Chicago Botanic Garden

Research Experiences for Undergraduates

Plant Biology & Conservation: From Genes to Ecosystems

Poster Symposium

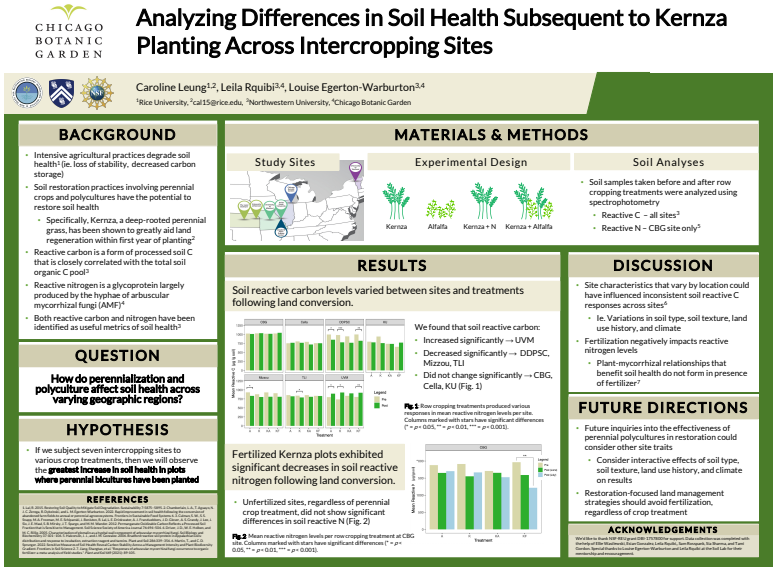
August 18, 2023

CHICAGO BOTANIC GARDEN

1) **Caroline Leung** is majoring in Biosciences with a concentration in Integrative Biology at Rice University and is expecting to graduate in 2024.

Title: Analyzing Differences in Soil Health Subsequent to Kernza Planting Across Intercropping Sites

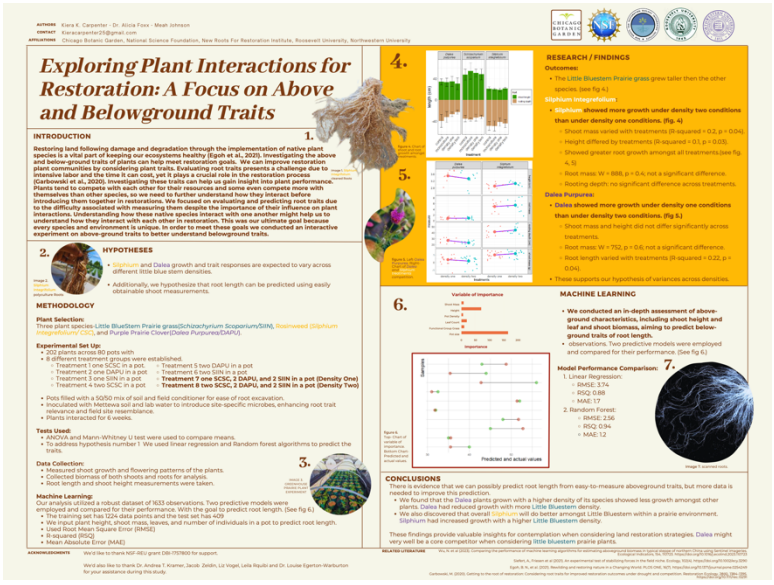
Abstract: Modern agricultural practices have been found to negatively impact soil health, decreasing soil stability, microbiome diversity, and carbon storage capacity. Prior work has shown that planting perennial crops in polyculture – such as Kernza, a deep-rooted perennial grass – can potentially restore soil health in degraded agroecosystems. Most studies describe the impact of these strategies at a single site; few have compared responses between sites across a geographic range. This study quantified reactive soil carbon levels before and after planting perennial monocultures and polycultures at seven sites across the United States. The response of soil reactive nitrogen levels to the perennial treatments was measured at one of the sites. Reactive carbon exhibited varying responses to planting between sites and treatments. Soil reactive nitrogen levels significantly decreased in fertilized plots - a pattern that did not appear in their non-fertilized counterparts. These results suggest that site characteristics which vary by location, such as soil type and climate, may influence observed effects of perennialization and polyculture on soil health, and that fertilization could negatively impact the efficacy of soil restoration efforts, though more long-term data is needed to optimize the use of perennialization and polyculture in restoration.



2) **Kiera Carpenter** is majoring in Sustainability Studies with a minor in Environmental Science at Roosevelt University and is expecting to graduate in 2023.

Title: Exploring Plant Interactions for Restoration: A Focus on Above and Belowground Traits

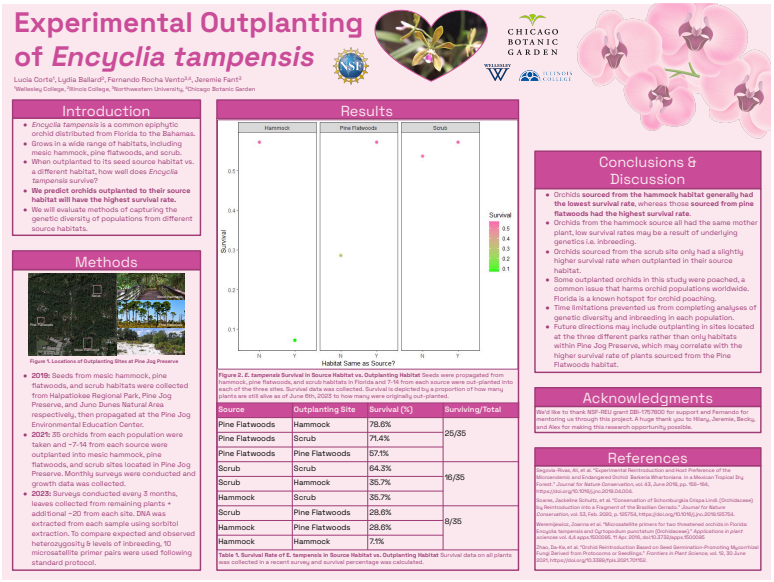
Abstract: The restoration of ecosystems relies on native plant species to survive, especially after damage and land degradation. It is important that we understand above and below ground traits to aid restoration. Investigating root traits enhances restoration insights by allowing us to understand plant behavior. Our hypotheses were that root length can be predicted using easily obtainable shoot measurements and that the growth of our plants (Silphium and Dalea) would vary across Little Blue Stem Densities. We conducted an interactive experiment with 202 plants across 80 pots, observing interactions over a six week period. Statistical methods and predictive models were employed to assess root traits. Linear regression and Random Forest algorithms predicted length using plant height, shoot mass, leaves and density. Our hypotheses were partially supported by the results of our experiment. While we need more information to confirm this, initial results indicate that we can possibly predict root length from easy-to-measure aboveground traits.



3) **Lucia Corte** is majoring in Biological Sciences with a minor in Statistics at Wellesley College and is expecting to graduate in 2026.

Title: Experimental Outplanting of *Encyclia tampensis*

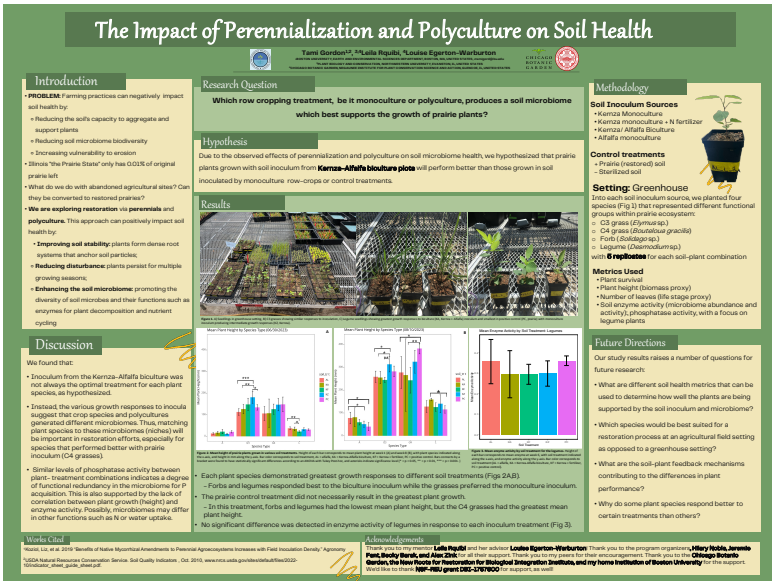
Abstract: *Encyclia tampensis* is a common epiphytic orchid distributed from Florida to the Bahamas. *E. tampensis* lacks habitat specialization and is capable of growing in a variety of habitats that exist in Florida, from areas with sparse vegetation, such as scrub, to areas with dense vegetation, such as mesic hammock and pine flatwoods. This study seeks to determine if matching seed source habitat to outplanting site habitat leads to a higher survival rate for reintroduced individuals. In 2019, seeds from mesic hammock, pine flatwoods, and scrub habitats were collected from Halpatiokee Regional Park, Pine Jog Preserve, and Juno Dunes Natural Area respectively, then propagated at the Pine Jog Environmental Education Center. 35 orchids from each population were taken and ~7-14 from each source were outplanted into mesic hammock, pine flatwoods, and scrub sites located in Pine Jog Preserve. Surveys were conducted every 1-3 months to collect growth and survival data. Leaves from surviving plants and an additional 20 from each site were collected to extract DNA and compare expected heterozygosity, observed heterozygosity, and levels of inbreeding. As of August 2020, Orchids sourced from the hammock habitat generally had the lowest survival rate, whereas those sourced from pine flatwoods had the highest survival rate.



4) **Tami Gordon** is majoring in Earth and Environmental Sciences with a minor in Ecosystems at Boston University and is expecting to graduate in 2025.

Title: The Impact of Perennialization and Polyculture on Soil Health

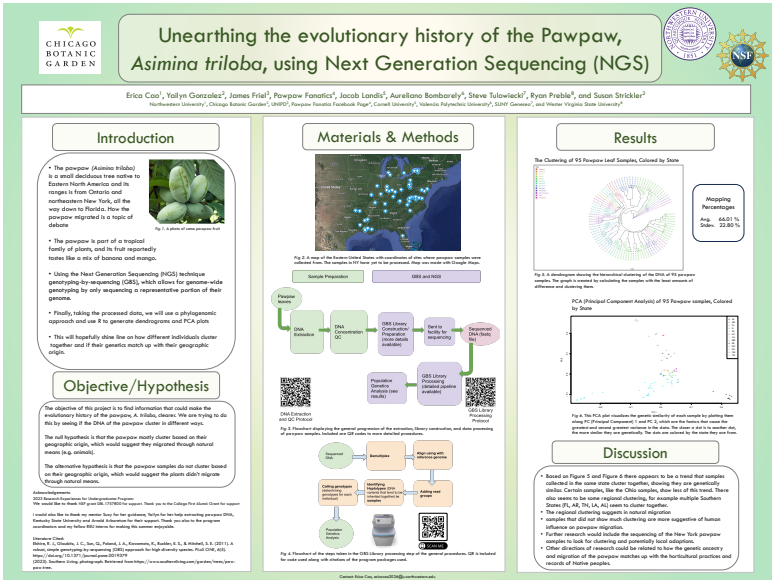
Abstract: Intensive agriculture practices have contributed to degradation of soil health and the loss of natural prairie ecosystems. Previous work suggests that the use of perennial crops can improve the health of degraded soil, with benefits to soil biodiversity and nutrient cycling. It is not yet established which combinations of perennial crops most effectively restore soil health, or whether these gains in soil health are sufficient to support the restoration of degraded sites to natural ecosystems. This study explored whether several different row cropping treatments produced a soil microbiome that could support the growth of prairie plants. Sterilized soil was inoculated with soil taken from plots planted with one of four different row crop treatments Four species of native prairie plants were planted in pots with the inoculated soil. Plant height was measured weekly. At six weeks, an enzyme analysis was run to determine the activity of phosphatase enzymes. After eight weeks, each species demonstrated the greatest amount of growth under a different soil treatment. The enzyme analysis found no significant differences in activity between treatments. These findings suggest that the use of perennialization and polyculture could be an effective step towards restoring former agricultural sites to native prairie ecosystems.



5) **Erica Cao** is majoring in Biology at Northwestern University and is expecting to graduate in 2026.

Title: Unearthing the evolutionary history of the Pawpaw, *Asimina triloba*, using Next Generation Sequencing (NGS)

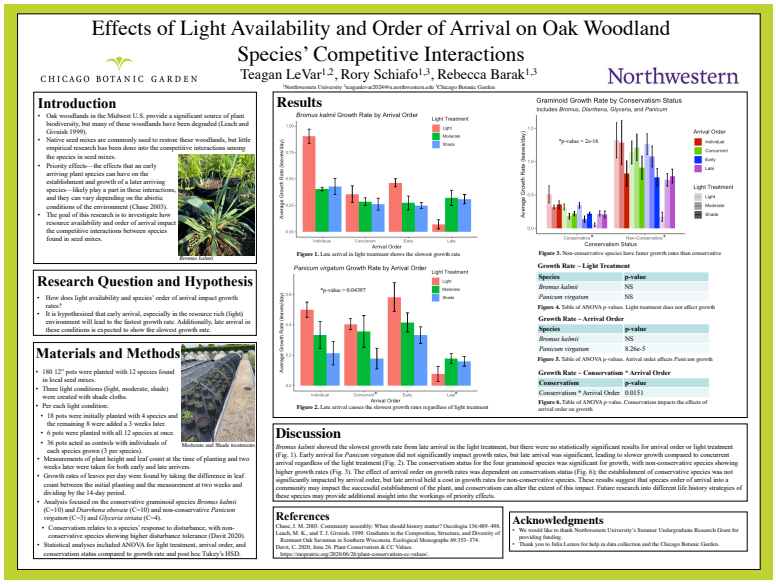
Abstract: The pawpaw (*Asimina triloba*), is a small deciduous tree native to eastern North America. They are part of a tropical family of fruits, and bear a fruit that tastes like a combination of bananas and mango. At its most northern range are the Ontario and New York pawpaws. Previous analysis on pawpaw populations has been done but those did not include pawpaws in the northernmost areas. This study uses genotyping-by-sequencing (GBS), a next generation sequencing technique, to find genetic similarity between different pawpaw individuals. First the DNA is extracted, then GBS libraries are constructed, then the libraries are sent out for sequencing, and lastly the libraries are processed. The processed DNA is then analyzed by creating dendrograms and PCA plots in R Studio to visualize the clustering. DNA from New York pawpaws were extracted using the DNAeasy Plant Mini Kit (Qiagen). As of August 16, 2023 GBS libraries of the New York pawpaws are currently in construction. The data processing protocol was refined from a previous protocol and tested on another collection of samples with geographic origins from various states. That data was analyzed and visualized in R Studio.



6) **Teagan LeVar** is majoring in Biology at Northwestern University and is expecting to graduate in 2024.

Title: Effects of Light Availability and Order of Arrival on Oak Woodland Species' Competitive Interactions

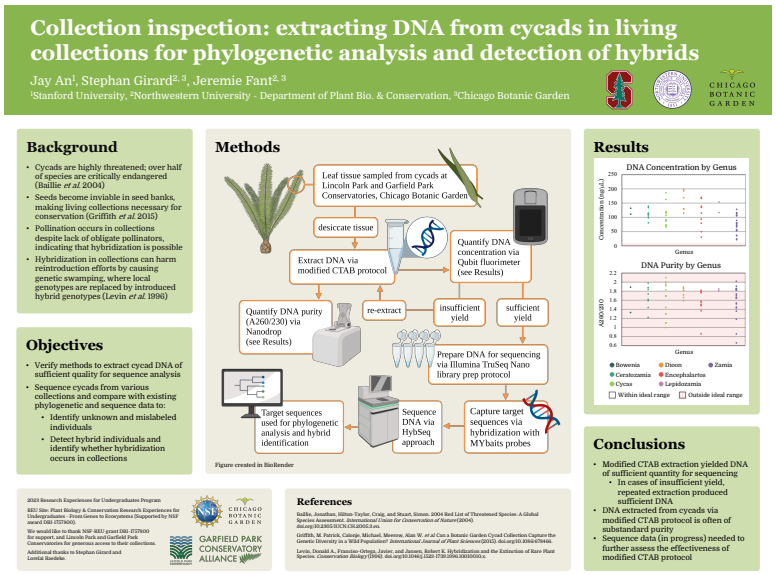
Abstract: In the Midwest U.S., oak woodlands provide a significant source of plant biodiversity, but many of these woodlands have been degraded. A common restoration tactic is the addition of native plants through seed mixes, and it is necessary to understand competitive interactions between species of seed mixes to effectively restore woodlands. In this experiment, 12 species from local seed mixes were used in experimental communities where arrival order and light availability were manipulated. Plant leaf count was taken at planting and two weeks later to determine growth rates during this time. Analysis focused on four graminoid species: conservative *Bromus kalmii* and *Diarrhena obovate* and non-conservative *Panicum virgatum* and *Glyceria striata*. Conservatism relates to species' responses to environmental disturbance, with non-conservative species showing higher tolerance. Non-conservative species had higher growth rates than conservative, and late arrival for these non-conservative species led to significantly reduced growth rates. Conservative species' establishment was not impacted by arrival order, and light availability did not significantly impact any species' growth. Additional research covering other life history strategies for these species may provide more insight into the impact of arrival order.



7) **Jay An** is majoring in Biology at Stanford University and is expecting to graduate in 2024.

Title: Collection inspection: extracting DNA from cycads in living collections for phylogenetic analysis and detection of hybrids

Abstract: Cycads are an ancient lineage of plants that is highly threatened in the wild. Because cycad seeds become inviable in seed bank conditions, cycad conservation is performed through living collections. In these collections, cycads of multiple genera and species are housed together in a conservatory setting. Despite the absence of obligate pollinators, natural pollination has been observed in collection cycads, indicating that hybridization is also possible. Since living collections may be used for reintroduction efforts, hybridization can risk genetic swamping, where introduced hybrid genotypes replace local genotypes in the wild. We investigated methods to extract DNA from cycads in living collections in order to generate sequence data that will be used to identify unknown individuals and determine whether hybridization occurs in cycad collections. DNA extraction was performed via a modified CTAB protocol, and resulting DNA yield and purity was assessed. We found that the extraction protocol yielded sufficient quantities of DNA from cycad tissue, however extracted DNA was often of substandard purity. Sequencing results will be needed to further assess the efficacy of the modified CTAB protocol to generate DNA of sufficient quantity and quality for phylogenetic analysis and hybrid identification.

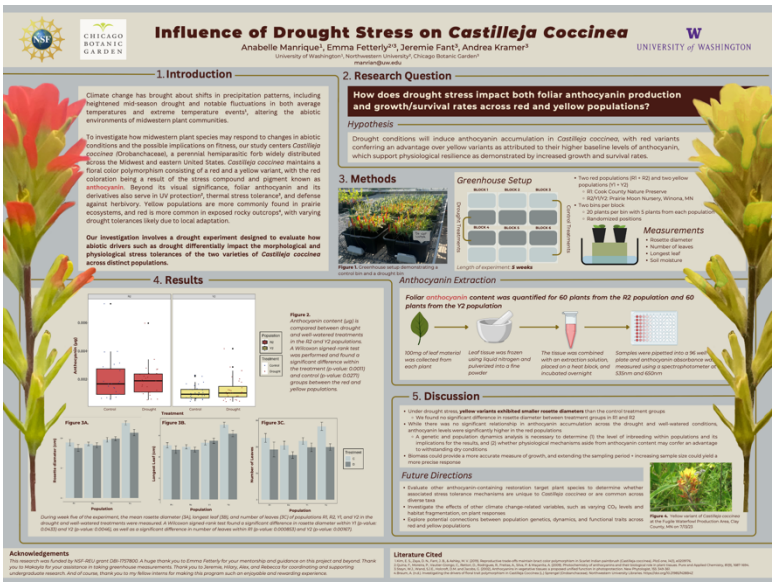


8) **Anabelle Manrique** is majoring in Plant Biology with a minor in Environmental Science and Terrestrial Resource Management at the University of Washington and is expecting to graduate in 2024.

Title: Influence of Drought Stress on *Castilleja Coccinea*

Abstract: This study investigates the response of *Castilleja coccinea* (Orobanchaceae) to changing abiotic conditions caused by climate change, specifically focusing on the impact of drought stress on the two color variants (red and yellow) across distinct populations. This research aims to understand how drought stress influences foliar anthocyanin production and growth/survival rates, shedding light on the adaptive strategies of these plant populations.

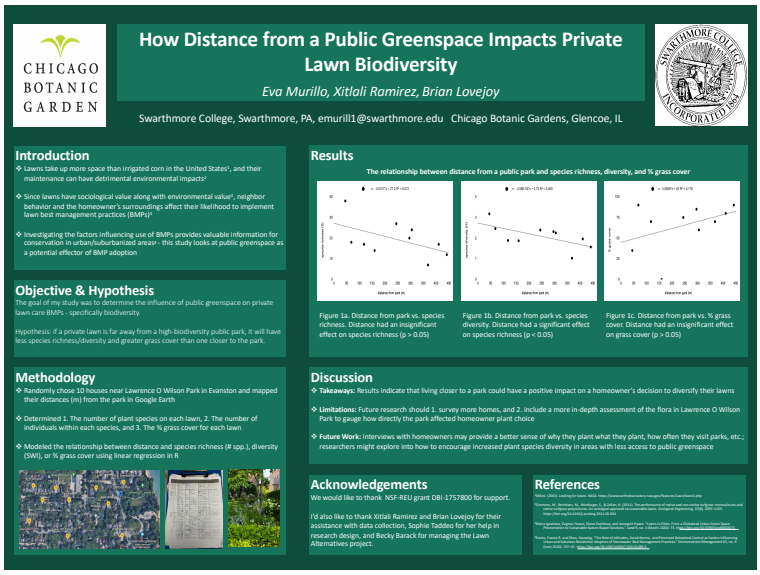
Through a controlled greenhouse experiment, four populations of *Castilleja coccinea* were subjected to well-watered and drought conditions. Various morphological traits and physiological measurements were taken, including: rosette diameter, leaf length, number of leaves, and anthocyanin content. Results indicate that yellow variants exhibit reduced rosette diameters under drought stress, while red populations show higher anthocyanin levels regardless of treatment. These findings raise questions regarding genetic and population-level factors impacting physiological resilience and drought tolerance. Furthermore, extending the study period and integrating biomass measurements could provide a more comprehensive understanding of *Castilleja coccinea*'s adaptive mechanisms in the face of changing environmental conditions. Overall, this study highlights the intricate connection between abiotic stresses, floral color polymorphism, and plant fitness in the context of climate change.



9) **Eva Murillo** is majoring in Ecology and Sociology at Swarthmore College and is expecting to graduate in 2026.

Title: How Distance from a Public Greenspace Impacts Private Lawn Biodiversity

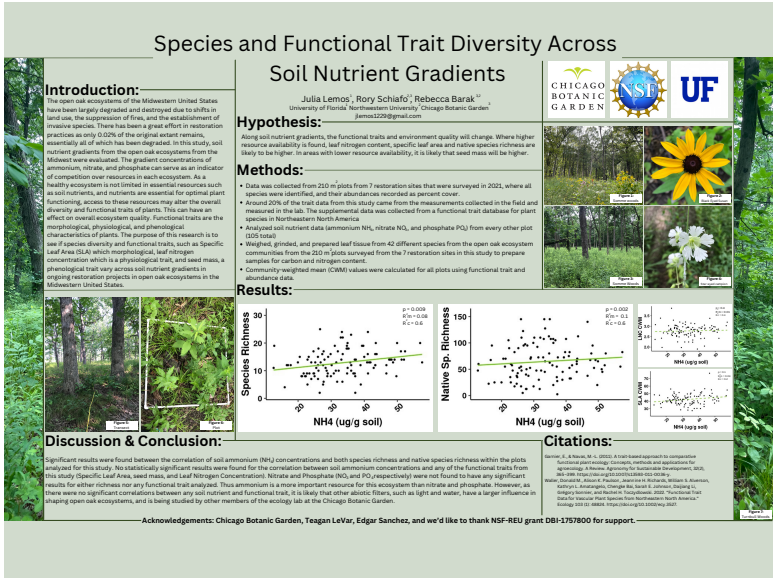
Abstract: Private lawns make up a significant portion of land use in the United States, and their management can damage the environment. Specifically, turfgrass lawns can diminish biodiversity, which reduces beneficial ecosystem services (i.e., pollination, flood mitigation) and worsens environmental problems (i.e., habitat fragmentation). Understanding which factors influence lawn biodiversity could aid in conserving ecosystems across the United States; this study investigates the public parks as one potential factor. To determine the influence of public parks over private lawn biodiversity, we surveyed ten private lawns at varying distances from park by 1. Counting the number of plant species and number of individuals per species, 2. Estimating % grass cover, and 3. Calculating the species diversity of each lawn. We then used regression analyses to model the relationship between distance from the park and species richness, species diversity, and % grass cover. Our data revealed a significant relationship between distance and species diversity, indicating that lawns closer to public parks are more likely to have higher species diversity. Future work might examine how homeowners interact with parks, and whether parks influence their planting practices.



10) **Julia Lemos** is majoring in Integrative Biology and Anthropology at the University of Florida and is expecting to graduate in 2026.

Title: Species and Functional Trait Diversity Across Soil Nutrient Gradients

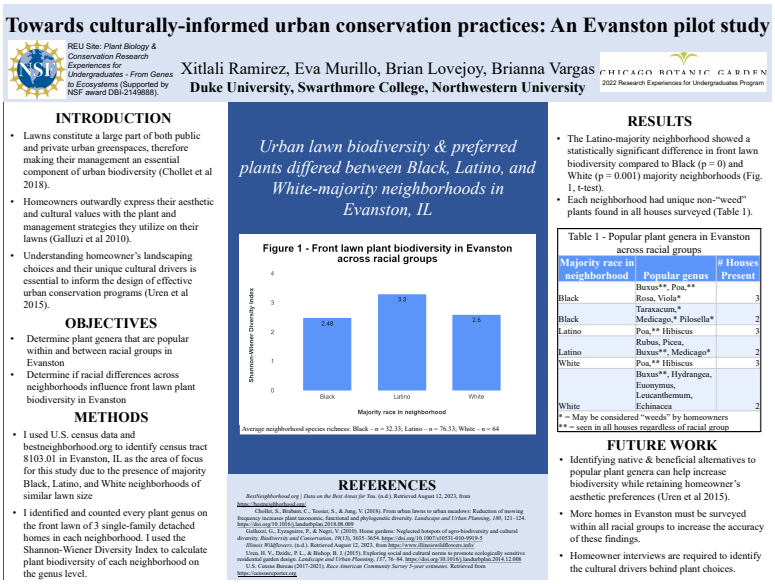
Abstract: Oak ecosystems across the Midwestern U.S. have been almost completely lost, and what remains has been heavily degraded. Ecological restoration efforts aim to restore the biodiversity and ecosystem quality found in pre-degraded oak ecosystems. This study aims to look at how both species diversity and functional traits (morphological, physiological, and phenological characteristics of plants) change across soil nutrient gradients. Total and native species richness were used as metrics of species diversity, and serve as indicators of ecosystem quality in this study. The functional traits measured were specific leaf area (SLA), leaf nitrogen content (LNC), and seed mass. Metrics of species diversity and functional trait community-weighted mean values were analyzed across gradients of ammonium (NH_4), nitrate (NO_3), and phosphate (PO_4). There was an increase in both overall and native species richness with increasing soil nutrient availability. However, there was no relationship between functional traits and soil nutrients. By establishing the relationships between both native species richness and functional traits with soil nutrient gradients, we are able to assess the ability of functional traits to serve as an indicator of environmental quality. Our results suggest that species diversity metrics, and not functional trait values, remain the better indicator of ecosystem quality in restorations.



11) **Xitlali Ramirez** is majoring in Environmental Science and Policy with a minor in Earth and Climate Sciences at Duke University and is expecting to graduate in 2024.

Title: Towards culturally-informed urban conservation practices: An Evanston pilot study

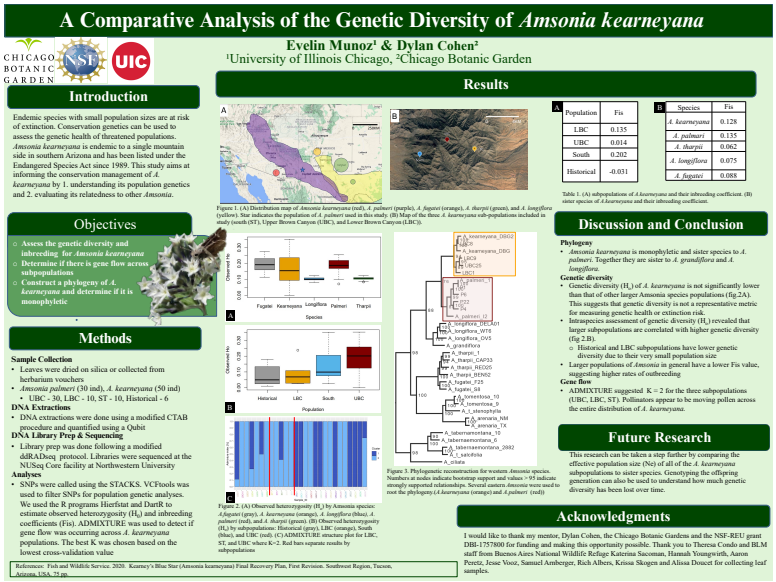
Abstract: Lawns constitute a large part of both public and private urban greenspaces, therefore making their management an essential component of urban biodiversity. Homeowners outwardly express their aesthetic and cultural values with the plant and management strategies they utilize on their lawns. While lawns are recognized as essential for maintaining urban biodiversity, the effect of cultural and racial background on plant diversity has yet to be studied as a tool for urban conservation. In my pilot study, I identified 3 neighborhoods with different racial majorities in Evanston, IL and found that each neighborhood had popular and distinct plants found in all studied houses. More homes in Evanston must be surveyed to increase the accuracy of these results. Additionally, homeowner interviews are required to identify the cultural drivers behind plant choices. Once plant preferences and the cultural drivers behind them are identified, native and beneficial alternatives to these popular plants can help increase biodiversity and ecosystem health while maintaining homeowners' aesthetic preferences.



12) **Evelin Munoz** is majoring in General Biology with a minor in Earth and Environmental Sciences at the University of Illinois at Chicago and is expecting to graduate in 2024.

Title: A Comparative Analysis of the Genetic Diversity of *Amsonia kearneyana*

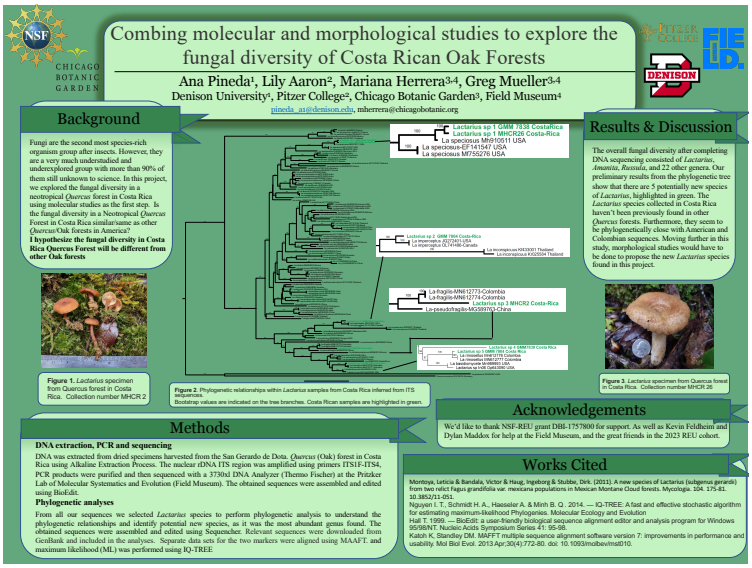
Abstract: Endemic species with small population sizes are at risk of extinction. Conservation genetics can be used to assess the genetic health of threatened populations and inform future management projects. *Amsonia kearneyana* is endemic to a single mountainside in southern Arizona and has been listed under the Endangered Species Act since 1989. This study aims at informing the conservation management of *A. kearneyana* by understanding its population genetics and evaluating its relatedness to other *Amsonia*. DNA was extracted from three subpopulations of *A.kearneyana* (UBC, LBC, and South), *A. kearneyana* herbarium specimen, and sister *Amsonia* species. The genetic diversity of *A.kearneyana* was assessed via a comparative analysis of observed heterozygosity (Ho) and inbreeding coefficient (FIS). The genetic structure of *A.kearneyana* was also evaluated to estimate gene flow. Our results suggest that *A.kearneyana* is monophyletic and sister species to *A. palmeri*. Structure plots indicate that gene flow is occurring across all subpopulations, and the genetic diversity of *A.kearneyana* is not significantly lower than that of other larger sister populations. This research can be taken a step further by comparing the effective population size (Ne) of all of the *A. kearneyana* subpopulations to sister species for a better comparison of overall genetic health.



13) **Ana Pineda** is majoring in Biology and Data Analytics at Denison University and is expecting to graduate in 2026.

Title: Combing molecular and morphological studies to explore the fungal diversity of Costa Rican Oak Forests

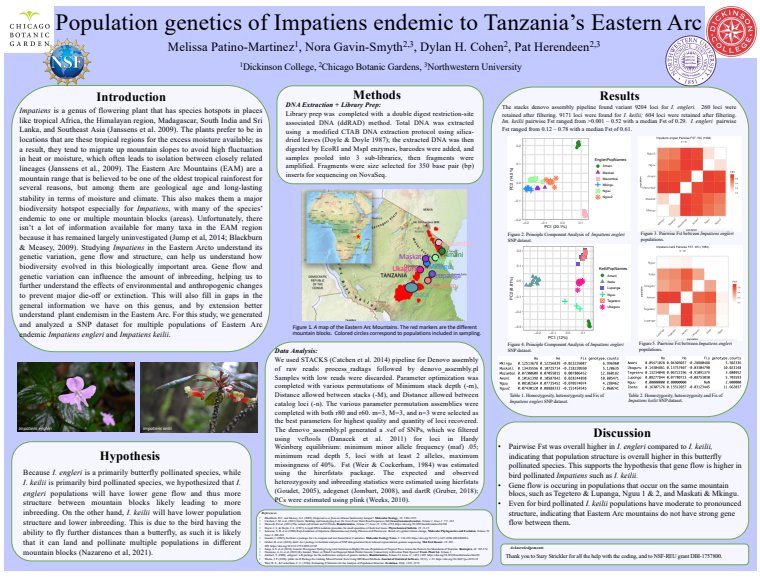
Abstract: Research on neotropical fungi has increased substantially in the last decade. As result, several new species have been described but fungal diversity and distribution in neotropics are unknown yet. In this project, we explore the fungal diversity in a Neotropical Quercus Forest in Costa Rica. We used dried specimens collected in 2022 to extract DNA, amplify the rDNA ITS and perform molecular analysis to identify the species. *Lactarius*, *Amanita*, and *Russula* were the most abundant genera. We focused on *Lactarius* species to perform phylogenetic analysis. Our results show that there are 5 new potential species of *Lactarius* inhabiting the *Quercus* forest in Costa Rica. These species are different from *Lactarius* species previously described in *Quercus* forests in America.



14) **Melissa Patino-Martinez** is majoring in Biology and Spanish with a minor in Latin American, Latinx and Caribbean Studies at Dickinson College and is expecting to graduate in 2024.

Title: Population genetics of Impatiens endemic to Tanzania's Eastern Arc

Abstract: Impatiens is a genus of flowering plant that has species all over the world, these plants tend to prefer moist, tropical climates and often migrate up mountain sides to avoid fluctuation of environment. Our focus was on species endemic to the Eastern Arc Mountains, as they are known to be a biodiversity hotspot, with a large portion of endemic flora and fauna. Interestingly though, they are not as very studied, so this work is an effort to fill in the gaps in our knowledge and to understand how gene flow, inbreeding and environmental and human factors might affect. We analyzed a SNP dataset for multiple populations of *Impatiens engleri*, which is a primarily butterfly pollinated flowering plant, and *Impatiens keilii*, which is a primarily bird pollinated flowering plant. Due to the differences in primary pollinator species, we hypothesized that there would be less gene flow, genetic variation, and more structure for *I. engleri* over *I. keilii*. Through a double digest restriction-site associated (ddRAD) method, DNA was extracted, digested, barcoded, and pooled into sublibraries to be amplified. After this, through the use of STACKS and other programs we were able to analyze the dataset for loci, heterozygosity, homozygosity, Fis and then Principle Component Analysis (PCA) to visualize the results. Ultimately, our results found that our hypothesis that gene flow is higher in bird pollinated *Impatiens* such as *I. keilii* was correct. It was also found that gene flow did occur between populations of the same mountain block.



15) **Marian Arevalo** is majoring in Elementary Education with a minor in Middle School Science at Northeastern Illinois University and is expecting to graduate in 2024.

Title: How the plant's microbiome affects its health

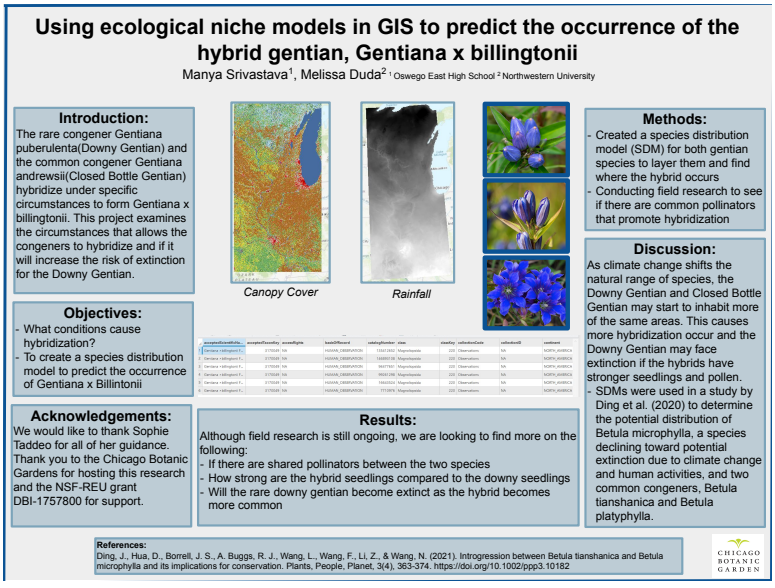
Abstract: Plants' health is greatly determined by its microbiome. A plant's microbiome consists of 3 sections. These sections are called the phyllo sphere, the endosphere, and the rhizosphere. However the most important section is the rhizosphere as it's the area around a plant root that is inhabited by a unique population of microorganisms that can either positively or negatively impact a plant's development. We learned a lot of insightful information regarding the different rhizosphere organisms and how they impact plant immunity and growth. For example, we learned that there are both beneficial and harmful rhizosphere organisms. Beneficial rhizosphere bacteria that promote plant growth include pseudomonas, bacillus, as well as fungi from the deuteromycetes (Trichoderma and Gliocladium).

Rhizosphere bacteria that are deleterious to plant growth include pathogenic fungi (eg: parasites) and oomycetes. Pathogenic fungi, oomycetes, and nematodes. These types of bad bacteria rob plants from important minerals such as magnesium. A lack of minerals leads to malabsorption in the plant. This can be deadly for the plant as malabsorption does not allow the plant to receive the nutrients needed to survive and grow. Furthermore, we learned about a technique that Botany professionals use in their plant nurseries. This technique is known as AMF colonization. This technique consists of inoculating the plant with the friendly fungi known as mycorrhizal fungi to restore a healthy soil microbiome. This type of fungi is considered friendly bacteria because they give plants an enormous boost in immunity and growth by protecting their host from harmful bacteria such as parasites.

16) **Manya Srivastava** is studying at Oswego East High School.

Title: Using ecological niche models in GIS to predict the occurrence of the hybrid gentian, Gentiana x billingtonii

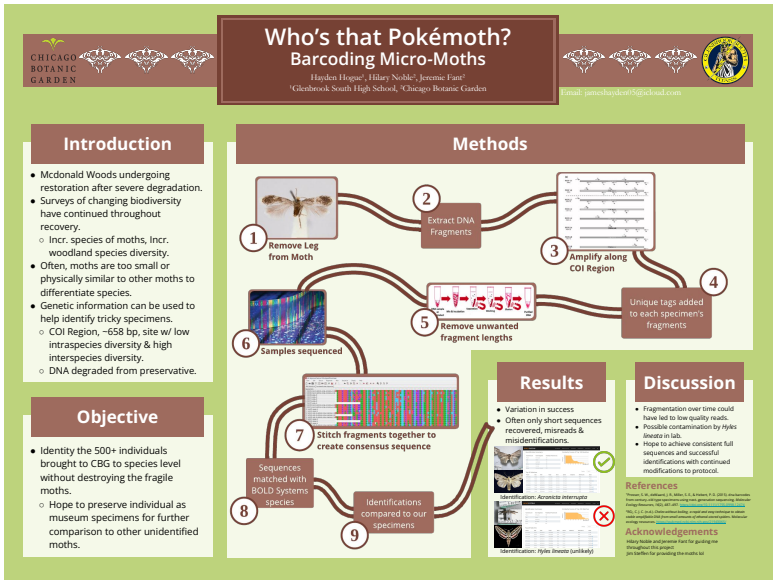
Abstract: Natural hybridization involves successful mating in nature between individuals from two populations. For rare species, hybridization may accelerate extinction rates through the loss of traits that make that species unique, but paradoxically, it can also allow a species to gain traits to adapt to changing conditions. This research aims to identify the mechanisms promoting hybridization in rare species to understand the potential risk of extinction better. This process was investigated in two species that can hybridize, Gentiana puberulenta, a species considered rare in some of its range, and Gentiana andrewsii, a more common species. Ecological niche models in GIS (geographic information system) software were used to predict the occurrence of hybrid species at study sites.



17) **Hayden Hogue** is studying at Glenbrook South High School.

Title: Who's that Pokémoth? Barcoding Micro-Moths

Abstract: The McDonald Woods, once severely degraded post-European colonization, has ongoing efforts to restore it to its pre-settlement condition. Ecologist Jim Steffen has led the endeavor to document the forest's moths, pollinators which can indicate broader species diversity. However, due to interspecific physical similarity and small size, over 500 specimens remain unidentified. In response to this challenge, we have turned to genetic analysis using the COI region, a genetic "barcode" approximately 650 base pairs in length, characterized by high interspecific diversity and low intraspecific diversity. We extracted the DNA with a Chelex protocol, and amplification along the COI region created fragments we stitched together to reference to the online species database BOLDSystems. However, since the moths in our collection have been preserved in Dichlorvos, a pesticide that denatures DNA, fragment quality is unpredictable. Our most recent data yielded varied success, with both plausible and unlikely identifications. Despite this, we hope to see more consistent, quality results with modifications we have made this summer.



PROGRAM INFORMATION:
The Chicago Botanic Garden has hosted a Research Experiences for Undergraduates (REU) Site, supported in-part by NSF, since 2003. This year 27 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 as well as staff from the Garden. 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, 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, Becky Barak, Hilary Noble, and Alex Zink

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 has been as rewarding for you as it was for the students.

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

Institutional Partners: The Morton Arboretum and UIC CIM^{2}AS Program for fostering a network of institutions that seek to train the next generation of scientists. Thank you in particular to the Biology department of UIC for hosting the lunch and poster symposium.

Funders: This summer program was supported in part by NSF-REU DBI-2149888 (Barak, Fant) and the Charles and Margery Barancik Foundation.