Virtual Symposium Agenda
46th Annual Southern California Botanists Symposium

Living on the Edge: Plants in Extreme Environments

Saturday, October 24, 2020
Accessible through Video Conference on ZOOM

9:00-9:05 **Opening Remarks**

9:05-9:15 **Meeting of the General Membership**

9:15-9:40 ***Solving a Palm Mystery One Trait at a Time*, Lorena Villanueva Almanza, Ph.D.**, Freelance Science Writer and Outreach Coordinator for the California Botanical Society.

9:40-10:05 ***It's a Dry Heat: The Tenacious Cactaceae of Southern California*, Michelle Cloud-Hughes, Ph.D.,** Proprietor, Desert Solitaire Botany and Ecological Restoration.

10:05-10:35 **Poster Session 1**

10:35-10:45 **Break**

10:45-11:10 ***Parasites on the Edge*, Adam Schneider, Ph.D.**, Assistant Professor of Biology, Hendrix College.

11:10-11:35 ***In Between Worlds: The Amphibious Life in Mediterranean Vernal Pools*, Jorge Montiel, Ph.D. Candidate**, University of California, Merced.

11:35-12:00 ***A Vascular Flora of the Southern Inyo Mountains, Inyo County, California*, Maria Jesus**, Graduate Student, California Botanic Garden/Claremont Graduate University.

12:00-1:00 **Lunch**

1:00-1:25 ***The Role of Demographic and Evolutionary Processes in Buffering Populations from Climate Change*, Seema Sheth, Ph.D.**, Assistant Professor, Department of Plant and Microbial Biology, North Carolina State University.

1:25-1:50 ***Bushmallows – The Genus* Malacothamnus, Keir Morse, Ph.D. Candidate**, California Botanic Garden/Claremont Graduate University.

1:50-2:15 ***Resolving the Phylogeny of a Genus of Obscure Shrubs: A Revised Classification of* Glossopetalon *(Crossosomataceae)*, Maya Allen, Ph.D. Candidate**, University of New Mexico.

2:15-2:25 **Break**

2:25-2:55 **Poster Session 2**

2:55-3:20 ***Endless Forms: Herbarium Digitization of Imperiled Plants with Extreme Morphological Adaptions*, Mare Nazaire Ph.D.**, Administrative Curator, CBG-POM Herbarium.

3:20-3:45 ***Implications for Constraints on Niche Evolution from 15 Years of Study Across a Plant Species' Range*, Jason Sexton, Ph.D.**, Associate Professor, University of California, Merced.

3:45-3:50 **Closing Remarks**

3:50-5:00 **Mixer**

Please stay around to enjoy a jam session by Sage Against the Machine at 5:00 PM.

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Speaker Abstracts

***Solving a Palm Mystery One Trait at a Time*, Lorena Villanueva Almanza, Ph.D.**

Washingtonia is an American genus of palms currently composed of two species, *W. filifera* and *W. robusta*. Poor understanding of their morphology and distribution led initially to the description of numerous new species and later, to a simplification resulting in the current understanding of the genus. This widely distributed group of palms native to the Baja California peninsula, southern California, Sonora, and Arizona has been a taxonomic challenge due to a lack in type specimens, incomplete protologues, highly variable vegetative morphology, human dispersal, limited fieldwork in native populations, and poor representation in herbaria.

In the wild, both distinct forms occur in the extremes of a 1300-km gradient, linked by morphological intermediates, suggesting that there is continuous morphological variation of the two forms instead of the long-held idea of two species. We addressed this hypothesis by taking measurements of morphological traits of stems and functional traits of leaves in 17 sites spanning the whole distribution range of the genus in Mexico and the US. We examined the relationship between the plants' traits and latitude, individually, and between all traits combined (using a Principal Component Analysis) and latitude. We compared a linear model against a non-linear model to test whether traits of *Washingtonia* change gradually along the latitudinal gradient or if there are clear geographical breaks among populations.

We also used Genotyping By Sequencing (GBS) data to understand population structure and delimit species. Using both a de novo and reference-based approaches, we analyzed 173 *Washingtonia* individuals from 21 populations across its distribution range through multivariate and Bayesian methods.

We found strong statistical support for the hypothesis that there is a gradual change in the vegetative morphological traits of *Washingtonia* along the latitudinal gradient of Peninsular California, instead of two clear morphologically distinguishable species with a hybrid zone. However, we also found that *Washingtonia* populations are highly structured with four major geographic regions having unique genotypes. Based on previous morphological results and the evidence herein we propose recognizing a single species of *Washingtonia* with four subspecies. Our findings suggest *Washingtonia* is composed of one highly variable species and that local differentiation of populations is related to environmental gradients. Our results provide a robust phylogenetic analysis of *Washingtonia* settling a taxonomic debate that has lasted over a century.

***It's a Dry Heat: The Tenacious Cactaceae of Southern California*, Michelle Cloud-Hughes, Ph.D.**

The cacti are botanical icons of the desert southwest and are an important biological component of our desert biomes. Species within the Cactaceae have a broad range of morphological, physiological, and genetic adaptations which allows them to inhabit harsh environments that exclude many other plant species. Most cactus species occur in hot, dry regions where water is extremely limited, and their adaptations reflect the need to conserve water. Morphological adaptations within the Cactaceae include succulent, photosynthetic stems to allow for maximal water storage, thick cuticles and epidermal layers, the nearly-complete replacement of leaves with protective spines, ribbed stems to allow for stem expansion when water is available, stems shaped to minimize surface area for water loss while maximizing volume for water storage, and shallow roots to take rapid advantage of rare rainfall. Physiologically, cacti utilize CAM photosynthesis to minimize water loss during the day, although this comes at the cost of slow growth. Cacti also exhibit a high degree of polyploidy, which can confer genetic advantage in adapting to harsh environments. Many species can also reproduce both clonally and sexually, allowing them to hedge their reproductive bets.

Southern California is home to approximately 37 cactus species in 12 genera. This presentation will provide an overview of Cactaceae evolutionary history and adaptations as well as a closer look at the genera and species that inhabit southern California.

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Speaker Abstracts

***Parasites on the Edge*, Adam Schneider, Ph.D.**

Parasitic plants challenge stereotypical conceptions of "plantness". Using my own research in the Orobanchaceae, I will explore two ecological, evolutionary, and floristic implications of the unique life history found in this guild of plants.

First, I will explore the microbial ecology found on the "edge" of parasitic plants. The reduction in morphological and anatomical complexity of holoparasitic *Orobanche*, coupled with its unique heterotrophic physiology, is associated with an ecologically reduced microbiome. A study of the focal species *O. hederae*, recently published with Connor Fitzpatrick, revealed increased homogenization between shoot and root tissues, with lower overall diversity and far fewer co-associations among individual bacterial members inhabiting the parasite compared to its host. Future research will explore these patterns across a wider range of host-parasite pairs and abiotic environments and seek to compare the relative effects of parasite-host versus parasite-soil interactions in microbial community assembly.

Shifting gears, I will talk about several species in the genus *Aphyllon* that are on the "edge" of being described as new to science. Though host-specific lineages are common and well supported by molecular phylogenetics, difficulty in morphological diagnosis limits the practical ability to describe and recognize new taxa. To illustrate this, I will explain why the range of "real" *Aphyllon* fasciculatum is limited to the Sierra Nevada and eastward, and why most specimens collected in California and Baja California should be called "*Aphyllon franciscanum*". Comprehensive descriptions and diagnoses for both species were facilitated by a morphometric study conducted with Ben Benton and in press with Systematic Botany.

Finally, your help is needed for additional field collections and observations that can help evaluate several other putative taxa in *Aphyllon*.

***In Between Worlds: The Amphibious Life in Mediterranean Vernal Pools*, Jorge Montiel**

Vernal pools are extreme ecosystems encompassing phases of water saturation and severe desiccation (normally within a year); oscillation between these two scenarios makes vernal pools highly stressful environments. Vernal pool organisms are specialized to such stressful conditions like no others; for example, plants go through a metamorphosis that drastically alters their morphology, often from an aquatic grass-like phase (isoetoide) to a terrestrial spiny-weed morphology. Additionally, photosynthetic pathways may also transition; aquatic plants using CAM and C3 transition to the C4 photosynthetic pathway as they transition to a terrestrial phase. The mechanism behind this amphibious behaviour remains unknown. Studies in plant-microbial interactions have shown that those microbes living in symbiosis with plants ("endophytes") alleviate environmental stress. However, vernal pool microbial organisms remain poorly understood, including those living in symbiosis with plants. My first research approach has been to analyze the prokaryotic community living in vernal pool water, soils, and plant tissues. Preliminary results revealed two specific niches (water and soil) for prokaryotes (bacteria and archaea), with water microbial communities following biogeographical patterns similar to larger organisms. Future analysis on plant tissues will compare the distributions of microbial plant endophytes and address the role microbes may play in helping plants tolerate these extreme environments.

***A Vascular Flora of the Southern Inyo Mountains, Inyo County, California*, Maria Jesus**

The southern Inyo Mountains are a desert mountain range located between Death Valley National Park and the Sierra Nevada in Inyo County, California. This arid region is home to numerous rare and endemic plants, plants at the edge of their range, and plants adapted to harsh conditions. My research focuses on cataloging the flora of this understudied region. The study area is approximately 433 km2 (167 mi2) and includes the western edge of the Great Basin Desert and Mojave Desert bioregions. Pinus longaeva is found near the high point at 2953 m (9690 ft) - a mere 10 km (6 mi) from the low point of 579 m (1900 ft) at the edge of Saline Valley. Prior to this study, less than 100

specimens had been collected away from main roads. Much of this undisturbed landscape is protected by wilderness designation. However, the center of the study area is unprotected and is urgently threatened by gold mining. Here, calcareous rock outcrops abound, and several narrow endemics occur near the southern extent of their range. Mojave Desert plant communities are expected to shift in response to climate change and specimens from this otherwise unimpacted area may provide important evidence of such changes. My study aims to document baseline botanical data that are needed for these urgent conservation issues while also filling in a botanical black hole.

***The Role of Demographic and Evolutionary Processes in Buffering Populations from Climate Change*, Seema Sheth, Ph.D.**

Adaptive evolution is a key means for populations to persist under environmental change. Evolutionary rescue, whereby a declining population becomes stable or growing due to adaptive evolution, directly bridges the evolutionary process of adaptation and the ecological process of demography. Yet, whether populations can adapt quickly enough to keep up with the rapid pace of changing climate remains largely unknown, and range limit theory suggests that the probability of evolutionary rescue varies across species' ranges. Populations may adapt by timing their phenology to **escape** stressful conditions, or evolve to physiologically **avoid** stress in increasingly harsh and variable environments. In this talk, I will use the scarlet monkeyflower (*Erythranthe cardinalis*, Phrymaceae), a perennial herb that spans a broad latitudinal gradient in western North America, as a model system for assessing demographic and evolutionary responses to recent climate change.

***Bushmallows – The Genus* Malacothamnus, Keir Morse**

Malacothamnus is a genus of fire-following shrubs in the mallow family (Malvaceae) with 16 taxa ranked as rare in California by the California Native Plant Society. Management of these rare taxa is confounded by conflicting taxonomic treatments and unclear morphological boundaries between taxa. Here I present an introduction to *Malacothamnus* and some preliminary results of the work currently underway to resolve the taxonomy of the genus.

***Resolving the Phylogeny of a Genus of Obscure Shrubs: A Revised Classification of* Glossopetalon *(Crossosomataceae)*, Maya Allen**

Glossopetalon inhabits arid regions in the American west and northern Mexico on limestone substrates. The genus comprises four species: *G. clokeyi*; *G. pungens*; *G. texense*; and *G. spinescens*. Three of the species are narrow endemics. The fourth, *G. spinescens*, is a widespread species with six recognized varieties. All six varieties are intricately branched shrubs that have been difficult to identify due to a lack of clearly delineating morphological characters. Characters typically used to differentiate the varieties of *G. spinescens*, such as stem coloration, leaf blade size, and presence of stipules, are highly variable within and among populations. Additionally, there has not been a robust study of the phylogeny of this genus and the species relationship are unknown. A custom protocol of double digest restriction-site associated DNA sequencing (ddRAD) was used to resolve the phylogeny of *Glossopetalon* and address if population genetic data analyses (such as STRUCTURE, SVDquartets, and phylogenetic networks) support the recognition of six varieties of *G. spinescens*. *Glossopetalon* was fully supported as monophyletic and *G. pungens* was resolved sister to the remaining taxa in the genus. The varieties of *G. spinescens* were resolved as two distinct lineages corresponding to their biogeography – one to the northwest (lineage 1) and one to southeast (lineage 2). *Glossopetalon clokeyi* was resolved at the base of lineage 1 and *G. texense* was embedded within lineage 2 sister to var. *spinescens*. Taxonomic changes include the recognition of *G. texense* and *G. clokeyi* as varieties of *G. spinescens* and description of a unique population from northern Arizona as a new variety – *G. spinescens* var. *goodwinii*.

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Speaker Abstracts

***Endless Forms: Herbarium Digitization of Imperiled Plants with Extreme Morphological Adaptions*, Mare Nazaire Ph.D.**

Only 36 areas on earth contain almost half of the world's plant diversity. Biodiversity hotspots occupy only 2.3% of the earth's land surface but harbor a high proportion of endemic species and house most undescribed plant diversity. An important biotic component of biodiversity hotspots includes plants with unusual morphologies, such as succulence, carnivory, and epiphytism. These plants are highly adapted to live in extreme environments but face serious threats of extinction due to changing climate and land use regimes. The Endless Forms Thematic Collections Network (TCN) aims to build digital resources to document the vascular plants in 15 families that exhibit unique adaptations to extreme environments, and to promote scientific investigation and public understanding of these potentially imperiled plants through the aggregation of over two million herbarium specimens. Through a recent award made by the National Science Foundation, the Herbarium at California Botanic Garden (RSA) will enhance the Endless Forms TCN by digitizing over 70,000 herbarium specimens representing all families, some of which are especially diverse (cacti, agave, spurge) in California, a world biodiversity hotspot. Availability of specimen data through digitization facilitates research to further explore morphological adaptations, patterns of diversification and endemism, and ecological niche evolution of these highly unusual plants. The digitization of Endless Forms plant specimens enables researchers to study contemporary patterns of distribution and predict future environmental change, as well as help to mitigate negative impacts such as climate change and shifts in land use, and importantly, to implement conservation measures on these imperiled plants. Outreach efforts and redacting collection information to protect sensitive species will also be discussed.

***Implications for Constraints on Niche Evolution from 15 Years of Study Across a Plant Species' Range*, Jason Sexton, Ph.D.**

As global temperatures continue to rise, populations at the warm edges of species' ranges will face increasing pressures that will cause evolution through natural selection in the best-case scenario, and extirpation in the worst. In this vein, studies of warm-edge populations, which occupy locations near a critical edge of their niche, can inform us about the processes and limits to niche evolution. I have studied eco-evolutionary patterns of an annual plant, *Mimulus laciniatus*, for 15 years across its species range in the California Sierra Nevada. In this talk, I will summarize and discuss the results of experimental gene flow, transplant and resurrection experiments, population genetics studies, and field censuses as they relate to constraints on niche evolution at, approaching, and beyond the warm edge of this species range. I will also highlight recent results suggesting that natural selection has reduced genetic variation in warm-edge populations and shifted phenological trait means in response to extreme, modern drought and climate warming. Finally, I will briefly place these findings in the context of broad patterns that have been found across studies examining species range limits.

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Poster Abstracts

Poster Session 1

Documenting the Range and Upper Elevational Population Trends in Endemic Desert Perennial Orocopia Sage **(Salvia greatae), Melanie J. Davis**, Lynn C. Sweet, Scott A. Heacox and Cameron W. Barrows

Orocopia sage, *Salvia greatae* Brandegee (Lamiaceae) is a shrub endemic to the Orocopia and Chocolate Mountains within the Colorado Desert of Riverside and Imperial counties, California. Very little is published on the demographics, distribution, range, ecology or threats to S. greatae. Core habitat of the species is primarily described as alluvial fans, slopes, and washes between 30-450m elevation. This study was designed to establish long term plots focused specifically on documenting threats and describing the demographic patterns of *S. greatae* populations. Study plots were selected by compiling historical herbarium localities, previous surveys, and records of regional vegetation mapping. Surveys performed in winter of 2019 found trends that differ from the documented elevational distribution of the species; finding larger and healthier populations thriving up to 1002m elevation on rugged slopes. Populations at mid-elevation showed higher mortality rates, and populations previously recorded at lower elevations (presumably within core habitat in the Salt Creek watershed to the Salton Sea) were no longer detectable. This indicates that the current described habitat of *S. greatae* may have been biased toward the lower, accessible populations, which may have been composed of waif occurrences, as opposed to core, stable populations. Declines noted in mid- and lower-elevation populations are consistent with drying due to anthropogenic climate change and altered hydrology that resulted from the construction of a canal that bisects the lowest reaches of the documented distribution. Conservation efforts should focus on further documenting the range of the species and monitoring populations at risk due to climate change.

A Vascular Flora of the Salmon and Manter Creek Watersheds in the Southern Sierra Nevada, Tulare County, California, **Nina House**

My study aims to document the flora of the Manter and Salmon Creek watersheds in the southern Sierra Nevada, Tulare County, CA, a 51 sq. mi. area of the Kern Plateau. There are several aspects of this area that make it worthy of botanical exploration. The Kern Plateau is an ecologically unique area in the southern Sierra Nevada that is home to numerous endemic species. Additionally, the Domeland Wilderness makes up 25 sq. mi. of the study site and represents an area that has seen little in the way of botanical exploration. These qualities provide an opportunity to document important botanical discoveries, including new county records, species at the edge of their range, and disjunct plant populations. This study is being performed at a crucial time, as there are many projected impacts from land use and climate change in this remote region. Disturbance from cattle grazing, off highway vehicular use, and drought have been documented at the site and will all have lasting impacts on the flora. To date, I have completed a total of 13 field trips, totaling 46 days in the field and resulting in the collection of 917 plant vouchers. My primary goal is to produce an annotated checklist of the regional flora. With an additional twelve trips planned for summer 2021, I anticipate contributing much more to our botanical understanding of this region.

The Resilience of Flowers: 38 of 44 Species Correctively Reorient After Disturbance, **Leah Makler** and Dena Grossenbacher

A flower's ability to right itself after being knocked over by wind, rain, or animals could be essential to its reproductive success. Such 'corrective reorientation' could be tied with certain morphological traits, such as floral symmetry. Bilaterally symmetric flowers require specialized pollinator handling and thus may benefit more from corrective reorientation than radial flowers. In this study, we experimentally tested for corrective reorientation in 19 bilateral and 26 radial species of flowering plants at the Santa Barbara Botanic Garden. We found that most species (38 of 44) experienced corrective reorientation, and that there was no difference between radially and bilaterally

symmetric species. Furthermore, after accounting for phylogeny, we found no evidence of correlated evolution of floral symmetry and corrective reorientation. These results imply that floral reorientation may be equally adaptive for both radially and bilaterally symmetric flowers. However, corrective reorientation could also simply be a byproduct of the vegetative response to being disoriented (e.g., phototropism), but further analysis is needed to determine the true cause of this phenomenon.

Exploring Plant Diversity on a Glacial and Edaphic Sky-island in the Eastern Sierra Nevada: A Flora of Coyote Ridge and Flat, Inyo County, CA, **Martin Dale Purdy**

California's Sierra Nevada mountain range supports a disproportionate share of the state's plant diversity and is one of the most floristically diverse regions of its size in the United States. The high Sierra Nevada, in particular, has been identified as an important center of species richness and endemism within the state. Anthropogenic climate warming is expected to disproportionately affect mountain ecosystems, and models have predicted serious habitat contraction for many alpine plant taxa. A specimen-based inventory of plant taxa at Coyote Ridge and Coyote Flat is underway in order to establish baseline data for one such sensitive alpine habitat. Located in the northwest corner of Inyo County, CA, the study site is ca. 50 square miles and ranges from 8,500 to 13,500 feet in elevation. This area is notable in the Sierra Nevada for containing an unusually high diversity of rock types and lacking signs of recent glaciation. High floristic diversity is expected due to the area's diverse geology, topography, and habitats. Plant diversity is being documented through the collection of physical specimens connected to georeferenced iNaturalist observations. Both vascular and non-vascular plants are being collected, and all specimens will be deposited in regional herbaria. As of September 2020, the second year of a three-year study, 779 collections have been made over 53 days of fieldwork. Preliminary results and fieldwork highlights will be shared on the poster.

Santa Barbara Botanic Garden Tissue Bank: A Resource for Plant Genetics Research, **E.A. Thomas**, K.E. Hasenstab-Lehman, C. Matt Guilliams

Biorepositories are critical resources for DNA-based research, providing material from which researchers can conduct biodiversity studies. These investigations range from understanding the genetic structure of rare populations on the landscape, to description of new or cryptic taxa based on improved phylogenetic inference. Tissues gathered by local researchers can be used by international colleagues in studies of trait evolution and biogeography for groups of taxonomic interest, especially when costs or permits would prohibit their own fieldwork.

The Santa Barbara Botanic Garden is establishing a repository for plant tissue collections connected to the Global Genome Biodiversity Network, with an emphasis on the flora of California and the California Channel Islands. Island taxa currently make up nearly 30% of the tissue bank, 1,900 of the 6,200 collections. Island endemics and rare mainland species are among the most highly represented taxa in the repository, including several species of *Dudleya, Crocanthemum greenei*, *Eriodictyon capitatum,* and *Berberis pinnata subsp. insularis*. Prominently featured plant families include Crassulaceae with 1,300 tissues, Asteraceae with 900 tissues, Boraginaceae with 650 tissues, and Malvaceae with 350 tissues.

The tissue bank is growing with every field season as researchers contribute collections. Practices for tissue collection, recording metadata, and long-term tissue storage and curation are discussed, as well as opportunities to collaborate using this new resource. This repository will be accessible to researchers for tissue loans and will accept and curate tissue contributions.

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Poster Abstracts

Poster Session 2

Untangling a Mistaken Identity: Describing the Two Species Within **Aphyllon fasciculatum, Ben E. Benton** and Adam C. Schneider

A recent phylogenetic study of the western hemisphere broomrapes (genus *Aphyllon*) showed strong support for a non-monophyletic *Aphyllon fasciculatum*. Undescribed lineages correspond to unique host preferences, but similarities in overall morphology have hindered taxonomic revision. We collected and analyzed morphometric data from 95 herbarium specimens and 61 iNaturalist observations across the geographical range using principal component analysis and multiple correspondence analysis, respectively. Overall, we found a high degree of overlap in physical characteristics, but the plant coloration, shape of the corolla lobes, calyx cup depth, and calyx lobe length of the two species currently recognized as *A. fasciculatum* were distinctive. This information will support our forthcoming description of a new species within the genus *Aphyllon* and the creation of a field-appropriate dichotomous key.

Recruitment Limitations of the Northern Island Mallow **(Malva assurgentiflora *subsp.* assurgentiflora)** *on Anacapa Island*, **Stephanie Calloway**, Jenn Yost, C. Matt Guilliams, Kristen Hasenstaab-Lehman, and Matt Ritter

The northern island mallow, *Malva assurgentiflora* (Kellogg) M.F. Ray subsp. *assurgentiflora* (Malvaceae), is a perennial shrub endemic to Anacapa and San Miguel Islands. On Anacapa, naturally occurring *Malva* are presumed extirpated. Fortunately, prior to extirpation, seed was collected by biologists and used to create a new population on East Anacapa Island, where plants are managed by the National Park Service in a 3600m^2 restoration site. While *Malva* restoration efforts on Anacapa are noteworthy, there are challenges that need to be addressed in order to prevent potential extirpation in the wild once again. In the years following restoration, biologists have documented only five new *Malva* seedlings, with just two remaining as of June 2020. Since this species is known to be a prolific seeder with high germination rates, it is likely that other barriers are limiting recruitment. One barrier may be the Anacapa deer mouse (*Peromyscus maniculatus* subsp. *anacapae*) - Anacapa's only land mammal. Biologists commonly observe seed predation of *Malva* fruits by deer mice. While this is hypothesized to be a significant barrier to recruitment, there have been no studies documenting this or other possible limitations. In 2020, we began a series of related experiments designed to characterize recruitment limitations during *Malva's* early life history stages, including the following: 1) pre-dispersal and post dispersal exclusion of deer mice, 2) seed and seedling removal experiments, 3) field germination trials, 4) quantification of seed production potential, and 5) analysis of demographic data. Here, we present preliminary findings and an overview of planned work.

Investigating Germination Cues for the Endangered Lompoc Yerba Santa **(Eriodictyon capitatum)**, Heather Schneider, **Sean Carson**, Sarah Termondt

Understanding the germination cues of rare plants is critical to their conservation, restoration, and management. We used a greenhouse study to investigate the germination of *Eriodictyon capitatum* (Namaceae) seeds to understand the species' life history and to inform restoration efforts. *Eriodictyon capitatum* is a woody shrub that is listed as rare by the state of California and endangered by the US Fish and Wildlife Service. Limited to just seven extant occurrences, *E. capitatum* does not readily produce seeds at most sites, but it does spread clonally, sometimes leading to low genetic diversity in aboveground vegetation. We collected seeds from one wild occurrence and measured germination rates in response to each of five physical treatments: control, dry heat, hot soak, liquid smoke, and scarification. Each physical treatment was replicated under both light and dark conditions. The highest percent germination was recorded with the liquid smoke treatment and the fastest germination occurred when seeds were sown in the dark while treated with liquid smoke. The significant impact of liquid smoke on seed germination suggests that *E. capitatum* is adapted to fire

and that periodic fires could potentially promote aboveground genetic diversity by eliciting a flush of germination from the soil seed bank. These findings can facilitate future propagation efforts, inform management, and also highlight the important role of fire in the life history of this endangered plant.

***Extreme Conditions in Extreme Environments: An Extreme Restoration Challenge*, Joanna Tang** and Carla D'Antonio

Only 5% of California's historic endemic vernal pool ecosystems are still extant. A major threat to these unique seasonally-flooded wetlands is invasive non-native grasses, as vernal pools often exist within a grassland matrix. We assessed vegetation cover in a suite of south coast vernal pools that had been restored in the past 30 years and found that non-native cover increased with time since restoration. These findings indicate that even restored vernal pools suffer reinvasion in the long run. Although the extreme hydrologic conditions of vernal pools have historically favored specially-adapted endemic species and precluded generalist invaders, climate change causing the disruption of the historic hydrologic regime and even more extreme drought conditions can instead favor invasive species. The disrupted extreme conditions of vernal pools can no longer be relied upon to prevent reinvasion in restoration projects, but as budget constraints of restoration projects often preclude continual long-term intensive weeding to prevent reinvasion, new cost-effective management techniques must be developed to safeguard vernal pools in the long run.

***Morphological Analysis and Ecological Niche Modeling of Dwarf Mistletoes in the* Arceuthobium campylopodum-occidentale *Species Complex,* Nicholas J. Torres**, Madison E. Panzino, Joann Lam, Jada E. Smith, Trina R. Miller, and Alisa R. Hernandez, William J. Hoese, Joshua P. Der

Dwarf mistletoes (*Arceuthobium* spp.) are highly reduced obligate hemiparasites that attack conifers. The *Arceuthobium campylopodum-occidentale* species complex is distributed throughout Western North America and is notoriously difficult to differentiate; consequently, taxonomists disagree about the number of taxa that should be recognized. We hypothesized that the *Arceuthobium campylopodum-occidentale* complex is composed of separate species and used morphological analysis and niche modeling to examine its taxonomic diversity. We predicted morphology would differ across taxa and taxa would occupy distinct niches. We also examined the importance of host distribution and climate in predicting mistletoe distributions. The host niche hypothesis predicts that host distribution mediates parasite distribution, while the parasite niche hypothesis predicts that the parasite's own physiological requirements determine parasite distribution. We compared morphological characters from herbarium specimens of *Arceuthobium abietinum, A. campylopodum, A. cyanocarpum, A. microcarpum,* and *A. occidentale.* Our niche models used occurrence and bioclimatic data for each mistletoe taxon and their hosts. *A. cyanocarpum* is morphologically distinguished from the other taxa by its reduced size, and several taxa had distinct niches. These results suggest that some members of this complex represent distinct species. Our data support the parasite-niche hypothesis, and while hosts are important in predicting mistletoe niches, mistletoe and host niches differ because mistletoes parasitize multiple host species in a subset of their range. *Arceuthobium* is an ecologically important genus, providing habitat and food for animals. By gaining a better understanding of biodiversity in this group, we obtain insight into the eco-evolutionary dynamics of dwarf mistletoes and their hosts.