



Chicago Botanic Garden

Research Experiences for Undergraduates (REU) Program

Plant Biology & Conservation: From Genes to Ecosystems

Final Poster Presentations

August 16, 2018



1) **Emily Orr** is majoring in Biology with a Bioinformatics Emphasis at University of Missouri-Kansas City and is expecting to graduate in 2018.

Title: Insights into the role of mountain range location on genetic structure of *Penstemon pachyphyllus*

Abstract: Seed sourcing for restoration relies on our understanding of population genetic structure and factors influencing gene flow among wild, seed-source populations. Factors influencing genetic structure and gene flow vary by species and may include habitat fragmentation, landscape barriers, and pollinator movement. Our study examined the genetic structure of *Penstemon pachyphyllus*, a species of restoration concern in the Great Basin region of the Intermountain West. Mountain range location and distance between populations are known to influence *Penstemon pachyphyllus* genetic structure. We sought to determine whether or not six wild populations, located on two mountain ranges, reflected patterns of genetic structure similar to previous findings. We quantified neutral allelic variation among 189 individuals using four polymorphic microsatellite loci. We observed moderate gene flow among mountain ranges, however isolation by distance could not be identified as a driver of genetic isolation. Future research should aim to quantify the possible influence of habitat connectivity on genetic structure in *Penstemon pachyphyllus*. Specifically, populations with low genetic diversity should be identified. Our findings show that seed should continue to be collected from all six of our study populations to maximize genetic diversity.

2) **Iris Moore** is majoring in Plant Science at Purdue University and is expecting to graduate in 2020.

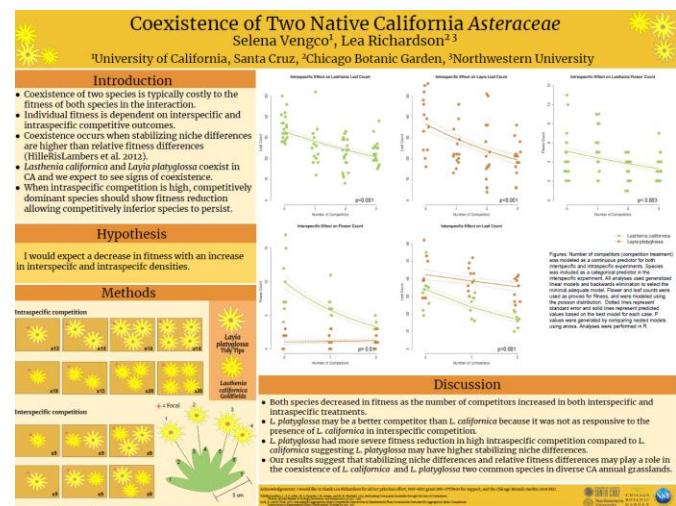
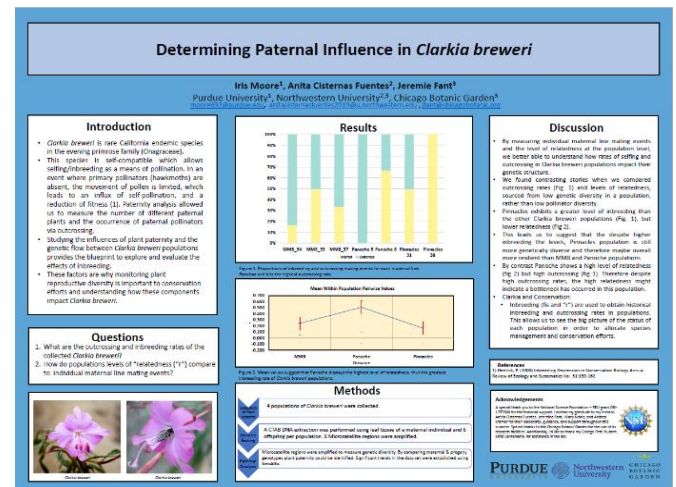
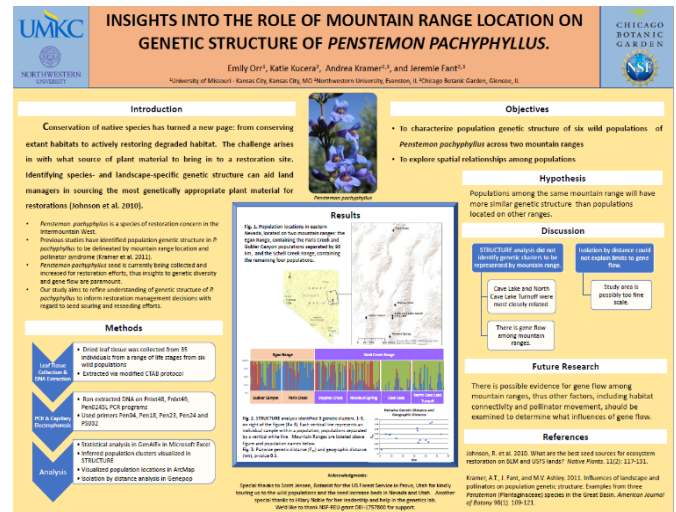
Title: Determining paternal influence in *Clarkia breweri*

Abstract: *Clarkia breweri* is rare California endemic species in the evening primrose family (Onagraceae). This species is self-compatible which allows selfing/inbreeding as a means of pollination. In an event where primary pollinators (hawkmoths) are absent, the movement of pollen is limited, which leads to an influx of self-pollination, and a reduction of fitness. Species that exhibit inbreeding depression have reduced levels of genetic diversity that ultimately leads to issues such as a decreased influence of establishment, mutation accumulation, and other consequences. We conducted a series of genetic and paternity testing to measure maternal line mating events and the level of relatedness as a population; our results reveal the rates of selfing and outcrossing in *Clarkia breweri* populations. Inbreeding (fis and "r") are used to obtain historical inbreeding and outcrossing rates in populations. This allows us to see the big picture of the inbreeding status of each population in order to allocate species management and conservation efforts.

3) **Selena Vengco** is majoring in Ecology and Evolution at University of California-Santa Cruz and is expecting to graduate in 2019.

Title: Coexistence of two native California *Asteraceae*

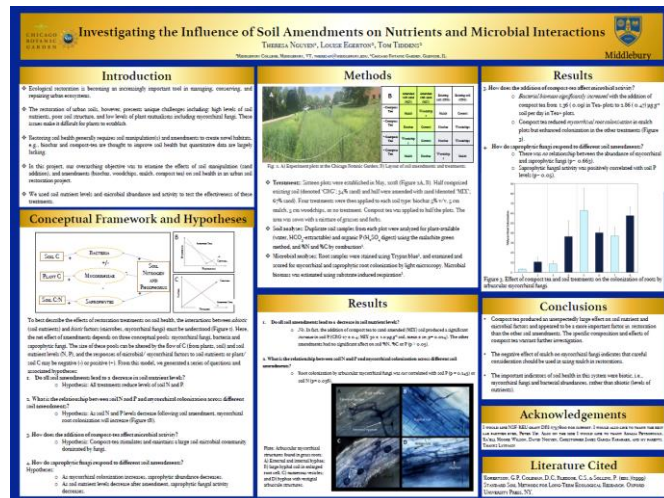
Abstract: Coexistence of multiple species isn't without costs. High stabilizing niche differences suppress competitively dominant species by reducing their fitness and allowing competitively inferior species to persist in a community. High relative fitness differences allow species to competitively exclude one another, decreasing biodiversity. We expect increasing the number of competitors in interspecific and intraspecific competition treatments to reduce fitness. *Lasthenia californica* and *Layia platyglossa* are two common species that coexist in diverse California annual grasslands. We planted them into different densities of interspecific and intraspecific competition ranging from 0-2 and 0-3 competitors, respectively. Across all treatments and species fitness decreased as number of competitors increased. *L. platyglossa* was less sensitive to the presence of *L. californica* suggesting higher relative fitness than *L. californica*. *L. platyglossa* had a steeper decline in fitness with increasing intraspecific competition than *L. californica*, suggesting greater stabilizing niche differences. Because *L. platyglossa* may experience higher stabilizing niche differences and relative fitness than *L. californica*, this could allow both species to coexist.



4) **Pigeon Nguyen** is attending Middlebury College and is expecting to graduate in 2021.

Title: Investigating the influence of soil amendments on nutrients and microbial interactions

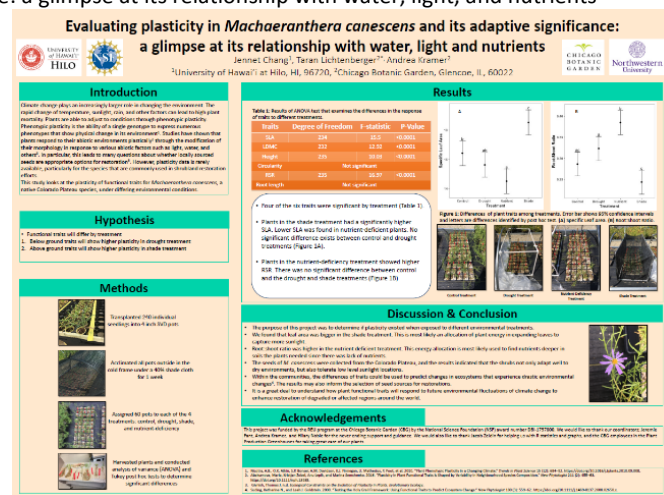
Abstract: Soil health is important as it reflects and influences the health of an overall ecosystem. Microbial activities of fungal and bacterial populations take a large part in determining soil quality. Many propositions exist on the topic of how to improve soil quality. The goal of this project was to look at different soil amendments, specifically biochar, compost, woodchips, and mulch, and their influences on soil nutrients and microbial activity. There were four main hypotheses pertaining to this project: (1) All the treatments will reduce nitrogen and phosphorus level, (2) as the nitrogen and phosphorus levels decrease there would be more mycorrhizal colonization, (3) compost tea will stimulate and support a strong fungal community, (4a) as mycorrhizal colonization increases, saprophytic colonization decreases, (4b) as nutrient levels decrease, saprophytic colonization decreases. The results from this project indicate that treatments do not significantly alter nitrogen levels but do for phosphorus. Additionally, there was no correlation between soil amendments and mycorrhizal colonization. The compost tea did not appear to have any relationship with fungal communities. There was no correlation between mycorrhizal and saprophyte colonization, and lastly there was no correlation between nutrient levels and saprophytic colonization. However, there was a correlation between fungal substrate induced respiration and soil amendments.



5) **Jennet Chang** is majoring in Tropical Science in Horticulture at University of Hawaii at Hilo and is expecting to graduate in 2019.

Title: Evaluating plasticity in *Machaeranthera canescens* and its adaptive significance: a glimpse at its relationship with water, light, and nutrients

Abstract: *Machaeranthera canescens* are perennial forbs that are used for restoration and serve as food for bees and birds. Not only is it important to grow plants for restoration of ecosystems, it is also essential to understand the phenotypic plasticity of different plant species to changing environments. Phenotypic plasticity is the ability of a plants given genotype to produce different phenotypes when exposed to different environmental climates. In this study we tested how plastic *M. canescens* is by placing them under controlled environmental conditions and measuring their functional traits. There were four treatments: control, drought, nutrient deficiency, and shade. A total of 240 seedlings were placed in the cold frame for 5 weeks exposed to sunlight and then harvested for data collection. We used 6 functional traits to determine plasticity and 4 were found to be significant. Those traits were specific leaf area (SLA), leaf dry matter content (LDMC), height, and root:shoot ratio (RSR). Plants in the shade treatment had higher SLA with low root:shoot ratio while the nutrient-deficiency treatment showed the opposite with root:shoot ratio being high and SLA being low. Our results indicate that *Machaeranthera canescens* is plastic and can adapt to conditions of low water and sunlight.



6) **Jordan Craven** is majoring in Biology at Hanover College and is expecting to graduate in 2019.

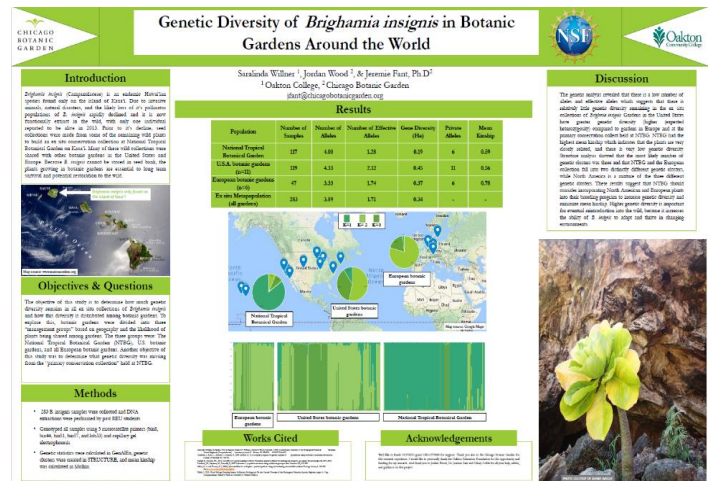
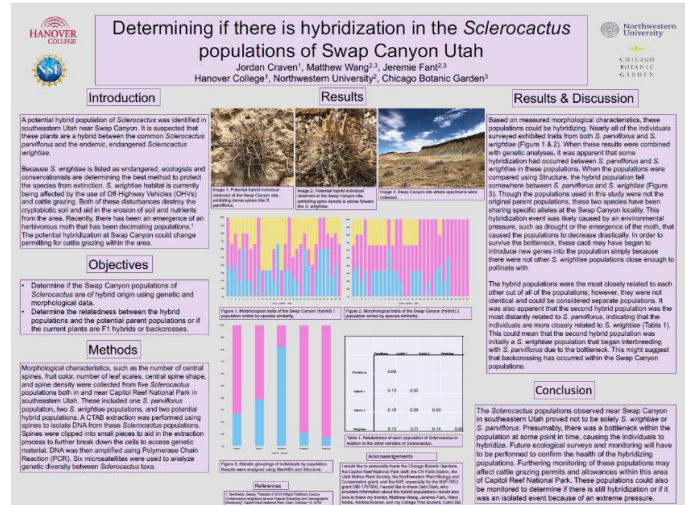
Title: Determining if there is hybridization in the *Sclerocactus* populations of Swap Canyon Utah

Abstract: In 2012, Deb Clark, who was then the head botanist at Capitol Reef National Park in Torrey, Utah, observed two *Sclerocactus* populations near Swap Canyon that shared physical similarities with both *Sclerocactus parviflorus* and *Sclerocactus wrightiae*. *S. parviflorus* is widespread throughout the southwest, while *S. wrightiae* is endemic to Wayne and Emery counties in Utah and is listed as endangered. The suspected hybrid populations are in a section of Capitol Reef National Park that is currently grazed by cattle, which trample the cryptobiotic soil which leads to erosion, or trample the plants themselves. For this study, microsatellites were used to compare genetic diversity between the hybrid populations and the known *Sclerocactus* taxa. Morphological characters, including spine density, central spine shape, number of central spines, fruit color, and number of leaf scales, were used to analyze physical characteristics that may determine the identity of the plants. DNA was extracted from spines so that the mucilaginous byproducts were decreased, and so that minimal damage was done to the plants. Based on the results of the genetic studies and the morphological observations, it is apparent that the *Sclerocactus* populations found near Swap Canyon are hybrids of *S. wrightiae* and *S. parviflorus*. From this conclusion, it can be speculated that the *Sclerocactus* populations of Swap Canyon underwent a drastic decrease in numbers, which vastly reduced the existing gene pool. The Swap Canyon cacti could have accepted pollen from other *Sclerocactus* populations to be able to reproduce, which could be a potential explanation for the overlap in genetic and morphological characteristics.

7) **Saralinda Willner** is a student at Oakton Community College.

Title: Genetic diversity of *Brighamia insignis* in botanic gardens around the world

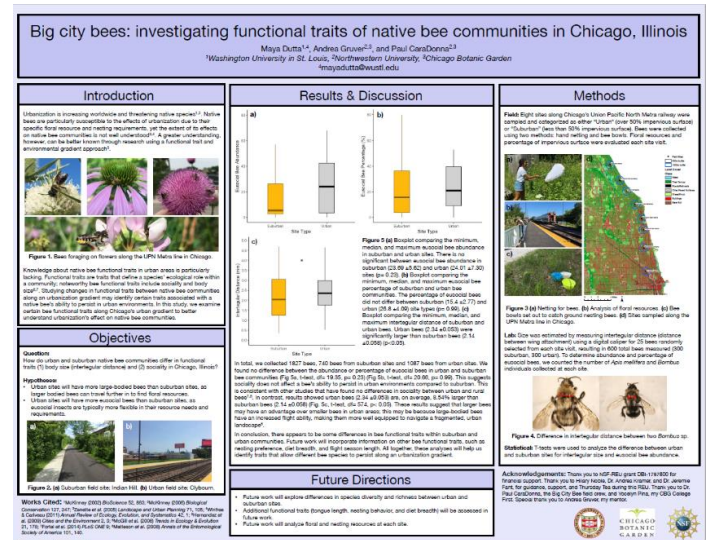
Abstract: *Brighamia insignis* (Campanulaceae) is an endemic Hawai'ian species found only on the island of Kaua'i. It experienced a bottleneck effect due to a rapid decline in number of remaining wild population and individuals. It is now functionally extinct in the wild, with only one individual reported to be alive in 2013. Before extinction, seeds were collected from some of the remaining wild plants to build an ex situ conservation collection at National Tropical Botanical Garden (NTBG). The plants were shared with other gardens around the world as well. I have been studying the genetic diversity of ex situ samples of *b. insignis* from gardens around the world using molecular markers. I have divided the samples up into 3 broad categories, NTBG, Mainland USA, and European Collections. These are the following questions I am looking to answer: How much diversity is left in *Brighamia insignis*? Is there genetic variation between the NTBG, U.S. gardens, and European ex-situ *Brighmia insignis* collections? What genetic diversity is missing from the primary conservation collection held at NTBG?



8) **Maya Dutta** is majoring in Environmental Biology at Washington University in St Louis and is expecting to graduate in 2019.

Title: Big city bees: investigating functional traits of native bee communities in Chicago, Illinois

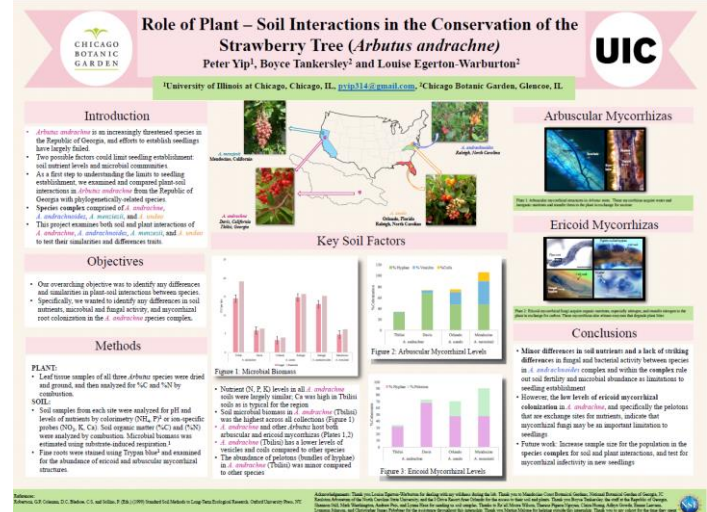
Abstract: Urbanization is increasing globally and threatening native species. Thus, it is important to understand how ecological communities are responding to changes associated with urbanization. Native bees are particularly susceptible to the effects of urbanization due to their specific floral resource and nesting requirements. However, studies about bees in urban areas are lacking. Additionally, little is known about native bee functional traits – traits that define the ecological role of a species – in urban environments. Studying changes in functional traits between urban and suburban bee communities may help us identify what traits help species persist in urban environments. This study investigates the differences in two functional traits, body size and sociality, in urban and suburban bee communities in Chicago, Illinois. Results show bee body size is larger in urban sites than in suburban sites. This suggests being larger-bodied is an advantage in urban areas, likely because large-bodied bees are better at navigating a fragmented, urban landscape. In contrast, results showed no differences in the abundance or percentage of eusocial bees in urban and suburban communities – this indicates that sociality does not affect a bee's ability to persist in urban environments. Future work will evaluate more functional traits and landscape factors.



9) **Peter Yip** is majoring in Engineering at University of Illinois at Chicago and is expecting to graduate in 2021.

Title: Role of plant-soil interactions in the conservation of the Strawberry Tree (*Arbutus andrachne*)

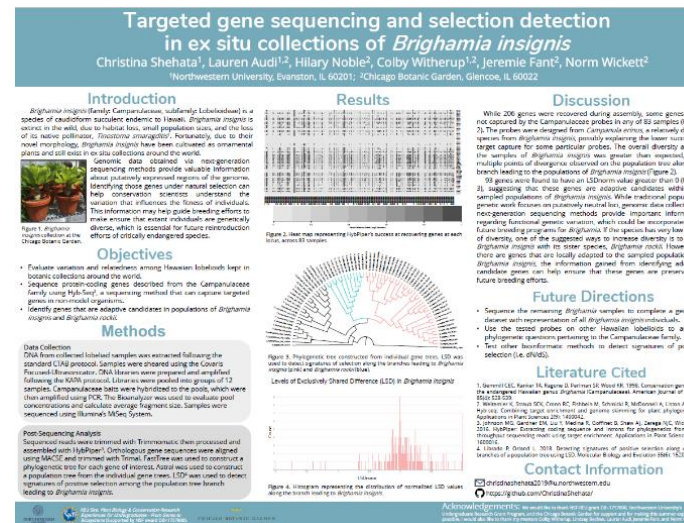
Abstract: The *Arbutus andrachne* is becoming an endangered species due to the failure of seedlings development. Therefore, to understand how to conserve this species; our objective in this research was to examine both plant and soil interactions of the *Arbutus andrachne*, *Arbutus unedo*, and *Arbutus andrachnoides*, which are similar species to the *Arbutus andrachne*. Using leaf tissue samples and soil samples, we compare the fungal and bacterial activity, root colonization, plant and soil nutrient levels. We found a significant difference in the ericoid mycorrhiza, specifically the pelotons (bundles of hyphae) were a minor percentage than the rest of the complex species. The effect of having a lack of pelotons is a lack of intake in nutrients.



10) **Christina Shehata** is majoring in Neuroscience at Northwestern University and is expecting to graduate in 2019.

Title: Targeted gene sequencing and selection detection in ex situ collections of *Brighamia insignis*

Abstract: Conservation genomics is an expanding field that uses genomic data to inform conservation efforts for critically endangered species. Here, we collected genomic data from *Brighamia insignis* (family: Campanulaceae, subfamily: Lobelioideae), a functionally extinct plant species endemic in Hawaii. We used Hyb-Seq, a sequencing method that can capture targeted protein-coding genes within the genomes of non-model organisms, and LSD, a selection detection method, to identify 93 adaptive candidate genes within populations of *Brighamia insignis*. Genomic data and information about functional genetic variation can help inform breeding and conservation efforts aiming to make the genetically diverse populations for future reintroduction efforts of critically endangered species. Sequencing the remaining Hawaiian lobelioid samples in collection will further elucidate the phylogenetic relationships within the Campanulaceae family and complete a genomic dataset with representation of all *Brighamia insignis* individuals, further contributing to the effort to save *Brighamia insignis* from extinction.



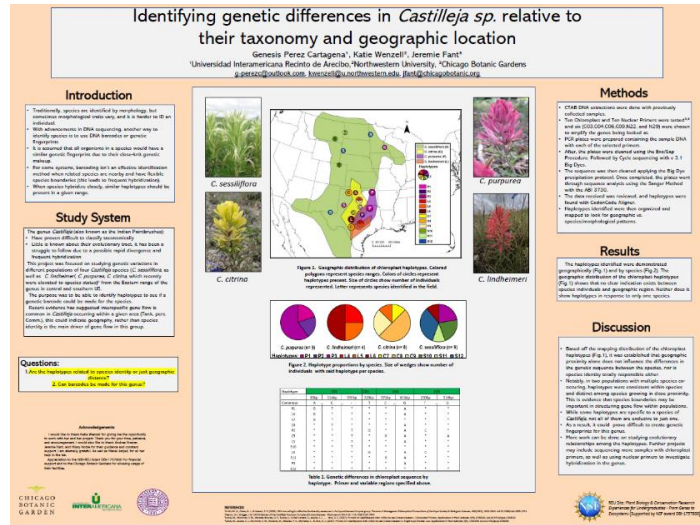
11) **Genesis Perez** is majoring in Biology at Inter American University of Puerto Rico-Arecibo and is expecting to graduate in 2021.

Title: Identifying genetic differences in *Castilleja sp.* Relative to their taxonomy and geographic location

Abstract: In the genus *Castilleja* (the Indian Paintbrushes), related species often grow together, and hybridization frequently occurs. This results in intermediate morphs which can result in blurred species boundaries throughout its range.

Castilleja have variable morphological traits, and putative hybrids can cause difficulty in identifying and classifying these species by morphology and difficulty in following their evolutionary history. The purpose of this project was to study samples of four closely related *Castilleja* species (*C. sessiliflora*, *C. citrina*, *C. lindheimeri*, and *C. purpurea*) by sequencing DNA with the purpose of identifying hybridization and if barcoding each species can be a possibility for this genus.

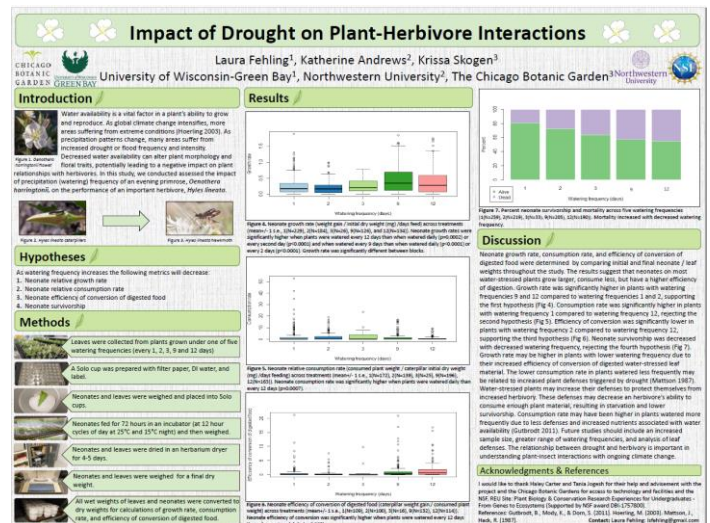
Barcodes could be a useful way to accurately identify the Paintbrushes when difficult to do so based on phenotypic traits. This could help future identifications of the species and putative hybrids. They would also aid in understanding the evolution of the Paintbrushes. Results showed that barcoding might not be an efficient way to identify *Castilleja* as it is for other systems, and it was also found that geographic distance might not play as much of a role as previously thought. However nuclear markers would be useful to see if gene flow is necessarily for maintaining species identity.



12) **Laura Fehling** is majoring in Environmental Science at University of Wisconsin-Green Bay and is expecting to graduate in 2019.

Title: Impact of drought on plant-herbivore interactions

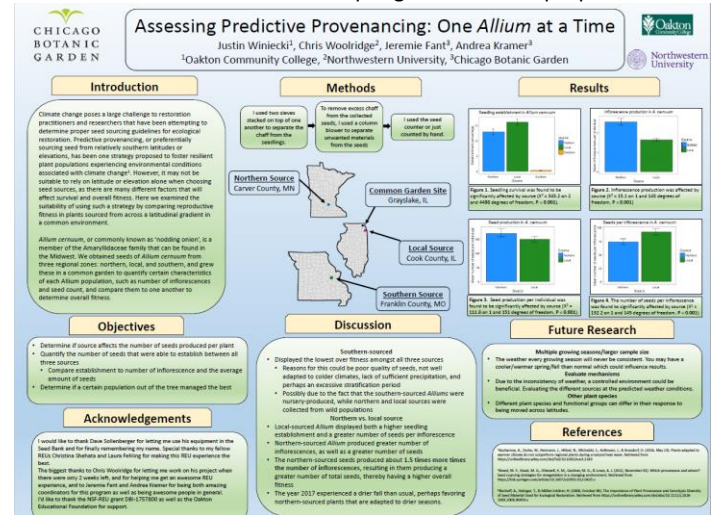
Abstract: Global climate change has shown to be altering precipitation patterns resulting in more extreme weather conditions. Droughts and flooding have become more intense and persistent creating a more stressful environment for fauna and flora. Receiving minimal amounts of water or excessive amounts can have a negative impact on a plant's ability to grow and in turn impact its relationship with herbivores and pollinators. The focus of the study was to examine how the volume of water a plant receives impacts its herbivore species. Study species *Oenothera harringtonii* were grown from seeds of 16 different maternal lines collected from a wild population near Florence, Colorado. Plants were grown in a greenhouse at the Chicago Botanic Garden and received six different water treatments varying from 100ml of water daily to 100ml every 12 days. Growth assays using *Hyles lineata* neonates and the leaves of *Oenothera harringtonii* were set up and conducted for 72 hours of feeding. Neonate growth rate, consumption rate, and efficiency of conversion of digested food were determined using the mass of leaves and neonates taken three times throughout the course of the experiment. Neonates feeding on drought-stressed plants were found to have higher growth rates and efficiencies of conversion of digested food, but not consumption rates. Neonate mortality rate was found to increase as watering frequency decreased. These results showed that neonates grew and digested food more efficiently feeding on plants that received the least water but suffered higher mortality rates. This also showed that the amount of water a plant receives can impact its relationship with herbivores.



13) **Justin Winiacki** is majoring in Biological Science at Oakton Community College and is expecting to graduate in 2020

Title: Assessing Predictive Provenancing: One *Allium* at a Time

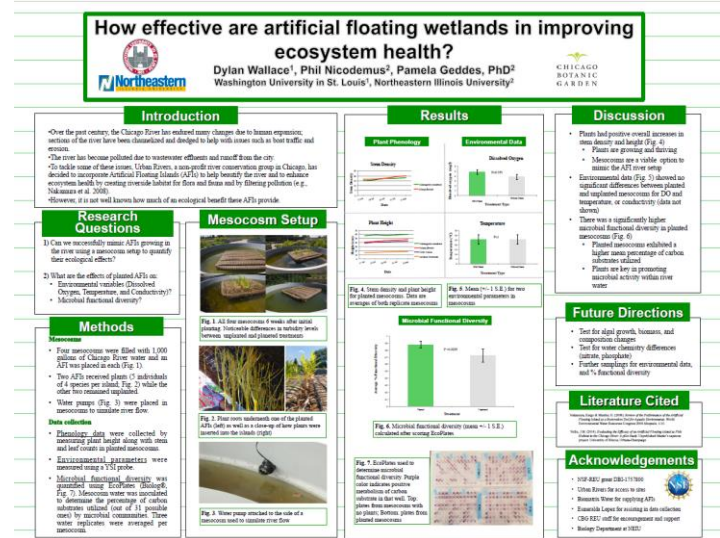
Abstract: Rising temperatures pose a threat to both restoration practitioners and researchers that have been attempting to determine proper seed sourcing guidelines for ecological restoration. Predictive provenancing, or preferentially sourcing seed from relatively southern latitudes or elevations, has been one strategy proposed to foster resilient plant populations experiencing environmental conditions associated with climate change. By introducing plant material from southern latitudes into northern restoration areas, it could allow the plants in the restoration to be better adapted to changes in climate. However, a possible negative consequence of predictive provenancing is maladaptation, where differently-sourced plant material may not be suited to the local environmental conditions. Using a common garden experiment, we examined the reproductive fitness of *Allium cernuum* from three regional sources across a latitudinal gradient in a common environment. The objective is to find which source of *Allium* showed the best overall fitness. We measured seed establishment, average seed count, and seed per inflorescence and found that the northern-sourced *Allium* showed the best overall fitness. Several consecutive growing seasons and a larger sample size are required to properly be able to determine seed sourcing guidelines.



14) **Dylan Wallace** is majoring in Environmental Earth Sciences at Washington University in St Louis and is expecting to graduate in 2019.

Title: How effective are artificial floating wetlands in improving ecosystem health?

Abstract: Urban Rivers, a non-profit river conservation group based on the Chicago river, has used artificial floating islands (AFIs) to help restore habitat, beautify the river, absorb pollution and increase ecosystem health. Our study's goal was to determine if we could mimic the Chicago River AFI setup in mesocosms and see how a planted AFI could affect dissolved oxygen, conductivity, temperature, and microbial functional diversity. To test this, four mesocosms were filled with 1000 gallons of river water and AFIs were placed on each (two planted and two unplanted). Islands had 5 individuals of 4 species per island and mesocosms were each equipped with a pump to help mimic river flow. From there, Phenology data was tracked to determine if plants were actually thriving and mimicking an AFI river setup. Furthermore, environmental data was measured with a YSI probe while microbial functional diversity was calculated using ecoplates (Biolog®) plates. Results showed that plants were indeed growing at a positive rate, demonstrating increases in stem density and height, but environmental data showed no significant differences between planted and unplanted mesocosms. Microbial functional diversity however, had significant differences between planted and unplanted mesocosms showing more carbon substrate utilization within the planted variety. Future research will test for algal growth, biomass, nitrate, and phosphate to further identify the affects of AFIs.



Mereida Flukes is majoring in Biology at University of Illinois at Urbana-Champaign and is expecting to graduate in 2021.

Title: Using genetics to help Hawai'ian's endangered flora

PROGRAM INFORMATION:

The Chicago Botanic Garden has hosted a Research Experiences for Undergraduates (REU) Site, supported in-part by NSF, for 13 years. This year 18 students participated in our ten-week summer undergraduate research experience, which is one of only a few programs in the country that offers undergraduate students an opportunity to explore a diverse array of scientific fields related to plant biology and conservation. Students are mentored by faculty and graduate students from the joint Chicago Botanic Garden–Northwestern University Graduate Program in Plant Biology and Conservation and other graduate programs. Their research projects are based at the Daniel F. and Ada L. Rice Plant Conservation Science Center, and they receive training in all aspects of the research process, from hypothesis formulation through experimental design, data collection, analysis, and ultimately presentation of results through this public research symposium. REU interns also serve as research mentors for high school students participating in the Garden’s College First program, assist with teaching a topic related to their research as a part of Camp CBG, and participate in field trips, workshops, and professional development activities. Additionally, students and their mentors often pursue opportunities to present at national scientific meetings or publish findings in peer-reviewed journals following completion of the program.

REU Coordinators: Jeremie Fant, Andrea Kramer, Hilary Noble

BIG THANKS TO:

Mentors: This science training program would not be possible without your dedication. We appreciate all the time and effort you have put into these students and hope that it is been as rewarding for you as it was for the students.

College First and Camp CBG programs: Your partnership allowed for a richer growth of our students through mentorship and science communication.

Funders: This summer program was supported in part by NSF-REU DBI-1757800 (Kramer, Fant) and the Charles and Margery Barancik Foundation.

Poster Judges: Greg Mueller (Chief Scientist and Negaunee Foundation Vice President of Science), Kay Havens (Medard and Elizabeth Welch Director, Plant Science and Conservation), Linda Bergstrom (Director, Content and Editorial).