MAPPING, SURVEYS, & TOOLS

23.01 Ecology and distribution of *Lewisia leeana*, quill-leaf lewisia (Montiaceae), in eastern Fresno County

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The purpose of this study is to determine the ecology and map the distribution of the disjunctive population of *Lewisia leeana* (Montiaceae) in eastern Fresno County. Mapping was carried out during 52 hiking days in 2013-2016 which included photographing, establishing location with GPS, and posting to iNaturalist. The ongoing baseline study focuses on expanding the five areas where 15 observations of *L. leeana* were made from 1900 through 2006. A total 250 observations of *L. leeana* have been posted to iNaturalist. *L. leeana* is almost always found in soil of granitic origin on north facing slopes at elevations greater than 2600m, and it shows no consistent associations with any other organisms. An additional 1,382 other plants and fungi (158 species) were identified during the study and posted to iNaturalist. Continued study of the distribution of *L. leeana* may help monitor effects of climate change. I recommend followup monitoring of key locations every five years.

23.02 Plant skeletons of California deserts

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Identifying plants in various stages of development is a crucial but often challenging task once a plant has begun to senesce. This is especially true of many species that are found in the desert, as many have a short growth period and exist most of the year as dry remnants. Due to the dry desert climate, these remains of plants, or "skeletons" are well preserved and can therefore be used for identification. Sclerenchyma is a plant tissue that provides mechanical stiffness and strength, and is the main structural support in a plant. Fibers and sclereids are specific types of sclerenchyma cells, and fibers act as a skeleton for a plant body and are left behind once the growing season has ended. Many species of plants in the desert persist year-round as these fiber skeletons, making it possible to identify them long past flowering and fruiting. This photo collection of noteworthy skeletons of California desert plant species is a small sample of what can be seen in the field; all photos shown on the poster and more are available on CalPhotos.

23.03 Updated native plant survey of the Palos Verdes Peninsula: Existing plants and new finds

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The Palos Verdes Peninsula (PVP), which is in the South Bay area of southern California, is known for its scenic coastline, island history, and remnant patches of coastal sage scrub (CSS). These CSS patches dot the landscape and provide some of the last remaining CSS between Orange County and the Santa Monica Mountains. The PVP is also home to many rare plants such as *Dudleya virens* subsp*. insularis* (Crassulaceae), *Calochortus catalinae* (Liliaceae) and *Crossosoma californicum* (Crossosomataceae). The last detailed botanical survey of the PVP was conducted by Angelika Brinkmann-Busi (California Native Plant Society, South Coast Chapter Conservation Chair) back in the early 1990s. The purpose of this study was to provide an updated look at the native vascular component of the PVP. Surveys were conducted over the past few years with several new species being added to the original flora, such as *Piperia michaelii* (Orchidaceae) and *Calystegia occidentalis* subsp*. occidentalis* (Convolvulaceae).

23.04 Assessing the rarity status of the newly described Shasta County endemic, *Adiantum shastense* (Pteridaceae), by employing innovative tools in geographic information systems

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Assessing the status of plants with a limited distribution in California has been extremely time consuming. In the past, the California Native Plant Society (CNPS) has employed the same detailed method for assessing the distribution of watchlist, California Rare Plant Rank (CRPR) 4 plants, that is used for assessing the distribution of threatened or endangered CRPR 1B and 2B species. While a sound approach, this method has proven to be excessive when applied to CRPR 4 plants, which may have dozens if not hundreds of records, and for which records are not updated or maintained in our databases once included. Current technologies, along with the advancement of newly available public datasets, have allowed CNPS to develop new tools to estimate a total number of occurrences for these uncommon plants that is still credible, yet not nearly as time consuming. The previous method involved handling each collection individually, while the new tools allow for easy batch processing and assimilation of data. A recently described Shasta County endemic, Shasta maidenhair fern (*Adiantum shastense* Huiet & A.R. Sm. [Pteridaceae]), was put through our new process in October of 2016 and provided us with an estimate of 51 occurrences from the initial 116 collections and observations. This helped lead to the general consensus that Shasta maidenhair fern meets the criteria for addition to CRPR 4 of the *CNPS Inventory of Rare and Endangered Plants*, and it was subsequently added to CRPR 4.3 of the *CNPS Inventory* in November of 2016.

23.05 Vegetation classification for the Mojave Desert Inventory and Monitoring Network of National Parks

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In collaboration with the National Park Service, California Native Plant Society (CNPS) and NatureServe ecologists compiled over 9,000 vegetation surveys and analyzed over 4,000 surveys from three parks and environs of the Mojave Desert and related ecoregions. We developed a vegetation classification, identifying approximately 105 alliances from Lake Mead National Recreation Area, Mojave National Preserve, and Death Valley National Park. Data analyses of the three park areas spanned more than 4 million acres, and enabled cross-analyses with other parks and preserves such as Joshua Tree National Park (in California) and Red Rock Canyon National Conservation Area (in Nevada). We used classification and ordination methods including agglomerative cluster analysis, indicator species analysis, and Nonmetric Multidimensional Scaling (NMS). This dynamic analysis process allowed for broad development and interpretation of the U.S. National Vegetation Classification (USNVC) hierarchy through networking of ecologists across the nation. This helped increase exposure to and peer review of the USNVC, resulting in updates at the macrogroup, group, alliance, and association levels. We elucidated various examples of the revised USNVC with changes at the alliance and association levels in the project. For instance, we moved the *Pleuraphis rigida* (Poaceae) Desert Grassland Alliance to the North American Warm Semi-Desert Dune & Sand Flats Group in one macrogroup, while we defined a separate *Cylindropuntia acanthocarpa* (Cactaceae) / *Pleuraphis rigida* Shrubland Alliance in the Mojave Mid-elevation Mixed Desert Scrub Group. We simplified or expanded other alliances, e.g., collapsing nine alliances into four and expanding three others in the Semi-Desert Shrub & Herb Dry Wash & Colluvial Slope Group.

23.06 A visual guide to *Carex* (Cyperaceae) of Marin County

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Sedges (*Carex* species [Cyperaceae]) are perhaps best known for their taxonomic difficulty. Yet *Carex* is the largest genus of flowering plants in California, comprising a major component of plant diversity in the state. Sedges are ecologically important in a wide variety of habitats, especially in wet to mesic environments. Wetlands in California have been disproportionately impacted by human activities over the past two centuries, and there is insufficient information on the local status of many sedge species, because they are seldom identified beyond genus, except by experts. To aid a wide range of users in Marin County, we developed an interactive visual identification tool, utilizing high resolution scans and microphotographs of sedge species known to occur in the county. This digital tool facilitates identification by visual comparison of morphological differences, and operates on web and mobile platforms. Users may select multiple characters from visual or text-based keys. The tool also features fact sheets for each species, and a glossary of terminology. This next generation field guide offers land managers, biologists, and naturalists a new way to appreciate the fascinating and misunderstood world of sedges.

23.07 Rare plant hotspots in San Mateo and Santa Clara counties

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Where are rare plant hotspots located in the Santa Clara Valley Chapter of the California Native Plant Society (CNPS) counties? This effort was inspired by the statewide organization's Important Plant Areas (IPAs) initiative in the 2015-2016 Conservation report, conversations with Don Mayall, and reviewing the East Bay Chapter's Guidebook to Botanical Priority Protection Areas. To make these maps, I conducted density analysis of California Natural Diversity Database (CNDDB) plant point records in San Mateo and Santa Clara counties, the two counties represented by the chapter. A total of 41 hotpots were identified. San Mateo County has 17 hotspots, with 13 in the Central Coast Subregion of the California Floristic Province and 4 in the San Francisco Bay Subregion. Santa Clara County has 24 hotspots, with 5 hotspots in the Central Coast Subregion and 19 in the San Francisco Bay Subregion. Each of the 41 hotspots described on the maps are provided with short summaries and land conservation status as provided by the Bay Area Greenbelt Alliance.

ECOLOGY

23.08 Facilitative effects of nurse shrubs on the growth and survival of California sage scrub native plants

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Recent and significant environmental changes have greatly affected native recruitment and re-establishment in chaparral and sage scrub plant communities. Larger, established shrubs of these water-limited environments may play important roles in facilitation, where neighboring plants may benefit from shared resources and protection from herbivory. Indeed, living plants strongly influence community structure and interactions; however, there is little information suggesting that dead shrubs in drought-affected landscapes may provide similar services as live shrubs. We conducted an experiment in the Cal Poly Pomona Voorhis Ecological Reserve to determine whether seedling growth depended on abiotic factors (microclimate conditions nurse plants create), or on biotic factors (herbivory). Two native woody shrubs, *Artemisia californica* (Asteraceae) and *Salvia mellifera* (Lamiaceae) and four annual native species, *Amsinckia intermedia* (Boraginaceae), *Deinandra fasciculata* (Asteraceae), *Phacelia distans* (Boraginaceae), and *Pseudognaphalium californicum* (Asteraceae) were outplanted and sown, respectively, in five blocks with three nurse treatments (live shrub, dead shrub, and exposed areas), with a nested caged and uncaged treatment in each. Environmental sensors and trail cameras were installed to measure abiotic factors and capture and estimate herbivore occupancy. Plant height, plant biomass, and abiotic data were analyzed to determine abiotic and biotic effects on growth and survivorship under nurse shrub and caged treatments. Cages deterred herbivory by small mammals in all blocks, and significantly affected *A. californica* and *S. mellifera* growth in 2016. Collection and analysis of shrub seedling growth is ongoing, and we expect to see similar patterns to those observed in the previous year.

23.09 Investigating allelopathy and soil moisture as factors determining community composition of a Southern California black walnut woodland

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Soil moisture and allelopathy can affect both plant germination and establishment. Understanding their interaction can help explain the distribution of native and invasive plant species and provide methods for cultural control of invasive plants. *Juglans californica* (Juglandaceae), a Southern California endemic tree, produces juglone. Juglone's allelopathic effects have been studied on agriculturally significant crops but how it could affect invasive and native species occurring under the canopy of *J. californica* has not been studied. *Brassica nigra* (Brassicaceae) is an invasive forb that produces allelopathic mustard oils and is a dominant member of some walnut woodland communities. Since these allelochemicals are abundant during times of high soil moisture, it is likely both species' allelopathic potentials are most influential in winter than in summer. Invasive dominance in walnut woodlands may be due to invasive species' higher tolerance of allelopathy than native species'. Our ongoing greenhouse experiment tests the tolerance of three invasive and three native species to

allelochemicals from *J. californica* and *B. nigra*. Each species is being treated with one of the following: *J. californica* mulch, *B. nigra* mulch, hay mulch, allyl isothiocyanate, juglone, or water. To examine how soil moisture and allelopathy interact, each plant is also given a moisture regime: dry or wet. Each treatment combination is replicated four times. By studying the tolerance of these species to allelopathy, we can better understand why invasive species are more abundant in this ecosystem and determine if mulch derived from walnut litter can be useful in the management of invaded areas.

23.10 Restoration of invaded walnut woodlands using a trait-based community assembly approach

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Non-native plant invasions have been cited as a cause of decline of numerous plant communities, including Southern California walnut woodlands. These woodlands are dominated by *Juglans californica*, the California black walnut, which is a rare, endemic, allelopathic tree. Barriers to native community assembly in walnut woodlands include abiotic filters, such as light and water availability, biotic filters, including competition with invasive plant species, and allelopathy, due to the chemical juglone. Two experiments were conducted to assess how these abiotic and biotic environmental filters affect the establishment, growth, and reproduction of native and non-native annual plant species, with a focus on developing a trait-based restoration approach for this ecosystem. A laboratory experiment was used to assess species resistance to juglone at concentrations ranging from 0 to 0.5mM. A field experiment was conducted to examine native and non-native annual plant recruitment with respect to microclimate and competition. Communities containing native only, invasive only, or a mixture of both species types were assembled within canopy and exposed locations. Native *Amsinckia intermedia* (Boraginaceae) and invasive *Brassica nigra* (Brassicaceae) were the first species to germinate, and had the highest germination rates across all canopy and seeding treatments. Preliminary functional trait results showed a significant reduction in leaf size in both species when grown in exposed areas, compared to areas under the walnut canopy ($\beta = -25.0$, $p<0.001$). Results show that native, as compared to invasive, species tolerate higher concentrations of juglone during germination, and that the microclimate under walnut canopies may facilitate the growth of early-germinating species.

23.11 Defining good and bad Catalina mariposa lily habitat to refine habitat improvement methods in the Santa Susana Mountains

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Psomas, Los Angeles, CA, USA

Catalina mariposa lily (*Calochortus catalinae* [Liliaceae]) has a California Rare Plant Rank of 4.2. It is a California endemic perennial bulbiferous herb that grows in a variety of habitats in the south coast, the western transverse range, the northern lobe of the peninsular range, and Santa Catalina Island. The project area is located in Simi Valley in Ventura County, which regulates List 4 taxa as fully protected. Within one square mile of the project area, the Catalina mariposa lily grows in six different habitat types: wild oat (*Avena fatua* [Poaceae]) grassland, inland scrub oak (*Quercus berberidifolia* [Fagaceae]) scrub, coastal sage scrub, ripgut brome (*Bromus diandrus* [Poaceae]) grassland, disturbed chaparral, and black sage (*Salvia mellifera* [Lamiaceae]) succulent scrub. Surprisingly, the lily had the highest density and largest population within the wild oat grassland, a habitat dominated by a non-native annual grass. The lowest density and smallest population was within the ripgut brome grassland. A series of ANOVAs and linear regressions were performed to find the environmental characteristics that differentiated habitats with larger populations from habitats with smaller populations. A nonparametic analysis defined the community differences between the two groups. We found that more lilies occurred in habitats with greater biodiversity, lower vegetation cover, and higher cover of bare ground. Conversely, low biodiversity, high vegetation cover, and high thatch cover are all characteristics that occur in habitat with low lily density. This informs habitat improvement efforts to remove non-native plants that habitually create thatch, such as ripgut brome.

23.12 Effects of nutrient and water addition on the seed bank of a serpentine grassland system

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Californian serpentine soils are home to endemic plant communities which maintain a high level of diversity and coexistence of plant species. Global changes, such as climate change and nutrient enrichment are altering precipitation and nutrient dynamics, which significantly impact the composition and diversity of these plant communities. Past research at McLaughlin UC reserve has demonstrated that increased rainfall together with nutrient addition alters the composition and diversity of above ground plant communities, leading to increased biomass, high species turnover and reduced diversity. Even though the water and nitrogen addition treatments ended in 2014, above ground plant communities have not recovered to their original stage. However, the potential for recovery may still be present through a persistent seed bank, which may serve as a reservoir for species diversity. In order to determine if the seed bank has maintained diversity of the serpentine plant communities we sampled the seed bank in control and treatment plots and conducted a germination study in the greenhouse to determine species diversity and composition in the seed bank. If the below ground communities mimic the above ground communities, this may indicate an alternative stable state exists, with little possibility for recovery of the communities to their original stage. Alternatively, if the seed bank has maintained greater diversity and original species composition there may be restoration possibilities, including removal of litter cover or all above ground biomass as disturbance may stimulate germination from the seed bank.

LICHENS & MOSSES

23.13 Assessing sex-specific microhabitat associations in the Mojave Desert moss *Syntrichia caninervis* (Pottiaceae)

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Both a heavy reliance on asexual reproduction and the evolution of desiccation tolerance have allowed mosses to successfully inhabit arid environments worldwide. The species *Syntrichia caninervis* (Pottiaceae) is particularly successful in colonizing these environments. Studies on *S. caninervis* in the Mojave Desert, CA have observed a high female bias based upon phenotypic sex expression, and have suggested that male mosses may be restricted to shaded and moist microhabitats, because the rare expression of male gametangia is limited to these microsites. But sex expression is not necessarily a proxy for the distribution of sexes, as most ramets in a given population of *S. caninervis* do not express sex and could represent either males or females. Here, I use a novel genetic sex marker to test for the presence of sex-specific differences in microsite use in *S. caninervis* across 12 microhabitat variables in the Mojave Desert. A total of 54 collections were examined for sex expression, and sex of sterile samples was determined through PCR followed by restriction enzyme digestion and visualization of the digested products. Multivariate regression models applied to the microhabitat data will infer the presence or absence of sex-specific differences in microhabitat associations. The results may challenge current assumptions if they indicate that males and females are not microhabitat specific, as sex expression suggests. These findings will have important implications for resolving the ecological and evolutionary drivers of sex ratio bias in *S. caninervis,* providing context for understanding sex evolution in other types of plants.

23.14 Species delimitation and patterns of infraspecific variation in the moss *Anacolia menziesii* (Bartramiaceae)

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With a new California Native Plant Society (CNPS) chapter devoted to bryophytes (mosses, liverworts & hornworts) and active changes to bryophytes on the CNPS rare plants list, there is increasing interest in identifying conservation and management priorities among bryophytes. Here, we tested species circumscriptions in *Anacolia menziesii* (Bartramiaceae), a widespread and morphologically variable moss species that occurs throughout western North America. Historically, some have considered it to be a single heterogeneous species while others have considered it to be a species with two morphologically distinct subspecies or even as two separate species, *A. menziesii* and *A. baueri*. To test these alternative hypotheses, we measured morphological characters from more than 300 sporophyte individuals from more than 100 populations across the distribution of the species complex. We found no morphological evidence supporting the recognition of the California near-endemic *Anacolia baueri* as distinct from *A. menziesii*. Instead, we document striking morphological variation among individuals, both within populations and across the range of the species.

We also compare sporophyte dimensions to mean annual rainfall and other environmental variables to test whether environmental variation drives sporophyte dimensions across the distribution of the species.

23.15 Utilizing epiphytic lichens as an atmospheric bioindicator in California

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Lichen communities across California have degraded due to atmospheric pollutants such as heavy metal pollutants from point-source and nonpoint-source pollution, mainly from the Central Valley agricultural industry. The decline in lichen community health has occurred around urban areas and wildlands near pollution. It is critical to monitor the health of these communities, as lichens are primary successors, slowly creating habitat for vascular plants. Lichens rely on atmospheric inputs for growth and retain these elements in their thalli; this makes them good bioindicators for atmospheric pollution. Climate change in California is predicted to increase drought, which would cause stress resulting in a reduction of colonization. This compounded with pollution will likely affect the succession of vascular plants. Lichen health would be analyzed across California near urban centers and wildlands to compare species diversity, richness and pollutant levels. A gas chromatography mass spectrometer (GCMS) would indicate the quantity of heavy metals found in lichens such as selenium, cadmium, lead and sulphur. Thus, it is important to monitor and preserve these communities to ensure ecological stability. This study would assist in identifying areas with heavy atmospheric pollution, the most vulnerable lichen and plant communities, while creating a call to action of the reduction of pollutants for policy makers.

23.16 Status report on a rare moss from the San Francisco Bay Area, *Fissidens pauperculus* (Fissidentaceae): A template to aid in rare bryophyte conservation

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Bryophyte conservation has been gaining prominence in California since the initial addition of bryophytes to the California Native Plant Society (CNPS) *Inventory of Rare and Endangered Plants* in 2001 and with the founding of the CNPS Bryophyte Chapter in 2015. However, a gap in expertise among many botanical environmental consultants and the challenging nature of bryophyte identification frequently leads to rare bryophytes being ignored in rare plant surveys. We have prepared a status report on a rare bryophyte from the San Francisco Bay Area, *Fissidens pauperculus* (Fissidentaceae) (minute pocket moss) as a means to improve the understanding of the conservation status and identification of this rare moss. With both text and photographs, it covers these species' habitat requirements, known occurrences and their status, and both field and lab key characteristics to aid in identification. This status report could serve as a template for other rare bryophytes and becomes a useful tool to promote bryophyte conservation.

GENOMIC/GENETIC ANALYSIS

23.17 Using herbarium specimens to assess the loss of genetic diversity in the endangered *Streptanthus glandulosus niger* (Brassicaceae)

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Causes of endangerment include declines in population size, range contractions and fragmentation of once continuous populations. One potential consequence of these threats is the loss of genetic diversity. Higher genetic diversity leads to a greater capacity for adaptive evolution and so a loss of diversity may constrain a population's ability to evolve. In an era of climate change, this is especially important for species that cannot migrate with their preferred climate and must evolve *in situ*. We wanted to know how diversity in small, fragmented present-day populations compares to diversity 50 - 100 years ago, before suburban development. The Tiburon jewelflower (*Streptanthus glandulosus niger* [Brassicaceae]) is an annual plant endemic to serpentine soils on the Tiburon Peninsula, Marin County. It listed as endangered at the state and federal levels. It now exists as two small populations with no gene flow between them. We developed species-specific microsatellites to assess diversity at neutral markers and used herbarium samples (1902 - 1954) as our historical

reference. We found that (1) historical levels of genetic diversity were higher in terms of both allelic richness and observed heterozygosity, and (2) that the smaller of the two extant populations is experiencing drift. Elsewhere we have shown that the populations have experienced declines in growth rate over the last five years. We are currently testing whether a lack of genetic diversity may be contributing to population decline. Such information will help plan conservation programs, including the possibility of admixture between the two populations to restore genetic diversity.

23.18 A phylogenetic analysis of a putative species radiation in the genus *Suaeda* (Chenopodiaceae) from estuaries of northwestern Mexico

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Nearly 100 estuaries exist along the coast of Baja California and Sonora, Mexico, forming a series of unique wetland habitats isolated from each other by the surrounding arid landscape. The genus *Suaeda* Forssk. ex J.F. Gmel. (Chenopodiaceae) is common in these estuaries and appears to be in the process of diversification. Nine putative new species of *Suaeda* were detected by Wayne Ferren during fieldwork in this region in the 1980s, but additional taxonomic study was needed to before describing these as new to science. Nearly 350 specimens of both known and putative species of *Suaeda* were collected by Ferren from 1980-2000 and housed at the UCSB Natural History Museum at the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) for curation and research. To evaluate Ferren's hypotheses, DNA was extracted from four exemplars of each putative species, along with four outgroup species, and sequenced using high-throughput ddRADseq. The resulting data were then analyzed in pyRAD to infer a phylogeny. We compared the results of these genetic analyses against Ferren's taxonomic hypotheses and examine how these populations or species are phylogenetically related. Beyond the implications for taxonomy, we expect that these analyses will also demonstrate the unique biodiversity of these Mexican wetlands and their importance for conservation.

23.19 Using spatial phylogenetics to inform conservation at the archipelago-scale: An introduction to the Channel Islands Phylodiversity Project

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Conservation and land management actions are often prioritized in part using ahistorical measures of biodiversity such as taxonomic richness. Although familiar, these measures have shortcomings, including 1) treatment of all taxa as biologically equivalent, when it has long been recognized that taxa at a given rank differ greatly in depth and extent of evolutionary divergence and are therefore non-comparable, and 2) inability to detect spatial phylogenetic patterns in the area of interest, such as regions with concentrations neo- and paleo-endemism. An alternative approach is to incorporate phylogenetic history in biodiversity estimates. Phylogenetic diversity assessments overcome some of the shortcomings of ahistorical biodiversity metrics, but until recently have been difficult to implement. An ever-increasing volume of DNA sequence data and fine-scale geo-referenced specimen data coupled with new phylogenetic methods and phylodiversity metrics now permit the estimation of phylodiversity at relatively fine phylogenetic and spatial scales. Here we discuss the Channel Islands Phylodiversity Project (CIPP), a collaborative effort to understand the fine-scale distribution of plant phylodiversity on the California Channel Islands (ChI). The CIPP seeks to estimate phylodiversity on the ChI, including all 1,000+ plant minimum rank taxa (MRT) Here we outline the general goals of the CIPP, with an emphasis on spatial phylogenetic methods and metrics. We highlight our progress toward a phylogeny of the ChI flora, a tree that now includes over 700 of the ~1,000 ChI MRT, and conclude with a discussion of the novel perspective that spatial phylogenetics can provide toward the conservation of the remarkable ChI flora.

23.20 Identifying the genetic basis of serpentine adaptation in a California coastal endemic, *Aquilegia eximia* (Ranunculaceae)

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Plants in serpentine soils experience extreme nutrient limitation, elevated concentrations of heavy metals, high levels of Mg, among other extreme environmental factors. Plants inhabiting serpentine ecosystems have evolved a variety of mechanisms to survive in these inhospitable conditions. This project compares *Aquilegia eximia* (Ranunculaceae), a serpentine endemic along the California coast, to its more widespread serpentine-intolerant sister species, *Aquilegia formosa*. F1 hybrids between species have been utilized to create F2 populations, which will be planted in the greenhouse and phenotyped for their ability to grow on serpentine soil. This project will take advantage of the genomic resources available for *Aquilegia* to examine these two closely related species to elucidate the genetic basis of serpentine tolerance in *A. eximia*. I will perform a Quantitative Trait Locus mapping study using high throughput whole genome sequencing to genotype individual plants and link the phenotypic data for serpentine tolerance to particular loci along the chromosomes. This experiment plans to utilize upwards of 2,000 plants of various genotypes for our mapping population, which will allow us to examine the potential for particular genes' involvement in serpentine tolerance. This project has broader scale goals to identify new candidate genes that may give insight as to how adaptations to serpentine environments evolve in natural plant systems and how presence of these genes may affect the ability of plants to tolerate inhospitable environmental conditions. Understanding genetically how species become adapted to generally toxic soil is valuable knowledge that can be applied to many disciplines such as agriculture, restoration, and conservation.

23.21 How population decline can impact population genetics: A case study of eelgrass (*Zostera marina* [Zosteraceae]) in Morro Bay, CA

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In the last eight years, cover of California's native seagrass *Zostera marina* (Zosteraceae), has declined by over 95%. Eelgrass is an important ecosystem engineer, and large scale restoration efforts attempted in Morro Bay have all failed. The success of future restoration will hinge on a greater understanding of the factors influencing this eelgrass population. Previous research has demonstrated a link between population genetic diversity and eelgrass bed health, ecosystem functioning, resilience to climate change, and tolerance of disturbance. The genetic diversity of Morro Bay eelgrass has not been assessed until now. We characterized genetic diversity by conducting fragment length analysis of 10 microsatellite loci. We found that the diversity in the bay is comparable to other bays where severe population loss has not been recorded. Additionally, the diversity is uniformly distributed amongst beds, indicating that eelgrass in Morro Bay comprises one uniform population. We also found that the Morro Bay eelgrass population is genetically distinct from a northern population, and could represent a locally adapted population. These results suggest that eelgrass for restoration efforts should be sourced from within the bay, as the introduction of new alleles might result in outbreeding depression.

23.22 Genetic analysis of the endangered island barberry (*Berberis pinnata* subsp. *insularis* [Berberidaceae]): Seeking lost genotypes in botanic garden living collections

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At the time of this study, the island barberry, *Berberis pinnata* subsp. *insularis* (Berberidaceae), was known from only five individuals on Santa Cruz Island (SCI) and one clone allegedly extirpated from SCI that now exists only in California botanic gardens and more widely in horticulture. This study was undertaken to determine whether any other previously unknown genetic individuals persist in botanic garden living collections, and also to examine genetic diversity of the extant island individuals and related mainland plants (*Berberis pinnata* subsp. *pinnata*). Garden accession records were acquired to trace likely provenance of all living botanical garden plants at seven gardens. Tissue was sampled from the five island plants, the garden accessions (including the extirpated/ horticultural individual ('Shnilemoon')) and mainland plants of *B. pinnata* subsp. *pinnata*. Genotypes were characterized for 47 samples using ten microsatellite loci. Results confirmed that only five individuals were extant on SCI, and that only one of these island individuals was conserved ex situ in gardens. Genetic diversity is considerable amongst the six individuals of *B. pinnata* subsp. *insularis*. Their genotypes - especially those of plants from the north slope of SCI - are not clearly distinct from those of mainland plants. Individuals newly discovered on SCI in summer 2017 will be integrated into this genetic framework. These results highlight the need to genetically inform both *ex situ* and *in situ* conservation efforts in this critically imperiled island endemic.

23.23 Functional genetic variation in the endangered Torrey pine (*Pinus torreyana* Parry [Pinaceae]) and its association with colonization by bark beetles

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Torrey pine (*Pinus torreyana* [Pinaceae]) is a rare, iconic pine species found in only two localities in southern California, including the Del Mar/La Jolla region and Santa Rosa Island. It is a species of particular conservation concern as prolonged drought under climate change may increase its susceptibility to multiple stresses. One such stress, colonization by bark beetles, has presented a significant challenge to trees in the mainland population, while beetles are currently absent on the island. The ability of the species to respond to beetle attack may be determined, in part, by genetic variation, which past studies have shown to be remarkably low in the genetic loci surveyed. Here, we will implement a preliminary RNA-Seq study to 1) characterize the level of functional genome-wide variation in each population and 2) to determine whether genotype is associated with colonization status by bark beetles in the mainland population. We will extract RNA from 16 individuals (four island individuals; six colonized and six un-colonized mainland individuals paired across environments) for sequencing by Illumina, Inc. Focusing on single nucleotide polymorphisms, we will assess diversity measures across the genome and within gene families (such as those involved in oleoresin production) that may contribute to a tree's ability to withstand beetle attack. Finally, we will use discriminant function analysis to determine whether genotypes are differentiated among colonized and un-colonized individuals. This work will provide insight into the adaptive potential of the species to respond to a key biotic threat and will inform future conservation of this iconic pine.

RARE PLANTS

23.24 Using mark-recapture methods to estimate mortality for missing plants in a dormancy-prone rare plant (*Calochortus tiburonensis* [Liliaceae])

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Estimating population size and growth rate is an important metric in rare plant conservation. Many rare plants have a dormant phase when no aboveground parts exist, e.g., all the *Calochortus* [Liliaceae] and *Cypripedium* [Orchidaceae] species and some *Asclepias* [Apocynaceae] species. For these species, a census of aboveground plants will underestimate the population size, produce inaccurate population trajectories, and paint an unrealistically pessimistic picture of the population's status. We employed mark-recapture statistics based on an information theory approach to estimate the probability of dormancy (versus mortality) in the dormancy-prone *Calochortus tiburonensis*. Apparent survival probability corrected for dormancy showed that dormancy probabilities were high (38 - 52% of the population over 4 years), and apparent survival was also high (84 - 94%). Nearly every plant in our long-term study (93% of 943 plants) entered at least one year of dormancy in the past 4 years and some remained dormant for 3 consecutive years but later emerged. Results from our long-term demography work and life table response experiments (LTRE) show that dormancy is essential to this species' long-term persistence. Conventional census counts of aboveground plants would underestimate the population size and may erroneously conclude that in years with poor growing conditions, the population is in decline. In actuality, a higher number of plants may simply be dormant, an adaptive trait and not an indication of decline. Use of mark-recapture statistics in rare plant conservation can permit robust estimates of mortality and dormancy, and thus population stability. This technique is applicable to all plants of conservation concern with a dormant stage.

23.25 Coast yellow leptosiphon and Lassics lupine: Two imperiled species proposed for listing under the California Endangered Species Act

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The California Department of Fish and Wildlife (CDFW) is conducting one-year status reviews for two plants that were petitioned for listing under the California Endangered Species Act (CESA) in 2016. Coast yellow leptosiphon (*Leptosiphon*

croceus) is a low-growing annual plant in the Phlox family (Polemoniaceae) that is only known from one small population occupying an area of approximately 167 square meters (1,800 square feet), which is less than half the size of a basketball court. The population is located north of Half Moon Bay in Moss Beach, San Mateo County, in coastal prairie habitat atop a sea bluff at the edge of the coastline. Lassics lupine (*Lupinus constancei*) is a perennial plant of the pea family (Fabaceae) known from two small populations in the Lassics Mountains of Humboldt and Trinity counties. The plant only grows in and near serpentine soils within the Six Rivers National Forest, and one of the populations is within a designated wilderness area. CDFW is preparing a one-year status review for each species that will include a recommendation of whether or not listing is warranted. Status review reports are peer-reviewed and provide information on species' biology, population trends, habitat necessary for survival, threats, recommended management activities, and evaluate if a species is in serious danger of becoming extinct in all or a significant portion of its range.

23.26 Adding plants to the California endangered species list

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The California Endangered Species Act (CESA) is the primary law protecting plants and animals that are at risk of extinction in California. There are over 1,700 plant taxa in California with a California Rare Plant Rank of 1 or 2 and over 1,400 plant taxa with a NatureServe state rank of S1 or S2. Yet despite the large number of plants that are rare or at risk of extinction, only 155 of California's plant taxa are listed under CESA. An interested person may request that a plant be added to the California Endangered Species list by submitting a written petition to the California Fish and Game Commission with sufficient scientific information on topics including population trends, life history, habitat necessary for survival, and degree and immediacy of threats. After a petition is submitted, it is evaluated by the California Department of Fish and Wildlife, and deliberated by the California Fish and Game Commission at a meeting that is open to the public. If the California Fish and Game Commission determines that listing may be warranted, the plant becomes a candidate, and is afforded the protections of CESA while the California Department of Fish and Wildlife conducts a one-year status review. After the one-year status review report is complete, the California Fish and Game Commission will make a final determination on the listing at a meeting that is open to the public.

23.27 Rare plants on the San Francisco Public Utilities Commission Peninsula Watershed

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The San Francisco Public Utilities Commission (SFPUC) Peninsula Watershed lands straddle both the San Andreas Fault and Montara Mountain, the northernmost spur of the Santa Cruz Mountains. The serpentine formations associated with the fault and the decomposed granitic soils of Montara Mountain are biologically isolated near the end of a peninsula, and due to the coincidence of geology and long-term protection from development by the SFPUC, the Peninsula Watershed protects a unique assemblage of plant species. Some of these species are rare local endemics, such as the Montara Mountain Manzanita (*Arctostaphylos montaraensis* [Ericaceae]), the Crystal Springs fountain thistle (*Cirsium fontinale* var. *fontinale* [Asteraceae]), and the Crystal Springs lessingia (*Lessingia arachnoidea* [Asteraceae]), among others. The SFPUC is committed to the responsible management of its natural resources, including more than 23,000 acres of mostly undeveloped watershed land on the San Francisco Peninsula. The SFPUC adopted the Water Enterprise Environmental Stewardship Policy to protect the integrity of ecosystems and ecological processes that provide water (supply and natural filtration), and protect biodiversity, while contributing aesthetically to the local landscapes that exemplify the natural beauty for which California is famous. The SFPUC has initiated conservation strategies and management plans to direct actions that protect these plant species and their unique habitats. Actions include but are not limited to invasive plant management to protect and increase habitat, plant pathogen research, plant propagation, habitat protection through adaptive management, and conservation easements.

23.28 Investigating how the reproductive potential of triple ribbed milk vetch (*Astragalus tricarinatus* [Fabaceae]) is affected by co-occurring native and invasive species abundance on its typical habitat of unproductive soil

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The triple ribbed milk vetch (*Astragalus tricarinatus* [Fabaceae]) is a short lived perennial herb that is endemic to southern California along the ecotone of the Mojave and Colorado Deserts. It occurs primarily in the San Bernardino and Little San Bernardino Mountains between 450 and 1450 m. This study sought to further describe abundance in these mountain ranges, as well as quantify the impact of native vs. invasive plant species compositions co-occurring with *Astragalus* on its development and abundance of reproductive structures. First, historic areas of *Astragalus* occurrence were mapped and a species distribution model was created to predict suitable habitat in the region which was overlain onto imagery to manually search therein for its typical edaphic habitat. Subsequently, these sites were visited and where *Astragalus* was found, a plot study was performed in which plants were measured, reproductive structures counted, and microhabitat characteristics were recorded. Several new locales were recorded within its existing range including a single population containing more plants than the global population estimate from the last USFWS 5 year review for the species. Results from the plot study showed that increases in invasive cover led to a decrease in production of reproductive structures; while, increases in native plant cover led to an increase in production of reproductive structures. As a federally-listed species occurring in steep, remote habitats with few threats, these findings suggesting a possible correlation between invasive species presence and reproductive success should be investigated as they affect population dynamics and conservation of this species.

23.29 Five rare plants of the Pine Hill Preserve: A research update

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The Pine Hill Preserve in El Dorado County is a site of national significance for species diversity, containing over ten percent of California's plant species in just 7.5 square miles. The Preserve is centered in a 47-square mile area of unique Rescue soils (classified within gabbro), and therefore contains unusual plant communities and a multitude of special-status plants. The Preserve began land acquisition only 20 years ago with the mission to protect special-status plants, most of which were described in the last 50 years; this area therefore presents rich and relatively new botanical research opportunities. We performed a literature review for five of the special-status plants found in the Preserve: *Calystegia stebbinsii* (Convolvulaceae) (FE, CE, CRPR 1B.1), *Ceanothus roderickii* (Rhamnaceae) (FE, CR, CRPR 1B.1), *Chlorogalum grandiflorum* (Agavaceae) (BLM Sensitive, CRPR 1B.2), *Packera layneae* (Asteraceae) (FT, CR, CRPR 1B.2), and *Wyethia reticulata* (Asteraceae) (BLM Sensitive, CRPR 1B.2). For each of these species, we explore current and historical occurrence information, key identification characteristics, taxonomic status, threats to species' persistence, and propagation techniques and challenges. This summary will help inform land management for the preservation of these species, identify further research needs, and provide guidance for increased mitigation success that may include fire treatment, invasive plant removal, plant salvaging, and seed treatments to maximize germination.

RESTORATION

23.30 Impact of Terra-Sorb and varying supplemental watering intervals on plant survival on the Angeles National Forest

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Transplant shock and subsequent drought stress can have great impact on plant survival when container plants are out-planted into the wild. Hydrogels have been thought to aid in the reduction of drought stress on plants after planting. Studies have demonstrated that high water absorbing polymers can increase the drought tolerance of plants in containers, but have had varying results in the field across different species. It has also been noted that hydrogels have a greater positive impact on clay and sandy soils, than they do on loam soils. Experiments to test the incorporation of a potassium-based hydrogel, Terra-Sorb, as well as varying supplemental watering intervals had on plant survival were conducted in the field beginning in March of 2017 near Lakeview Terrace, California on the Angeles National Forest. The species included in the experiment were *Salvia mellifera* (Lamiaceae), *Artemisia californica* (Asteraceae), *Hazardia squarrosa* (Asteraceae), *Baccharis pilularis* (Asteraceae), and *Encelia californica* (Asteraceae). Two experimental treatments were established side by side. One tested for the effect of supplemental watering intervals, 2 and 4 weeks, on survival rate,

while the other tested the difference between Terra-Sorb-treated and non-treated plants. Preliminary results show no significant difference in either experiment. Additional data is expected to be collected as the experiment continues in an effort to see if there is a significant effect of Terra-Sorb or differing supplemental watering regimes on plant survival.

23.31 Habitat development on the Napa River: Napa County Flood Protection Project restoration progress

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In Napa, over-bank flooding events by the Napa River during the latter half of the 20th century resulted in cumulative economic damage of over 500 million dollars. As a result, the Napa County Flood Protection Project was initiated in 1964 with the U.S. Congress' authorization of a large-scale flood protection project along a six-mile reach of Napa River and a 1.4-mile reach of Napa Creek within the City of Napa. This flood control and riverine restoration project was jointly designed by USACE and Napa County Flood Control and Water Conservation District; phased implementation began over 15 years ago and received widespread attention for the innovative "Living River" approach to flood attenuation - achieving 100-year level flood protection by connecting the river to its historical floodplain. Conversion of the Project area from previously diked agricultural baylands to tidally influenced wetlands required levee removal and breaching, lowering levees, and channel modifications to create flood terraces. Restoration goals included creating and restoring brackish emergent marsh, tidal mudflats, seasonal emergent wetlands, shaded riverine aquatic habitat, riparian forest and scrub-shrub, oak woodlands, and grasslands. Systematic monitoring is occurring over a 40-year period and was first conducted by USACE before transferring responsibility to the District in 2012. In 2012 and 2017, on behalf of the District, Stillwater Sciences conducted vegetation monitoring studies to document changes in vegetation, soils, and hydrology of the restored area. We present our findings, track progress toward the 40-year Project goals, and provide information that is useful for guiding adaptive management.

23.32 Seedbank analysis from two soil depths in degraded chaparral

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Chaparral ecosystems are among the least understood biomes in California, making restoration extremely challenging. Seedbank stimulation has been an effective restoration tool in other ecosystems. By examining the seedbank in chaparral, stimulation protocols may be applied to lead to more effective and efficient restoration methods. Many native chaparral populations have experienced a change in fire regime. This leads to burial below the soil surface of long-lived native seeds, which are then covered by exotic seeds, often invasive annual grasses. We set out to examine if buried native seeds are viable and if they could be used as a tool for chaparral restoration by collecting soil samples (0-4 cm and >4-12 cm) from two degraded chaparral locations in Piru, California. Soil samples received one of four treatments: heating (100°F for 5 minutes), charate (rate of application [g/cm^2]), heating and charate, or a control. Preliminary results from germination experiments using these treatments suggest that natives (e.g., *Acmispon maritimus* [Fabaceae], *Emmenanthe pendulifora* [Boraginaceae]) are present and viable in these degraded soils. Despite the germination of these short-lived natives, native woody plants have yet to emerge. The natives exhibited greater abundance deeper in the soil (>4-12 cm) than in soil surface layers (0-4 cm), which were dominated by exotics (e.g., *Bromus madritensis* [Poaceae], *Erodium cicutarium* [Geraniaceae]). Our findings suggest seedbank stimulation could be an effective restoration method, made more efficient if exotic seeds are eliminated (e.g., topsoil removal).

23.33 Smooth tarplant is not smooth, but translocating it can be

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In urban southern California, conservation of rare plant populations often conflict with development. When those conflicts are unavoidable, lead agencies may require relocating the plant populations. Smooth tarplant (*Centromadia pungens* subsp. *laevis* [Asteraceae]) is an annual herb that is considered rare, threatened, or endangered in California and elsewhere (CNPS List 1B.1). This species' range extends south to Santee, in San Diego County. It is in Santee's town center that the last remnant of smooth tarplant's southernmost population was to be impacted by development. The

translocation of this population was done with seed collection and soil salvage. Associated species were also installed in the restoration area. After four years the translocation effort appears successful. Weeding was performed for the first three years of the five-year monitoring period. Annual monitoring includes examining seed viability, soil pH, plant height, and population size. The population size criteria vary based on annual rainfall; population success criteria were determined during monitoring of the source population for three years prior to project implementation. The restored tarplant population has surpassed the success criteria for population size in all years since being translocated. Challenges including weed cover and human intrusion from cyclists and transients have not prevented the project from meeting the population size criteria. Rare plant mitigation at this location is regarded as provisionally successful. This success is from thorough planning, including soil requirements, hydrology, and researching successful and unsuccessful translocation attempts of this species.

PESTS, INVASIVES, & CLIMATE CHANGE

23.34 A California pest control adviser's written recommendation for a use of herbicide should use measurements to address an issue which was raised by California Native Plant Society

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This abstract was prepared at the request of California Peace Academy in order to attempt to obtain renewal requirements for those engaged in pest control. *Section 12003 [a] and [b] of the Calfornia Food and Agriculture Code,* (the"written recommendation" rule), states that a California pest control adviser may describe an herbicide use, that a California pest control adviser must include the name of the EPA registered product and the dosage on written recommendations, and that a written recommendation which is adopted because no alternatives are feasible shall be certified by a California pest control adviser. Whether a use is put under a mitigation depends on a formulation of an EPA registered product and a measurement which puts herbicide use under mitigation. Measurement of a diameter or a radius puts the herbicide application under mitigation through a drip line. There will be less injury to an established California native plant because where there is a measurement drawn around the base of California native plants, there is less of an impact than with an herbicide because application which is used right up to the base of established California native plants. The exception is when the active ingredient or the dosage does not injure the base of established California native plants. A written recommendation may also describe integrated weed management, such as mechanical, cultural and biological controls, which may be considered as alternatives, to conserve California native plants.

23.35 Tree-ring growth sensitivity of *Pseudotsuga macrocarpa* (bigcone Douglas fir [Pinaceae]) to climate change along an elevational gradient

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Anthropogenic climate change is predicted to increase temperatures and reduce precipitation throughout most Mediterranean-climate regions. Many of these regions provide habitat to thousands of plant species with limited ranges and specific ecological requirements. Current projections indicate that species with narrow, limited distributions are at the greatest risk of climate-induced extinction. One such potentially vulnerable species is *Pseudotsuga macrocarpa* (bigcone Douglas fir [Pinaceae]), a large conifer endemic to southern California. While the species' geographic range is patchy and limited, it occurs at a wide range of elevations. Low elevation populations persist in relatively cool, north-facing montane "islands" surrounded by semi-arid chaparral. The dynamic relationship between climatic factors and a tree's annual radial growth is known as climate-growth sensitivity. Recent research has found that rear-edge populations (those at their dry distribution limit) showed the highest degree of radial growth sensitivity in response to rising temperatures. I hypothesize that the growth of low elevation *P. macrocarpa* populations has the highest degree of climate sensitivity. I am comparing annual radial growth rings of *P. macrocarpa* from 3 populations along an elevational gradient to past climate data from local weather stations. Using an increment borer, I extracted core samples from a minimum of 15 individuals in each population. Climate-growth relationships can provide indications for the future performance and sustainability of these populations as well as other plant species in similar climate regions. If my hypothesis is correct, it will suggest that rear-edge *P. macrocarpa* populations are at the highest risk of extirpation in a warmer, drier future.

23.36 Northward expansion of invasive shot hole borers (*Euwallacea* spp. nr. *fornicatus* [Curculionidae]) in riparian systems of central California

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The Polyphagous and Kuroshio shot hole borers (*Euwallacea* spp. nr. *fornicatus* [Curculionidae]) are recent invaders of southern Californian riparian habitats. These beetles have a broad host range including many native, dominant riparian woody plant species such as sycamores (*Platanus* spp. [Platanaceae]), oaks (*Quercus* spp. [Fagaceae]), willows (*Salix* spp. [Salicaceae]), cottonwoods (*Populus* spp. [Salicaceae]) and maples (*Acer* spp. [Sapindaceae]). The shot hole borers carry obligate fungal symbionts that are inoculated into host trees and often grow into the host's xylem, leading to branch dieback and mortality. The distribution of shot hole borers (SHB) in riparian habitats is not well known in the northern extent of their expanding range. Aside from two singletons detected in Santa Cruz and San Luis Obispo Counties in 2014 and 2016, respectively, the most northern known infestation was detected in Santa Barbara County in September 2016. To better characterize SHB distribution in central California, I deployed detection traps in Ventura and Santa Barbara Counties. Bottle traps baited with a chemical attractant (Quercivorol) were monitored bi-weekly. I found SHB in previously undetected areas in both Ventura and Santa Barbara Counties, indicating that the species' range is continuing to expand from initial detection locations, either due to natural or human facilitated dispersal. Future surveys (2017-2018) will be expanded both northward and into desert regions to better understand the rate of population expansion and potential limits to SHB establishment, as well as to evaluate host plant use in more mesic and xeric ecosystems than those currently infested in southern California.

23.37 Management of Bermuda buttercup (*Oxalis pes-caprae* [Oxalidaceae]) in the Peninsula Watershed of the San Francisco Public Utilities Commission

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Bermuda buttercup (*Oxalis pes-caprae* [Oxalidaceae]) is an invasive plant native to South Africa rated as a moderate threat to wildlands by the California Invasive Plant Council. Because the clone present in California does not produce seeds, it is only spread by the movement of bulbs. In spite of this, it has been found to be an aggressive weed of landscapes and agricultural fields. Because of its limited capacity for dispersal, in the past it was not considered a major threat to natural areas. However, it is now increasingly encroaching into wildland areas also. Control has been challenging because bulbs may not be susceptible to some herbicides, and some control techniques actually spread the bulbs. The present study is a preliminary test of several herbicides and herbicide combinations for the control of *Oxalis pes-caprae*. These herbicide trials seem to indicate high efficacy of imazapyr for control of Bermuda buttercup, including suppression of sprouting of bulbs. Furthermore, combinations of herbicides with different modes of action appear to be more effective in controlling Bermuda buttercup than applications of single herbicides.

23.38 Evaluation of current age and spatial distributions in California endemic *Sequoia sempervirens* (Cupressaceae) populations at hot, dry extremes of their range may help us predict the fate of these populations as climate changes

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Can we predict coast redwoods' future as climate changes? Their distribution highly correlates with summer fog, which has decreased over the past 70 years. Summer temperatures are predicted to increase, while annual precipitation is expected to decline in hotter, drier parts of the range. In the future, populations in southern Monterey County - the southern limit - as well as in the less foggy eastern parts of the range may no longer fall within the species' "climate envelope". Established trees may persist for some time, even as water deficits increase, but study of distributions of adults versus juveniles can show current trends in different populations and help determine the climate envelope for juvenile life stages specifically. At Landels-Hill Big Creek UC Reserve in Monterey County, near Big Sur, distribution of juveniles on north- and south-facing slopes along Big Creek and Devil's Creek showed significant differences compared to distribution of mature redwoods, with juveniles (< 2.5 cm diameter, and not directly sprouted from adults) being almost entirely absent

from upper parts of north- and south-facing slopes where mature trees are found. In contrast, at El Corte de Madera Creek Preserve in the cooler, wetter Santa Cruz Mountains, distribution of juveniles closely paralleled distribution of adults. Analyses of climate characteristics at LHBC, using weather data from Big Sur and a modified Hamon equation, showed that calculated climatic water deficit (CWD) significantly increased from 1994 to 2004. Understanding the threats to persistence of these populations may help us devise strategies to preserve them.

PLANT SCIENCE

23.39 Plant facilitation and stress: Is herbivory stressful enough?

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Interactions between plants generally exist along a continuum between competition and facilitation. Positive plant interactions are more frequently found in stressful environments, and the strength of these positive interactions are frequently seen to increase along a gradient of abiotic stress. Studies have also shown that competition can shift towards facilitation along an environmental gradient. While the effect of abiotic stressors on plant facilitation has been well studied, the effects of biotic interactions are less known, and the effect of the interaction between abiotic and biotic stressors is not well studied. One biotic stressor that is thought to mediate this gradient between negative and positive interactions is herbivory. We provide a systematic review of the literature pertaining to herbivory as a mediator of plant facilitation in relation to abiotic stressors. While other studies have found that herbivory can mediate plant facilitation, we ask if herbivory alone is sufficient to convert competition to facilitation between plants, or if other abiotic stressors are required in addition to herbivory. We also investigate how this varies with different taxa; we expect that some taxa may exert stronger herbivorous pressure than others, thus driving facilitation more strongly. This study increases our understanding of the effect herbivores have on plant communities, as well as the extent of the benefit of facilitation. This knowledge is particularly useful when examining the impact of facilitation on species at risk, as well as understanding further consequences of invasive herbivores.

23.40 Are the green and glaucous forms of *Dudleya brittonii* (Crassulaceae) distinct? A preliminary morphological analysis of *Dudleya brittonii*

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Dudleya Britton & Rose (Crassulaceae) is a western North American genus of succulent plants characteristic of rock outcrops and other sparsely vegetated habitats. Their distribution is centered in coastal southern California and adjacent Baja California, Mexico. Many taxa are narrow endemics. Maritime succulent scrub in coastal northwestern Baja California provides ideal habitat for large *Dudleya* species, such as *D. brittonii* D.A. Johans., which can be conspicuous members of the vegetation. As currently circumscribed, *D. brittonii* has two forms: a glaucous form and a green form. The green form occurs from Rosarito to 100 miles southward. The narrow range of the glaucous form is contained within the range of the green form. Where the two forms co-occur, they occupy different habitats. In this study we measured morphological features of *D. brittonii* to evaluate the distinctiveness of the green and glaucous forms and to examine the morphological affinities of a semi-glaucous population that occurs within the range of the green form but isolated from the glaucous form. We measured 13 characters on 34 samples of *D. brittonii*. Our preliminary results suggest that the green and glaucous forms of *D. brittonii* are morphologically distinct in several characters beyond glaucescence. Green form plants have narrow leaves that are widest nearer the apex, smaller inflorescence areas, and widely spaced peduncle bracts. Glaucous form plants have wider leaves that are widest nearer the base, large inflorescence areas, and closely spaced peduncle bracts. Measured semi-glaucous plants are similar to the green form for the features we measured.

23.41 A morphological analysis of *Plagiobothrys* "colonetensis" (Boraginaceae), a vernal pool endemic from northwestern Baja California, México

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Surveys in the vernal pools of northwestern Baja California, México have resulted in the discovery of a potentially new species of *Plagiobothrys* (Boraginaceae). This plant, which we provisionally call *P.* "colonetensis", co-occurs with *P. acanthocarpus* and *P. leptocladus*. Growing at an intermediate position along the vernal pool slope, it overlaps with *P. acanthocarpus* at upper micro-elevations and with *P. leptocladus* at lower micro-elevations. Morphologically, *P.* "colonetensis" appears to have some vegetative and floral features of *P. leptocladus*, but nutlet features are intermediate between the two congeners. Micro-elevation and morphology suggest the hybrid origin of *P*. "colonetensis", although no evidence of backcrossing between *P.* "colonetensis" and its congeners was observed. Here we evaluate the distinctiveness of *P*. "colonetensis" with respect to *P. acanthocarpus* and *P. leptocladus*. Twenty-six characters were measured from 20 nutlets of each *Plagiobothrys*. We examined differences among the samples using principal components analysis. Scatterplots of the principal components (PC) in various combinations show ± non-overlapping groupings corresponding to *P. acanthocarpus, P. leptocladus,* and *P.* "colonetensis". Although *P.* "colonetensis" has intermediate values for measured nutlet characters, differences among the two taxa and *P*. "colonetensis" appear to be non-clinal, supporting the hypothesis of a lack of on-going gene flow. A mechanism of potential reproductive isolation has not been determined, but an allopolyploid origin of *P*. "colonetensis" is possible. If confirmed, this study may provide an insight into diversification in vernal pool ecosystems, pointing to a role for hybridization and polyploidization in the formation of new species.

23.42 Assessing the morphological distinctiveness of two endangered California shrubs: *Eriodictyon altissimum* (Boraginaceae) and *Eriodictyon capitatum* (Boraginaceae)

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Eriodictyon Benth. (Boraginaceae) is a western North American genus of 13 shrubs and perennial herbs. Several taxa are narrowly distributed, including the endangered Central Coast endemics, *E. altissimum* Wells and *E. capitatum* Eastwood. In the original description of *E. altissimum*, Wells noted that it has features of both *E. capitatum* and the widespread *E. californicum* Hook. & Arn. He speculated that *E. altissimum* may have resulted from a historical hybridization event between ancestors of these two species. Here, we measure morphological characters of these three *Eriodictyon* taxa to evaluate the distinctiveness of *E. altissimum* and *E. capitatum*; describe the morphological features that distinguish *E. altissimum* from *E. capitatum*; and assess Wells' hypothesis regarding the hybrid origin of *E. altissimum*. We measured several inflorescence and flower characters. We examined these data using ANOVA with post hoc comparisons, student's t tests, and principal components analysis (PCA). *Eriodictyon altissimum* and *E. capitatum* differ significantly in several characters and form non-overlapping clusters in PC scatterplots. We consider this strong evidence that *E. altissimum* and *E. capitatum* are morphologically distinct. They differ in internode length, calyx length, sepal lobe length, corolla tube length, corolla throat length, corolla throat width, trichome density, and trichome length. Regarding Wells' hypothesis, the three species differ significantly in all pairwise combinations. In PC scatterplots however, *E. californicum* occupies an intermediate position between *E. altissimum* and *E. capitatum*. We therefore feel that these data and results offer little to elucidate the origin of *E. altissimum*.

23.43 Determining effective seed pre-treatments for *Juniperus californica* (Cupressaceae)

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Juniperus californica (Cupressaceae) is a large shrub to small tree with a wide range throughout California, extending upward into Northern California in Shasta County and down into Baja California, Mexico, with limited occurrences in Nevada and Arizona. While there is extensive literature for successful propagation of other *Juniperus* species, methods to propagate *Juniperus californica* by seed remain unclear. Seed propagation of this species is challenging due to several factors, including low seed viability, a long after-ripening period, and multiple dormancy mechanisms that prevent

germination. This project details seed response to various combinations of seed pre-treatment to overcome the physical and internal dormancy of *Juniperus californica* seeds. In total, 19 pretreatment trials were conducted, involving both warm and cold stratification, soaking in hydrogen peroxide, sulfuric acid, citric acid and gibberellic acid for varying amounts of time, and fire. Preliminary results indicate that soaking in citric acid or hydrogen peroxide provide a germination response. Determining effective seed pre-treatments for *Juniperus californica* will contribute to public knowledge of seed propagation methods. Developing more successful propagation methods of *Juniperus* by seed will advance conservation efforts by providing a method for more plants to be propagated with greater genetic diversity for restoration projects than would be achieved using vegetative propagation methods that produce genetically identical offspring from a more limited number of founders.

SEED BANKING & CONSERVATION

23.44 California Plant Rescue: Conserving botanical diversity through collections, monitoring, and research

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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). We are working to secure and preserve seeds for all California native plant taxa, but our current work prioritizes those that are rare, threatened, or endangered. Specifically, our initiative has the goal to conserve 75% of all species ranked as rare and threatened in California (1B rankings in the CNPS Inventory of Rare and Endangered Plants) by 2020. This goal aligns with the Global Strategy for Plant Conservation, 2011-2020 as developed by the Convention on Biological Diversity. Through this collaborative we are sharing and implementing best practices in seed collecting, processing and storage, and are working to advance ex-situ conservation measures as a whole. Since the formalization of CaPR in 2015 our partner institutions have acquired new tools and equipment to improve seed processing and storage, recruited new volunteers, and have collected over 130 new accessions of high priority taxa. Partners have conducted several seed collection workshops and engaged the public through lectures to increase support for ex-situ conservation as an important conservation and management tool.

23.45 San Diego Zoo's Native Plant Seed Bank: A tool for conservation of native plant species and regional habitat management

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In 2001, the San Diego Zoo Institute for Conservation Research (SDZICR) established a Native Plant Seed Bank (NPSB) with the goal to conserve the diversity from many of San Diego's indigenous plants by drying and freezing orthodox seed for long-term storage. The NPSB provides insurance against catastrophic loss in the wild and protects against genetic degradation caused by habitat fragmentation including intensive coastal development. In addition to the seed conservation process, the NPSB develops dormancy-breaking protocols that ensure seeds can be grown as needed. Banked seed has been utilized for propagation for restoration of coastal cactus wren habitat and declining coastal sage scrub. A field gene bank of Tecate cypress (*Hesperocyparus forbseii* [Cupressaceae])trees was also established from banked seed and propagated to protect against increased wildfire frequency. Since 2004, we have worked in partnership

with Kew Royal Botanic Gardens, the Bureau of Land Management's Seeds of Success Program and other local government agencies including the San Diego Association of Governments (SANDAG). Our current efforts focus on the county's rare, threatened and endangered plants as recognized by the California Native Plant Society's rare plant inventory. As a regional partner in the California Plant Rescue project we strive to conserve the most at-risk plant species in California. The Center for Plant Conservation is also headquartered at the SDZICR and advises best practices of collecting and curating seeds. To date, the NPSB has collected over 720 accessions including 75 rare high priority species.

23.46 Testing the effect of relative humidity on the storage tolerance of southern California seeds

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Seed banks serve as a vital resource for preserving plant diversity through the long-term storage of seeds. When maintained at a low and constant humidity and temperature, the seeds of many plant species can remain viable in storage for decades, or potentially even hundreds of years. There is some debate as to how low the relative humidity of a seed collection should be in order to maintain long-term seed viability in freezer storage, and it may vary from species to species. To better understand the effect of relative humidity on seed storage tolerance, seeds from common southern California plants were collected, cleaned and dried at different intervals using silica gel to produce a range of relative humidity levels from 15% to 50%. Seeds of each relative humidity level will be stored in separate heat-sealed foil packets and kept at -23°C in the Rancho Santa Ana Botanic Garden Seed Bank for 50 years, with germination testing on agar occurring periodically. The first round of germination testing was conducted after two weeks in storage to gauge the initial effect of freezing at different humidity levels on seed viability. If an ideal seed humidity level for freezer storage can be identified, it will inform protocols for seed banking and contribute to our knowledge of the storage requirements for southern California native plants.

23.47 A look into 40 years of germination testing at the Rancho Santa Ana Botanic Garden Seed Bank

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Most seeds possess some form of dormancy to prevent germination before seeds are dispersed, and in many cases to prevent germination when ecological conditions are not ideal and seedling survival rate is low. Whether this dormancy is physical or chemical, certain queues from the environment need to occur in order to break dormancy and trigger germination. When propagating plants from seed, the challenge is to simulate these environmental queues and break seed dormancy. This can be especially challenging for plants of arid environments, like California, where seed dormancy levels are high. Here we take a look into over 40 years of germination data from over 1700 California native species from the Rancho Santa Ana Botanic Garden seed bank. Our protocol for germinating California native seed, especially for those difficult to germinate species, is described along with relevant applications towards conservation and restoration of California native plants.

HORTICULTURE/LANDSCAPING, PLANTS & POLLINATORS

23.48 Water influences how seed production responds to conspecific pollen and to pollen from invasive species

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Seed production is crucial to persistence of many plant species and can be influenced by water availability. Water can not only affect seed production directly but can also influence the performance of conspecific pollen donors and interference by heterospecific pollen on the stigma. Our study varied water availability to pollen recipients, conspecific pollen donors, and heterospecific donor plants. We focused on the California native *Phacelia parryi* (Boraginaceae) and the invasive *Brassica nigra* (Brassicaceae). These two species share insect pollinators, and deposition of pollen from *B. nigra*

interferes with seed production in *P. parryi*. Pollen recipients and donors (conspecific and heterospecific) were exposed to either a high or low water treatment. The design had all combinations of three factors: recipient (high or low water), conspecific pollen type (high or low water to the donor), and heterospecific pollen type (no heterospecific pollen, high water donor, or low water donor). Seeds were counted for each hand pollination. Hand-pollinations using conspecific pollen from high-watered donors produced significantly more seeds, regardless of recipient and heterospecific pollen donor treatments. We also found a three-way interaction between recipient treatment, conspecific donor treatment, and heterospecific donor treatment. When the recipient plant received high water, the presence of heterospecific pollen had more impact on seed set if the conspecific pollen came from a high-watered plant. Many native plants persist in heterogeneous environments, in which water availability can vary on small scales. This research showcases how that variability can influence the impact of conspecific and invasive pollen on seed production.

23.49 Proposal to landscape with native vegetation in urban spaces, case: Ecoparque, Tijuana, Baja California

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In the city of Tijuana, the use of exotic vegetation predominates over natives within gardens and public spaces. These plants require greater quantities of water to survive. In order to encourage the use of native plants within urban spaces, reduce water consumption and contribute to the maintenance of the ecosystem and local biodiversity, we propose a naturalistic landscape design that accentuates and exhibits the physiognomic qualities of aesthetic way within Ecoparque's academic linkage and applied research project that works as a driver of sustainability in the city. The landscape proposal is based on the understanding of the functioning of vegetation both individually and as a whole, that is, based on their needs, performance and qualities. It is the accommodation that is given within the exhibitions, working with plant communities with a harmonious development. Starting from the idea of a relationship between society and the natural environment, we have created walkable display areas that show first-hand learning based on interaction with smaller-scale habitats. These same principles can be replicated in the gardens of houses. Therefore, implementing a landscape proposal with native plants is a new perspective to promote their use as ornamentals, and recognize the potential they offer as natural elements of the region within urban spaces.

23.50 Sustainability and water management in the urban environment: Investigating the water source of trees at California State University, Fullerton, via stable hydrogen and oxygen isotopes

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To reduce overall campus water use, California State University, Fullerton, (CSUF) removed many of its lawns in 2015. Prior to turf removal, two-thirds of campus water usage went into landscaping. There are numerous trees on campus as well, over 2,300, of which only a small percentage is native. Most of these campus trees are watered. Because trees possess varied root systems it is possible that not all trees on campus need irrigation. Some trees possess extensive roots capable of utilizing deep groundwater sources. Currently it is not known at what depths in the soil profile CSUF campus trees source their water. In this study we seek to answer this tree water source question by sampling 21 tree species (3 native and 18 nonnative) and comparing the δ**D** and **δ^{18}O** values found in the xylem sap of these trees with the **δD** and **δ^{18}O** values of the trees' potential water sources (irrigation, precipitation, groundwater, and soil water). Water is extracted from tree twigs and soil via cryogenic extraction. One goal of this study, on which this poster focuses, is to establish a long-term sampling regime so that trees can continue to be monitored by CSUF students in subsequent years. At the present time this goal has been completed. This long-term study also aims to produce a list of campus trees that includes their corresponding water-use functional groups (irrigation versus groundwater users). The ultimate goal is for campus facilities management to use said list to further help them manage water resources.

23.51 The Theodore Payne archive

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In 1903 Theodore Payne started his very own nursery business in Los Angeles, CA. It was here that he developed his specialty in California native plants and wildflowers, and became avidly involved in designing gardens throughout Los Angeles that highlighted California native plants. The archive at the Theodore Payne Foundation hosts many of Payne's original plant and seed catalogs along with his personal notes, business records, and original landscape plans. A recent re-organization of the archive revealed many old photographs of Payne and his plants both in the wild and landscaped in Los Angeles. As CA native plants gain popularity with both city planners and homeowners let's take a look at some of the original horticultural introductions, made by Mr. Payne himself, that are still in use today. By displaying pieces from the archive that exhibit the origins of California native plant horticulture we can get a glimpse at how this niche industry has changed over the last century: which plants did he propagate or collect seed, where did he source his material, and what was his method of collection? Perhaps most importantly for those of us in the trade: who bought his plants?