the impacts *Colletotrichum* has on lupine host plants, and thus MBBs, we are introducing *L. formosus* to existing MBB habitat and mixing sources across geographic boundaries. This will provide genetic and habitat resiliency now and as the climate changes. We are also controlling for native scrub encroachment and using small scale disturbance to create conditions for lupine seedling recruitment. Finally, we are relocating the MBBs from nearby populations to provide genetic variation and boost numbers in the population.

Use of songbirds and other observable wildlife as metrics for selective acceptance of non-natives in restoration

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A fundamental goal in restoration is to limit non-native species. However, some researchers advocate an impact-based assessment to prioritize established non-native plant species for either control or "acceptance" into otherwise native ecosystems. We provide vegetation and wildlife monitoring results from three rare southern Californian habitats to demonstrate use of a relatively easy to measure parameter of ecosystem function, habitat provision, to assess impacts of non-native plant species. We monitored vegetation in restored needlegrass grasslands, coastal sage scrub (CSS) and riparian woodland sites. We trapped small mammals in all habitats over three consecutive nights per season. We surveyed birds using spot mapping (CSS) and qualitative assessments of two songbird species selected as indicators of habitat provision (grasslands). In CSS restoration sites native shrubs colonized annual grass-dominated areas that developed into shrub-dominated ecosystems over time. Trends of increasing native bird species richness and small mammal species richness and abundance indicated that, without control of annual grasses, increasing shrub cover provided improved native wildlife habitat. In needlegrass grasslands comprised of mixed native/non-native (*Bromus* and *Avena* species) grasses, *Sturnella neglecta* (Western Meadowlark) and *Ammodramus savannarum* (Grasshopper Sparrow) populations persisted over seven years. In riparian woodlands native small mammal captures from *Vinca major* (periwinkle)-dominated ground layer sites were > two times those in sites without *V. major* and species richness 1.75 times that of sites without *V. major*. Wildlife monitoring has stimulated us to view non-native species through a new lens to reduce workload and meet our goal of providing habitat for native fauna.

Conservation grazing to manage *Stipa pulchra* (Poaceae) populations: A demographic evaluation

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Due to the historic conversion of California's native grasslands to non-native annual grasslands, the management and conservation of native plant species is a central target of most management efforts within California. A key part of these efforts has been maintaining remnant populations of the iconic purple needlegrass (*Stipa pulchra* [Poaceae]). Conservation grazing has emerged as a useful management tool in these efforts, but we still have a poor understanding of how and when to implement these grazing practices. Here we present the results of a multi-year experiment evaluating the effects of grazing on population dynamics of *Stipa* at Vasco Caves Regional Preserve, CA. Within six paired grazed and ungrazed plots that were set up across an environmental gradient, we tagged *Stipa* across three demographic stages (seedling, juvenile and adult). For three years, we monitored survival and reproductive effort of tagged individuals. We used integral projection models to evaluate the population growth rates. *Stipa* population growth rates tracked rainfall such that they declined in dry years but increased in wet years. These patterns were exacerbated by resource environment and grazing. In dry years, grazing reduced the growth of individuals in low resource areas where overall *Stipa* populations were in decline, whereas grazing increased growth rates in high resource areas where overall *Stipa* population growth rates were increasing. Grazing can be a useful tool for maintaining and enhancing *Stipa* across a landscape when environmental conditions are additional taken into consideration when implementing grazing practices.

Community-based restoration of native Californian grasslands

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Native Californian grasslands have been heavily reduced and altered over the past 200 years, now comprising less than 1% of the grassland crop. This is primarily due to the overgrazing of cattle, urban development, and agricultural development, to the point of ecological insignificance. The shift from a native perennial grassland system to an invasive annual system has had widespread impacts on watershed health, species diversity and richness. Restoration efforts should be implemented to restore degraded ecosystems and promote native flora and fauna. For restoration to be successful many private and public entities such as Homeowner Associations, Community Centers, volunteers, park districts, federal and state agencies must work together. This would reduce costs, bring communities together, educate the public, engage citizens and most importantly promote native plant usage. Benefits of restoring native grasslands include

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slope stability, erosion control, promotion of native plants, less water usage, less risk of fire, habitat for native wildlife, low maintenance and reduction of pesticide use. With a climate that is rapidly changing, these benefits are increasingly important for the safety and security of human and wildlife health. Community based restoration would include community outreach and engaging homeowner associations. Project monitoring would include a comprehensive scientific analysis consisting of recording soil moisture, organic matter, bulk density, as well as a flora and fauna diversity and richness survey. Resampling will occur every 5–10 years to analyze the changes after restoration has occurred. Expectations for this project are to conserve, restore and stabilize.

California Plant Rescue: A collaborative vision to conserve the California flora

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The California Plant Rescue (CaPR) is a collaboration of not-for-profit botanical institutions working to conserve the wild species of California and the California Floristic Province. CaPR has the over-arching goal to secure the future of California's native flora by collecting seeds of California native plant species for long term preservation in regional seed banks (ex-situ conservation), and to record information from wild populations to support information needed for land management efforts (in-situ conservation). Since being founded in 2015, CaPR has made significant progress. Through partnerships with the Millennium Seed Bank and Bureau of Land Management, seed collection of rare species has increased significantly, and regular communication and standardization of practices among CaPR partners has improved the conservation value of these collections. While much progress has been made, the organization is still in its first chapter. I'll discuss the future of CaPR, emphasizing the collaborative nature of the project, and ways in which the California botanical community can help advance these efforts. The issues facing plant diversity in the 21st century will require novel and creative solutions, drawing on multiple areas of expertise. CaPR seeks to help organize those efforts and ensure that the flora of California flourishes in this century and beyond.

Vegetation Classification, Mapping, and Monitoring

Government agencies, NGOs, academic institutions, and consulting firms have been improving standards and products in vegetation mapping and classification since Geographic Information System and remote sensing technology have expanded in the late 20th century. Vegetation mapping and classification are important tools for species, habitat, and landscape assessment, analysis, monitoring, and conservation, driving many of today's decisions for land-use planning. This session showcases promising recent uses of vegetation mapping and monitoring for decision-making in conservation and management efforts throughout California.

Coordinated monitoring of wildlife and native plants in California: Vegetation alliances explain variation in avian community composition

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As a public trust agency, the California Department of Fish and Wildlife is responsible for conserving and managing fish, wildlife, and botanical resources throughout the state. Effective planning to protect these resources requires comprehensive monitoring of species populations and distributions at large spatial scales. The Department in collaboration with the University of California is working towards coordinating multi-species wildlife surveys and vegetation mapping throughout the state. For example, 226 random sites throughout the Mojave Desert ecoregion were concurrently surveyed for birds, reptiles, bats, other mammals >0.5 kg, and vegetation in 2016. Breeding passerine birds were surveyed at each site using automated sound recorders at different times of the morning over three consecutive days. We modeled avian occurrence using a multi-species occupancy model that adjusted for heterogeneities in detection probability. We also measured and classified vegetation alliances at these same sites using the National Vegetation Classification System that is used widely throughout the USA. Using hierarchical cluster analysis, we found that the composition of avian metacommunities estimated from occupancy modeling was partially explained by differences among vegetation alliances grouped on dominant plant genus. This finding highlights the value of coordinated natural resource monitoring for wildlife and plants. The conservation implication is that this type of data could help planners to protect wildlife species in part through a better understanding of the vegetation communities that support wildlife.

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Measuring the health of a mountain: Vegetation indicators for ecosystem health of Mount Tamalpais

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Mt. Tamalpais in Marin County is a biodiversity hotspot, hosting over 1,000 plant taxa in more than 100 recognized communities — as well as the animals and physical processes that maintain this rich landscape. Determining whether Mt. Tam is "healthy" was the focus of a year-long process, selecting indicators and metrics and determining status and trend in relation to goals, with information gleaned from available sources such as vegetation maps, species lists, rare and invasive plant inventories and monitoring, research, and plant community monitoring. Initial indicators included grasslands, redwood forests, oak woodlands, maritime chaparral, serpentine barrens, Sargent cypress stands, riparian areas, and wet meadows; these communities represented high diversity, iconic or rare plants, and sensitivity to stressors such as climate change, disease, absence of natural fire regime, and presence of invasive species. After workshop feedback, shrublands were added. The overall species list, percent of non-native and invasive plants in the flora, and provisional list of likely extirpated species were also examined. Having repeated landscape-scale vegetation maps, up-to-date rare and invasive plant population data, and reasonably comprehensive historic and recent local floras were essential in the process.

Interactive web platforms drive conservation assessments and planning: West Mojave ecoregion case study

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Conservation planning and assessments continue to progress rapidly as computing and prioritization methods become more advanced. However, there remain large challenges for organizations in terms of data access, usability of platforms, and collaboration among groups. The online web platform Data Basin allows users to easily share spatial datasets and bridges the divide between conservation planners, organizations, and stakeholders of all technical skill levels. Integrated tools such as the Environmental Evaluation Modeling System (EEMS) and new interactive tools such as EEMS Online facilitate participation and drive co-production of planning and prioritization in a transparent and easily understood process. This method of integrative conservation planning has taken place in the San Joaquin Valley and most recently in the Mojave Desert. In the West Mojave Ecoregion, a group of diverse environmental stakeholders came together to help drive, direct, and review a planning effort that identified areas of high conservation value and areas of lower conflict for solar energy development in the region. This involved the creation of a conservation value model that identified areas of high vegetation value, focal species habitat, occurrences of threatened and endangered species, and connectivity corridors. The process was facilitated by sharing data on Data Basin, synthesizing disparate data with EEMS logic models, and allowing for review and analysis to be undertaken by environmental stakeholders via EEMS Online. Ultimately the group identified 200,135 acres (6.2%) out of the 3.2 million acre study area as lower conflict land that may be suitable for solar development.

Rare Natural Communities

This session examines the identification of rare natural communities and the use of vegetation mapping to inform their conservation.

Red-listing ecosystems in the Americas: Some preliminary findings for California

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Everyone knows that coral reefs are in danger, and that the rainforests are disappearing — or do we? How much of these ecosystems are left, what are they threatened by, and how likely are they to disappear across their range? Accelerating land use and climate change threatens ecosystems worldwide. Conserving biodiversity hinges on our ability to understand changes in the condition of the ecosystems and the species they support. One important step is documenting the at-risk status of ecosystems. With generous support of major foundations and others, we have initiated the development of the IUCN Red List of Ecosystems across the Americas. Like the IUCN Red List of Species, a system that ranks species based on their risk of extinction, the Red List of Ecosystems ranks which ecosystem types should be considered "Vulnerable" "Endangered" or "Critically Endangered." Side by side with species ranking of conservation concern, the Red List of Ecosystems provides a more complete picture of the status of biodiversity. This process requires that we address a series of the technical issues and challenges, including how ecosystem types are classified, how we map their distribution, and then identify key ecological processes that could lead to their decline. How do we define and measure ecosystem degradation? And how does that differ across different ecosystem types? Starting with initial findings from Mediterranean ecosystems more broadly, we will identify some of California's more endangered upland and wetland ecosystems, the underlying reasons for their status, and information needs to complete the picture.

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Global, regional, and local rarity of vegetation communities as a foundation for the Bay Area Conservation Lands Network

Stuart Weiss, Tom Robinson

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The Bay Area Conservation Lands Network (CLN) is a conservation vision for 10 counties around San Francisco Bay (www.bayarealands.org). Vegetation rarity was central to the CLN process. A custom vegetation map, synthesized from available sources, was used as a "coarse filter" for biodiversity. The medium resolution classification into 51 vegetation types, including serpentine variants and climatic stratification of annual grasslands, represented ecological complexity of the region. Vegetation types were stratified by 33 "landscape units" — mountain ranges and valleys — to capture biogeographic diversity and local rarity. Conservation goals for each of the 500+ vegetation x landscape unit combinations were set at 90% for globally and regionally rarest, 75% for locally rare (<5% of the landscape unit), and 50% for common types. Marxan software generated local networks within landscape units to meet the goals, while maximizing conservation suitability. The serpentine community variants captured numerous rare endemics, and all rare species were explicitly included as a "fine-filter" based on CNDDB records. Consideration of local rarity, especially mesic vegetation within arid landscapes or conversely, arid vegetation within mesic landscapes, naturally created a "climate-smart" network. CLN was first released in 2011, followed by a 2014 Progress Report, and has been widely used to guide conservation decisions and assessments. In 2017, a CLN "Science Expansion" was started, with goals of incorporating ~140,000 acres of new protected lands to reconfigure the network, updating data sets including newer fine-scale vegetation maps, and incorporating conservation co-benefits such as water resources, viewsheds, rangelands, agriculture, and carbon storage.

Livestock grazing affects vernal pool specialists more than habitat generalists in montane vernal pools on the Modoc Plateau

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Although livestock grazing was initially considered a threat to California's rare vernal pool species, 21st century conservation strategies have utilized grazing as a tool to reduce non-native species cover and litter in Central Valley vernal pools. We asked whether livestock grazing conferred conservation benefits to montane vernal pools, which lack this dominant non-native species component. We further asked whether vernal pool specialists and habitat generalists respond differently to livestock grazing, reflecting the different evolutionary histories of these species. To explore the relative effects of livestock grazing and seasonal precipitation on montane vernal pools, we evaluated plant communities in 20 vernal pools on the Modoc Plateau, some of which had been fenced to exclude livestock for up to 20 years. We found that livestock exclosures strongly favored perennial vernal pool specialists over annual vernal pool specialists. By contrast, the cover of habitat generalists was influenced more by seasonal precipitation than by livestock grazing. Results suggest that over time, livestock exclosure may lead to a loss of cover of annual vernal pool specialists, species that land managers often wish to promote due to their endemism and rarity. However, perennial vernal pool specialists could be lost or greatly reduced where livestock grazing has been the long-term management strategy, and heavy utilization may also result in adverse impacts to annual species. Management that includes both fencing and grazing at varying spatial and temporal scales may be most effective at supporting the entire suite of species endemic to montane vernal pool habitats.

Connecting Californians with the chaparral, the state's most extensive, native ecosystem

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To discover how chaparral is being presented to the public, we examined nature centers, volunteer naturalist programs, publications, and curricula in Southern California. A number of nature centers do an excellent job presenting accurate content. However, the majority need updates to reflect current science and the major contribution chaparral makes to the state's biodiversity. Publications and curricula also need significant improvements. More than half of the nature centers reviewed offer extensive naturalist training courses. Passion and enthusiasm of staff and volunteer naturalists are as important as content in creating successful natural history programs. Utilizing active learning methodology vs. lecturing can be a key factor in a program's success. This approach combines active learning where students participate in the teaching process and meaningful interpretation that establishes personal connections with nature. The greater understanding resulting from this approach can inspire a diverse, new generation of long-term nature advocates and create an informed public that will appreciate the chaparral's value.

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The effects of cattle grazing on native annual forb persistence in California coastal prairies over 15 years

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Livestock grazing has been shown to benefit low-stature grassland plants, as grazing can keep tall exotic annual grass cover and thatch low, thereby reducing competition for light at the soil surface. Short-term studies suggest that cattle grazing can help to conserve native annual forbs, which comprise much of the native richness in northern California coastal prairies. This study is a longitudinal follow-up on a 2000–2001 comparison of native annuals forbs in grazed and ungrazed northern coastal prairies. We resampled sites from Monterey through Sonoma County in 2016–2017 and compared results to the earlier surveys to determine whether the effects of grazing on native annual forb species richness and cover has remained consistent over time. Shrub cover has increased substantially in ungrazed grasslands and a small amount in grazed grasslands since 2001. Although there continued to be significantly greater native annual species richness in grazed than ungrazed grasslands, there was a marginally significant treatment × time interaction. Average species richness declined in grazed prairies, and remained nearly constant in ungrazed prairies. Native annual forb cover varied greatly across sites, and there was no significant effect of grazing management or time on native annual forb cover. Overall, differences in native annual forb richness between grazed and ungrazed prairies may be shrinking. Our results suggest that cattle grazing helps maintain native annual forb diversity and reduce shrub cover, but that the cover and richness of native annual forbs is strongly affected by other factors, including variability in annual precipitation and localized site conditions.

A vascular flora of the Adobe Valley and surrounding hills, Mono County, CA

Sophia Winitsky

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This study aims to document the vascular flora of the Adobe Valley and surrounding hills in Mono County, CA. Less than 100 herbarium specimens are recorded from the 90 square mile study area based on a search of the Consortium of California Herbaria, with little botanical documentation away from well-established roads or in the alkali meadows. At the center of the study area the U.S. Fish and Wildlife Service manages the River Spring Preserve, a 638–acre alkali and freshwater wetland. The preserve emphasizes the importance of the alkali flat ecosystem, a habitat that is representative of Owens Valley, but severely threatened by drought, trampling by cattle and feral horses, off-road vehicles, and water diversion. Alkaline ecosystems farther south have experienced more severe water pumping making the Adobe Valley a good place to establish baseline information to better understand sustainable groundwater extraction. In addition, there is a need for a floristic checklist of the River Spring Preserve as specified in the Preserve's 2016 Management Plan. Many endemic species have the potential to occur in the Adobe Valley and surrounding hills, so far I have documented the following California Native Plant Society listed species: *Plagiobothrys salsus* (Boraginaceae), *Allium atrorubens* var. *cristatum* (Alliaceae), *Calochortus excavatus* (Liliaceae), *Ivesia kingii* var. *kingii* (Rosaceae), *Cymopterus globosus* (Apiaceae), *Crepis runcinata* subsp. *hallii* (Asteraceae), *Plagiobothrys parishii* (Boraginaceae), *Spartina gracilis* (Poaceae), and *Sphaeromeria potentilloides* var. *nitrophila* (Asteraceae), and *Tetradymia tetrameres* (Asteraceae). My goal is to systematically document the vascular flora of the region, publish a voucher-based checklist, and increase the overall understanding of this severely threatened ecosystem.

Planting *Carex scopulorum* (Cyperaceae) seedlings for subalpine meadow restoration

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Exclosures are shown to be an effective method in restoring above ground biomass production in meadows, yet there remains a deficit of minimally intrusive herbivore exclosure experiments adapted for restoration along a hydrologic gradient. This research focuses on the biomass accumulation, both above and below ground, associated with planted *Carex* (Cyperaceae) seedlings and determines effective establishment conditions. We are testing a restoration design by planting *Carex scopulorum* seedlings inside and outside cost-efficient, small mammal exclosures along a hydrologic gradient. We are analyzing the establishment requirements of *Carex scopulorum* seedlings to determine if: 1) plant metrics (growth, survival, total biomass) will be higher in herbivore exclosures; 2) plant metric maxima will occur equidistant from the extremities of the naturally occurring hydrologic gradient on site; and 3) the herbivory treatment will result in lower root-shoot ratio, higher compensatory growth, and greater bare ground and non-*Carex scopulorum* plant cover. Measurements of seedling growth include tiller density spread, leaf lengths and shoot counts, above and below biomass accumulation. In addition, variation in soil moisture, water table depth, and species composition are measured. Overall, we aim to help guide land managers in deciding where their planting efforts may be most effective with this species when restoring similarly degraded wetlands throughout the Yosemite National Park and the Sierra Nevada.

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Seedling recruitment of *Atriplex polycarpa* (Chenopodiaceae) in the San Joaquin Valley of California: The roles of invasive grass competition and their residual dry matter

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Invasive annual grasses dominate much of the American West. In the San Joaquin Valley of California, grasses widely invade upland habitats, with native saltbush shrublands existing in remnant patches. We tested the hypothesis that invasive grasses limit saltbush recruitment, leading to persistently invaded grasslands. One way this could happen is through competition for resources between the grasses and saltbush seedlings. Another possibility is that the dense cover of residual dry matter (RDM) produced by the grasses alters the habitat for saltbush seedlings. An experiment manipulating competition through weeding, RDM presence, and shade cast by the RDM was conducted. We tested the effect of competition and RDM presence on seeds and seedlings of the most common upland saltbush shrub in the southern San Joaquin Valley, *Atriplex polycarpa* S. Watson (Chenopodiaceae). Seeds were sown in plots to assess germination and emergence, seedling density, and percent vegetation cover. Parametric and non-parametric analyses were conducted as appropriate to assess treatment effects. Soil moisture and temperature were also measured and statistically analyzed. We found both competitive interactions and the addition of RDM significantly adversely affected germination and survival of *A. polycarpa* seedlings (competition: $F_{1,29} = 5.57$, $P = 0.033$, RDM: $F_{1,29} = 19.72$, $P < 0.001$) with no interaction between the treatments. *A. polycarpa* coverage was significantly lower in the unweeded and +RDM treatments compared to controls ($H1 = 11.89$, $P < 0.001$). Management efforts aimed at limiting grass competition, such as targeted grazing, may promote saltbush recruitment and enable ecological succession to mature saltbush shrublands.

Evidence for pre-settlement wildfires in perennial grass-dominated landscapes of the eastern Mojave Desert and implications for fire management in the Mojave National Preserve

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Portions of the eastern Mojave Desert region that receive significant monsoonal precipitation contain large areas dominated by perennial C4 grasses. Some of the best representations of these grass-dominated landscapes are in the eastern portion of the Mojave National Preserve (MNP), San Bernardino County, California. Since the late 1890s, livestock ranching significantly impacted perennial grass-dominated vegetation. Removal of livestock from much of the MNP around 2000, coupled with years of abundant warm-season precipitation, has led to a resurgence of perennial grasses. In savanna-like vegetation containing scattered junipers (*Juniperus osteosperma* [Cupressaceae]), old, weathered, fire-scarred juniper stumps provide evidence of extensive wildfires in pre-settlement and perhaps early settlement times (1800s–early 1900s). Early settlers selectively cut standing, fire-killed juniper trees for fuelwood. Axe cuts superimposed on charred wood surfaces demonstrate the occurrence of fire prior to woodcutting. Materials discarded by woodcutters help constrain the timing of wood harvest and the previous wildfires. The abundance of intact stumps provide a rich potential source of materials for detailed dendrochronological analyses of wildfire history. Information from charred stumps and historic information indicate that wildfire played a significant role in pre-settlement times in maintaining perennial grass-dominated landscapes in this region. However, more than three-quarters of the MNP is zoned for full wildfire suppression, including all of the most extensive areas dominated by perennial grasses. Detailed investigations of pre-settlement fire history in this area will help inform management approaches to wildfire within the MNP.