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Characterizing centromere and telomere sequences in the genomes of the aquatic ferns *Azolla filiculoides* and *Salvinia cucullata*

Centromeres and telomeres are universal components of eukaryotic genomes essential for cell division and preventing the deterioration of chromosomes due to DNA replication, respectively. Here we present a characterization of centromeres and telomeres in two aquatic ferns, *Azolla filiculoides* and *Salvinia cucullata*, the first such study in ferns. Using bioinformatic analyses we were able to identify centromere motifs between 185 and 194 bp long in *Azolla*, and in *Salvinia* we found centromere motifs between 179 and 194 bp long and the consensus motif of *Azolla* differed from *Salvinia*. Telomeres in both species were of the canonical 7 bp angiosperm type (TTTAGGG). The findings in this study suggest that telomere sequence has been highly conserved among ancient plant lineages while centromere sequences are divergent between even closely related fern genera.

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Ectomycorrhizal community effects on Monterey pine resistance to pitch canker

Pitch canker (*Fusarium circinatum*) is an exotic pathogen that was first identified in California in 1986, and has lead to significant mortality in native Monterey pine (*Pinus radiata*) populations. Monterey pines are obligately mycorrhizal, and mycorrhizal fungi have been shown to be important in conferring enhanced plant host resistance to abiotic and biotic stresses. My objective is to determine how mycorrhizal fungal communities can affect Monterey pine resistance to biotic stresses, such as the pitch canker pathogen.

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Long-term effects of CO_2 enrichment on plant genome and cell size.

A major unanswered question in plant biology, ecology, and conservation centers on identifying the structural and functional characteristics of plants that ultimately determine species and community responses to environmental change. Of particular importance is the response of individual plants and communities to long term enrichment of atmospheric carbon dioxide (CO_2). In general, plant species respond to increased CO_2 by building leaves with fewer, large stomata and decreased overall surface conductance. However, the underlying cellular mechanisms for these observed changes is poorly understood, as are the larger scale effects on plant species distributions and community dynamics. Previous research suggests coordinated changes in cell size and genome size can occur in response to changes in atmospheric CO_2. Together these changes result in the down regulation of maximum potential leaf surface conductance to CO_2 and water vapor. Here we evaluated the influence of long-term atmospheric CO_2 enrichment on a native California grassland at Stanford University, conducted in collaboration with the Jasper Ridge Global Change Experiment. Plant samples were collected and analyzed from both experimental plots with sustained elevated CO_2 for 18 years and control plots with ambient CO_2 levels. The objectives of this study were to determine if (1) stomatal size and density vary for individual species subjected to long-term elevated CO_2 relative to ambient conditions and, (2) to what extent variation in stomatal traits are associated with variation in genome size. The results of this study will provide valuable insight into plant community responses to environmental change.

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Pollination facilitation by foundational plants in an arid ecoystem

Magnet plants are particularly attractive to pollinators and can improve the reproductive success of their less attractive neighbours by increasing local pollinator abundances. Facilitation of shared pollinators may be important in deserts because harsh environmental conditions can lead to large spatial and temporal variation in floral abundances and pollinator populations. This project compares the contributions of creosote bush (*Larrea tridentata*) with buckhorn cholla (*Cylindropuntia acanthocarpa*) in the effective pollination of their neighbouring annuals. These flowering shrubs dominate the landscape of the Mojave Desert and I hypothesize that they act as magnet plants, representing conspicuous concentrations of floral resources for pollinators. To test the capacity for these foundational plants to act as magnets, I will contrast pollination services to patches of herbaceous annuals growing as the understory of a foundational plant with those growing in open areas. I expect annuals grown in association with magnets will show higher pollinator visitation rates, increased conspecific pollen deposition and higher seed set. To investigate the effect of magnet plant density and distribution, I will georeference all shrubs and cacti within the study area as well as map the surrounding floral phenology. I expect that magnets that are aggregated will be stronger facilitators than those that are dispersed, as they represent a decrease in foraging effort for pollinators. Pollinators provide critical ecosystem services but are undergoing a global decline, so understanding how plants interact via pollinators has become increasingly important. Understanding how magnet plant density and spatial distribution affect their interactions with pollinators may be important for the conservation of arid ecosystems.

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Sensitivity of obligate seeding chaparral shrubs in Los Angeles and Ventura counties

Chaparral shrub species generally exhibit one of three reproductive strategies in response to fire. They can be obligate seeders (species that persist via post-fire seed germination), obligate resprouters (species that recover after fire via resprouting from an underground burl), or facultative resprouters (species that germinate from seed and resprout from an underground burl after fire). These reproductive differences contribute to species diversity across Southern California mountains because different strategies dominate different environmental conditions. Obligate seeders, for example, dominate in xeric and nutrient poor sites, where obligate resprouters cannot. However, obligate seeders are expected to be extirpated by shorter fire return intervals due to having a maturation period longer than the time between fires. To determine if the range of obligate seeding species has changed over time, we first compared the 1930s Wieslander Vegetation Type Mapping (VTM) data to the 2001 CalVeg data collected by the U.S Forest Service. We determined that 78% of the area identified as chaparral in 1934 remained as chaparral in 2001, while only 36% of the area identified as obligate seeders remained as obligate seeders in 2001. This reduction of obligate seeder dominated chaparral led us to further ask: what state factors correlate with this change? To answer this question we will correlate elevation, slope, aspect, solar insolation, precipitation, min/max temperatures, and fire history with presence or absence of obligate seeding dominated communities to determine where obligate seeders are most vulnerable. Once determined, our results can be used to further focus restoration and conservation efforts on the most at risk areas. This will aid land managers to reduce future losses of obligate seeders and may therefore increase the likelihood of long-term persistence and stability of southern California chaparral despite increasing anthropogenic impacts and climate change.

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Genotyping using microsatellites shows strong genetic differentiation among populations of the Channel Islands endemic plant *Malva assurgentiflora* (Malvaceae)

Malva assurgentiflora (Kellogg) M.F. Ray [*Lavatera assurgentiflora*] (Malvaceae) is a charismatic, perennial shrub with showy rose-colored flowers. It is endemic to four of the eight California Channel Islands, where it is rare and highly localized. Thomas Philbrick hypothesized that the plants on the southern islands are distinct from those on the northern islands on the basis of morphological differences in the epicalyx, margin of the petal apex, and vestiture of the leaf and filament tube. The northern populations are characterized by a pubescent upper leaf surface, subentire petal apex, and a pubescent filament tube, while the southern populations have a glabrous to subglabrous upper leaf surface, erose petal apex, and glabrous to subglabrous filament tube. Philbrick created a new name *L. assurgentiflora* subsp. *glabra* for the southern plants. However, an early phylogenetic analysis by Martin Ray failed to find evidence for two evolutionary lineages in *M. assurgentiflora* corresponding to Philbrick's taxonomic concept. Here we use allele size data from nine microsatellite loci to examine genetic variation and structure among populations across the natural range of the species. Our sampling includes 206 individuals, 23 of which are from an anomalous and potentially naturally-occurring population on San Nicolas Island. Our preliminary results suggest that the northern and southern populations are genetically distinct. This result supports Philbrick's hypothesis on the basis of morphology that plants from the northern and southern Channel Islands may be distinct evolutionary lineages worthy of taxonomic recognition. Interestingly, if recognized taxonomically, the widely cultivated northern form would be among California's rarest plants in the wild, known from only four naturally-occurring plants as of 2017.

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

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, and biotic filters, including competition with invasive plant species, and allelopathy, due to the chemical juglone. Here we present two experiments designed 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 conducted to observe the effects of five juglone concentrations (from 0 to 0.5mM) on the germination of several native and invasive species. A field experiment was conducted to examine native and non-native annual recruitment with respect to microclimate and competition. Competition treatments included native species only, invasive species only, and both native and invasive species, all nested within canopy and open plot locations. Leaf size, phenology/timing of germination, plant stress, and growth rate were measured in each plot. In the field experiment, native *Amsinckia intermedia* and invasive *Brassica nigra* displayed similar phenology, being the first species to germinate. Both 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 ($\beta = -25.0$, $p<0.001$). Measurements will be taken and analyzed through the entire growing season in 2017.

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Morphological and genetic analysis of *Suaeda* from Mexican estuaries

Nearly 100 estuaries exist along the coast of Mexico, resulting in a series of unique and isolated habitats. The plant genus *Suaeda* Forssk ex J.F. Gmel., an unusual halophyte due to its sexual reproduction and dimorphic seeds, includes a high number of endemic taxa, which appear to have evolved due to the isolation of these estuaries. Nine new species of Suaeda have been proposed by the third author, but these species have yet to be studied in detail or formally published. In addition to nearly 350 specimens collected by Ferren from 1980-2000, seeds collected from both known and putative species of *Suaeda* were donated to the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) for curation and research. Morphological variation of these seeds were characterized using brightfield microscopy and the program ImageJ. They were also imaged using a scanning electron microscope to detect and describe variation in surface texture. To complement this morphological study, we will sequence four exemplars of each putative species, along with four known outgroup species, using high-throughput ddRADseq. To date, DNA has been extracted from herbarium specimens and Qubit assays have been conducted to measure DNA concentration. A series of morphological and genetic analyses are planned to evaluate Ferren's hypotheses regarding several new species of *Suaeda*, and how these populations or species are phylogenetically related. These analyses will also determine the effects of isolation on speciation in these unique wetlands of Mexico, with implications for preservation.

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The effect of functional diversity and topsoil removal on reinvasion of grassland communities after restoration into California old fields

Grasslands in California's coast ranges were historically dominated by a diverse mixture of native bunchgrasses and forbs, but today they are dominated by exotic annual grasses and forbs, particularly where past agricultural activities disrupted the root systems of perennial plants. Without human intervention, these former agricultural sites remain dominated by exotic species with little to no natural succession back to native species assemblages over many decades. Throughout California, restoration activities in these habitats have focused on the reestablishment of a small number of species particularly the perennial bunchgrass *Stipa pulchra*. To date, there has been little focus on restoration of a diversity of forbs and other lifeforms even though plant richness in CA grasslands arises from forb and not grass diversity in California. Little work has been done exploring the roles of forb functional diversity in influencing the persistence of native assemblages in the face of constant seed rain (or seed bank germination) of alien annual species. My proposed research seeks to explore how the functional diversity of the native community, and the removal of the exotic annual seed bank, via top soil scraping or seed bank manipulation prior to restoration, influence the reinvasion of old field grassland communities during restoration. To determine how these factors influence restoration outcomes, we manipulated the functional diversity of native grassland communities in a restoration experiment at Sedgwick Reserve in the Santa Ynez Valley. We created 5 seed mixes representing different functional assemblages of native herbaceous and woody species and seeded them into plots that had experienced two different seed bank removal techniques (or controls). Our goals were to determine how the presence or absence of an exotic annual grass seed bank influences the reinvasion rates after restoration and whether different groups of species established more or less well and differentially resisted reinvasion.

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The establishment and success of Sierra Nevada conifer seedlings under prolonged, climate-induced stress

Increasing temperatures, fluctuating precipitation, and lengthening growing seasons associated with climate change may cause geographical shifts in the climatic niches of many tree species. Stress from changing climate and interspecific competition is predicted to force species to migrate in latitude or elevation to avoid mortality, which may not be possible for high-elevation endemics. Research addressing these shifts must quantify the effect of climate on tree establishment, a stage largely ignored in assessments of future forest conditions. Our research bridges this gap in knowledge by using the *Abies concolor-Abies magnifica* ecotone in the Sierra Nevada, California, to quantify seedling response to long-term changes in regional climate. Data were collected across the ecotone in Yosemite National Park (YNP) and the Stanislaus National Forest, and paired with a 1981 dataset from YNP. Our primary objective was to evaluate the impact of recent climate change on forest community composition and ecotone stability. Indices of compositional change across the elevational gradient were calculated for 1981 and 2016, and indicate a decrease in regenerating *Abies magnifica* at lower elevations (Wilcox Rank-Sum W=60, p=0.005). Permutational multivariate analysis of variance indicated that variance in the overstory was explained more by elevation than year sampled (p=0.001, p=0.03), while seedling variation was explained equally by year and elevation (p=0.001). This suggests that the regenerating community has been more impacted by changes over time than the overstory. Community diversity increased over time, with increases in diversity at elevation bands that were historically dominated by a single species (Sorenson Index A=0.1619, p=0.001). Our findings indicate that significant changes have occurred in this ecotone in the past 30 years, and that continued compositional shifts can be expected in this ecotone with predicted changes in climate.

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

Recent and significant environmental changes have greatly affected native recruitment and re-establishment in chaparral and sage scrub plant communities. Established shrubs of these water-limited environments may be important in facilitation, where neighboring plants may benefit from shared resources and protection from herbivory. Living plants strongly influence community structure and interactions; however, there is little information suggesting that dead shrubs and trees in drought-affected landscapes may provide similar services as live shrubs. We conducted an experiment in Voorhis Ecological Reserve (VER) in Pomona, CA to determine whether seedling survival and growth depend on abiotic factors (microclimate conditions) or on biotic factors (herbivory). Two native woody shrubs (*Artemisia californica* and *Salvia mellifera*) and four annual native species (*Amsinckia intermedia*, *Deinandra fasciculata*, *Phacelia distans*, and *Pseudognaphalium californicum*) were each outplanted and sown in five blocks with three nurse treatments (live shrub, dead shrub, and exposed areas), and a nested caged and uncaged treatment within each nurse treatment. Environmental sensors and trail cameras were installed to measure abiotic factors and estimate herbivore occupancy. Leaf water potential, plant survival and height, and abiotic data were analyzed to determine abiotic and biotic effects on growth and survivorship under nurse shrub and caged treatments. Collection and analysis of data is ongoing.

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Does grazing of compost-amended grasslands impact carbon sequestration?

Compost application to grasslands is a novel approach aimed at mitigating greenhouse gases by increasing carbon sequestration without affecting ecological diversity. However, a significant portion of grasslands are utilized for grazing by agriculture, and the impacts of grazing on compost-applied grasslands are mostly unknown. Our research objective is to evaluate the feasibility of compost application to grazed grasslands as a method to increase soil carbon sequestration. My specific questions ask which combinations of compost and grazing applications: (1) increase soil organic carbon (SOC) and below-ground biomass, and (2) increase or decrease species richness.

To test these questions, I marked twenty ~0.4-hectare grassland plots in Solano County, CA. I applied a 1.3-cm thick layer of compost to half of each plot, and then placed a smaller grazing exclosure on portions of each plot, effectively yielding a control (- compost & + grazing) and three treatments (- compost & - grazing; + compost & - grazing; + compost & + grazing). I will collect soil cores, plant biomass samples and measure biodiversity from each plot three times per year over a two-year period. While we expect grazing to reduce SOC and below-ground biomass in grasslands with and without compost, grazed grasslands with compost will likely have relatively higher biomass and carbon storage. We anticipate grazing to increase biodiversity in grasslands with and without compost, but grasslands with compost will have relatively higher biodiversity.

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Patterns of polyploid formation in manzanitas

Genome duplication is a profound mechanism for reproductive isolation and hybrid speciation in sympatry. The formation of polyploid species through genome duplication is widely recognized and is considered to have occurred numerous times during the evolutionary history of flowering plants. The genus *Arctostaphylos* contains 105 minimum rank taxa and is primarily distributed throughout the California Floristic Province — all but one taxon occurs within the region's boundary. Of this large number, 37 taxa are documented polyploids, indicating a strong relationship between genome duplication and species richness in the group. The Sierra Nevada is home to two widely distributed diploid manzanita species, *A. patula* and *A. viscida*. A third sierran species, *A. mewukka*, was demonstrated as the resulting allopolyploid from hybridization between *A. patula* and *A. viscida*. Two subspecies of *A. mewukka* are currently recognized, and may have arisen from separate and independent hybridization events, as recurrent formation of polyploid taxa through repeated hybridization events is a commonly observed pattern in plant evolution. In addition, maternal and paternal input may not be consistent at each event, and reciprocal parentage may be occurring among progenitors. Our goal is to determine parentage of *A. mewukka* at locations throughout its distribution by comparing maternally inherited cpDNA with regions of nrDNA undergoing concerted evolution. Results will illustrate patterns of hybridization and polyploid formation in manzanitas.

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Phylogeography of *Arctostaphylos uva-ursi*

Though most of the species diversity of the manzanita genus *Arctostaphylos* is concentrated within the California Floristic Province, one species, *Arctostaphylos uva-ursi*, has a circumboreal distribution. *A. uva-ursi* ranges throughout North America (including California) and northern Europe and Asia, and includes a disjunct subspecies in Guatemala. Variations in leaf morphology, stem pubescence, and chromosome number exist across its range, most distinctively in North America, and several "forms" have been named in addition to the Guatemalan subspecies. In light of the intraspecific variation and unique distribution of this species, we investigate the biogeographic history of *A. uva-ursi* from a phylogenetic perspective, utilizing nuclear and chloroplast DNA. Hypotheses to test include a Western North American origin of the species and an early divergence from the rest of *Arctostaphylos.*

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Abiotic conditions of *Trillium ovatum* at Big Basin Redwoods State Park

Redwood forests provide numerous environmental services that are vital to the health of both humans and wildlife; therefore, the study of redwood trees is a saturated subject. However, very little attention is paid to the understory species—even those that are ubiquitous. This study explored the preferred abiotic conditions of *Trillium ovatum* by analyzing the presence, absence, and abundance of this species along a trail in Big Basin Redwoods State Park in California. The abiotic conditions along the trail analyzed were elevation, aspect, slope, and distance from stream course. The preferred abiotic conditions of *T. ovatum* included southeast, north, and southwest-facing aspects, and lower elevations closer to stream courses. The inferred optimal conditions for *T. ovatum* along with its lengthy maturation period reinforce the idea that the plant can be a reliable indicator for redwood forest recovery.