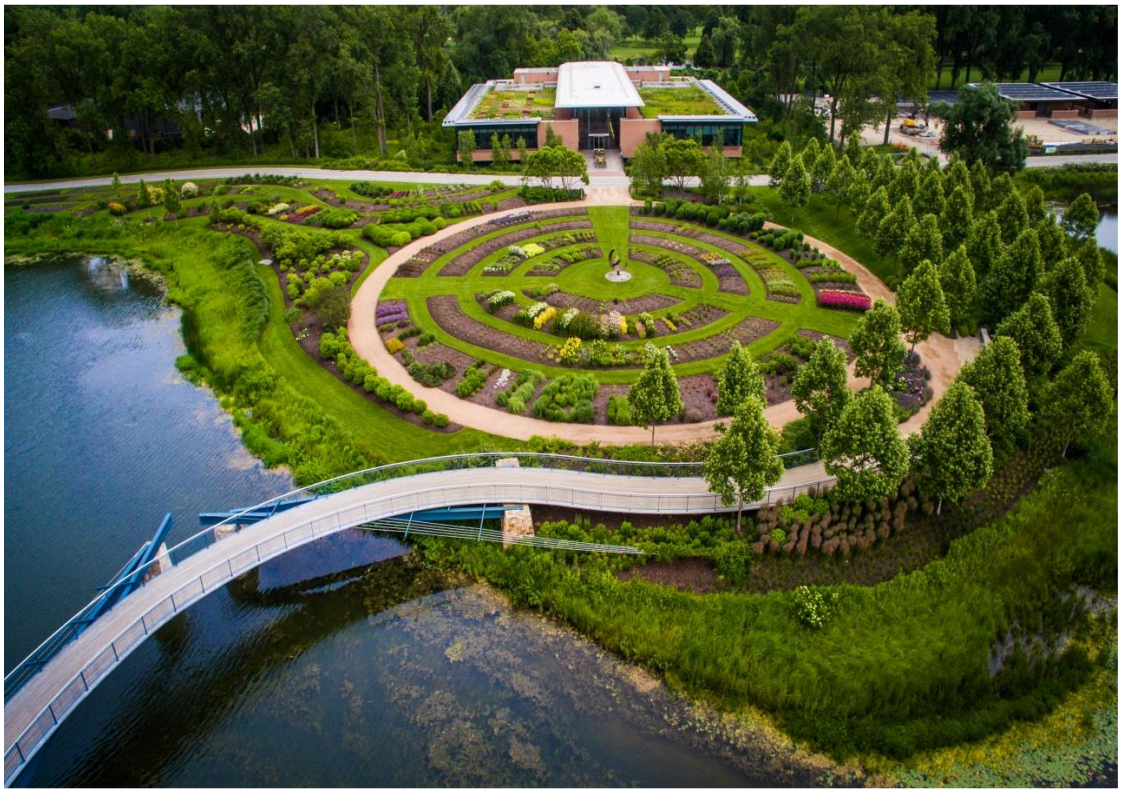


Chicago Botanic Garden

Plant Biology and Conservation Internships Program

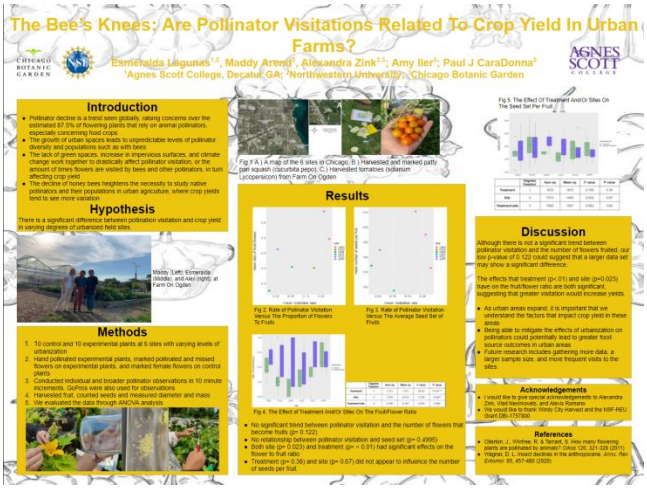
Plant Biology & Conservation: From Genes to Ecosystems

Poster Symposium

August 19, 2021

1) **Esmeralda Lagunas** is majoring in biology with a minor in Environmental and Sustainability Studies at Agnes Scott College and is expected to graduate in 2022. Alexandra Zink mentored this project.

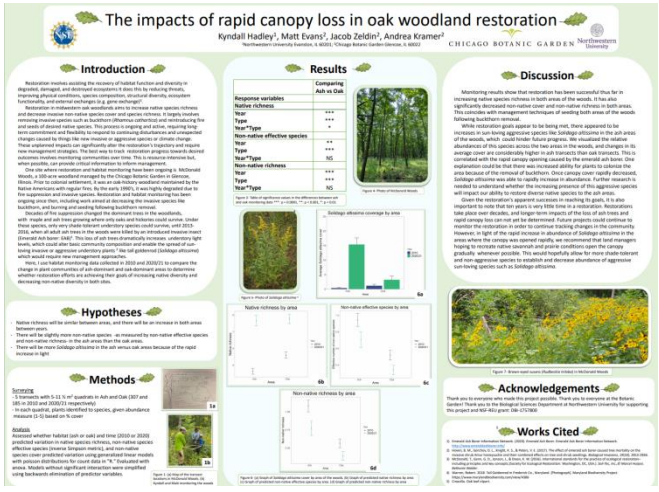
Title: Effects of Urbanization On Plant-Pollinator Interactions



Abstract: As urban areas continue to grow and expand outwards, the loss of natural environments, green spaces, and an increase in impervious surfaces causes vast variation of pollinator communities. An estimated 87.5% of plants rely on animal pollination, including several food crops. However, pollinator decline is a trend seen globally, especially due to climate change, yet the full effects of pollinator decline in urban areas, especially in urban farms, is not fully documented, or are varied in their results. This project aims to better understand the effects of urbanization on plant pollinators by taking into consideration three main factors: 1. Impervious surfaces, 2. Floral resources, 3. Pollen Limitation. We used six sites for our study, five in varying states of urbanization throughout the city of Chicago and one at the Chicago Botanic Garden as a more suburban site. We had 10 control and 10 experimental plants each of patty pan squash (*Cucurbita pepo*), and sungold tomatoes (*Solanum lycopersicum*) at each site. The squash acted as a generalist pollinator plant while the sungolds acted as a specialized pollinator plant since it can only be buzz-pollinated by specific bees and other animal pollinators. We self pollinated the experimental plants to observe whether there was any relation to pollinator visitation and crop yield, as well as conducted both individual and broader pollinator observations at the sites to find whether there was a difference in the amount of pollinators and the types of pollinators present. Although our data set was small, we were able to find that both site (0.023) and treatment (p=<0.01) had marginally significant effects on the flower-to-fruit ratio.

2) **Kyndall Hadley** is studying biological sciences with a minor in global health studies at Northwestern University. She is expecting to graduate in 2022.

Title: The impacts of rapid canopy loss in oak woodland restoration.

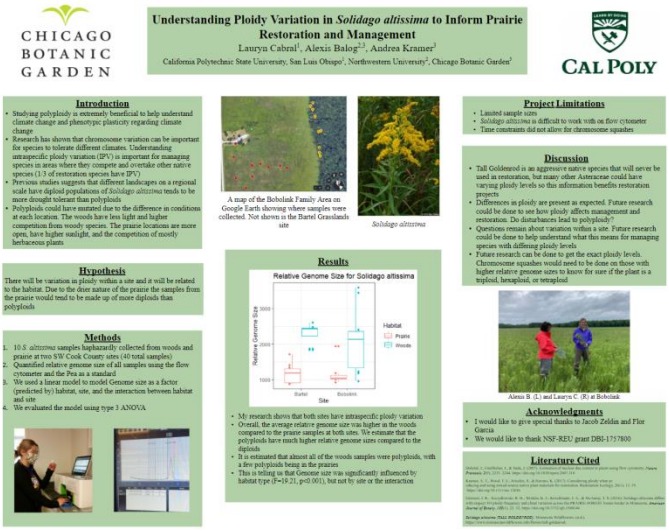


Abstract: In Midwestern oak woodlands, restorations aim to assist the recovery of habitat function, increase native species richness, and decrease invasive non-native species cover and species richness. Ongoing monitoring and restoration has occurred at McDonald Woods in Glencoe, IL. Fire suppression had changed the dominant trees in the woodlands, increasing the presence of ash trees until 2013-2016, when all adult ash trees were killed by the invasive insect, Emerald ash borer. This project used monitoring data collected in 2010 and 2020/21 to compare the change in plant communities of ash-dominant and oak-dominant areas to determine whether restoration efforts are achieving their goals. Monitoring data were analyzed using generalized linear models in "R." Results show that restoration has been successful thus far in increasing native species richness and decreasing non-native cover and non-native richness in both areas. Upon visualization of the relative abundances of the sun-loving, aggressive species *Solidago altissima*, its cover is considerably higher in formerly ash-dominant transects. In light of the rapid increase in abundance of *Solidago altissima* in the areas where the canopy was opened rapidly, we recommend that land managers hoping to recreate native savannah and prairie conditions open the canopy gradually whenever possible.

3) **Lauryn Cabral** is majoring in Agriculture and Environmental Plant Science at California Polytechnic State University San Luis Obispo with a minor in Land Rehabilitation and Restoration Ecology. Alexis Balog and Andrea Kramer mentored this project.

Title: Understanding Ploidy Variation in *Solidago altissima* to Inform Prairie Restoration and Management

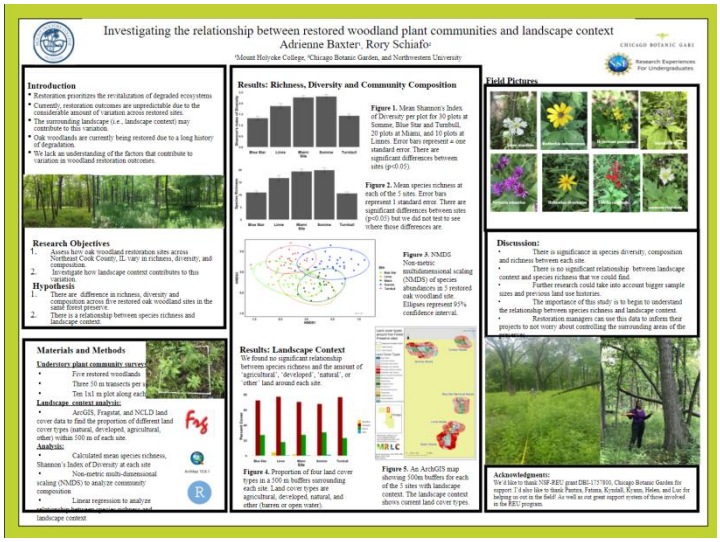
Abstract: Studying polyploidy is extremely beneficial to help understand climate change and phenotypic plasticity regarding climate change. Research has shown that chromosome variation can be important for species to tolerate different climates. Understanding intraspecific ploidy variation (IPV) is important for managing species in areas where they compete and overtake other native species (1/3 of restoration species have IPV). Previous studies suggests that different landscapes on a regional scale have diploid populations of Solidago altissima tends to be more drought tolerant than polyploids. Polyploids could have mutated due to the difference in conditions at each location. The woods have less light and higher competition from woody species. The prairie locations are more open, have higher sunlight, and the competition of mostly herbaceous plants. After running a type 3 ANOVA through R the data showed the average relative genome size was higher in the woods compared to the prairie samples at both sites. We estimate that the polyploids have much higher relative genome sizes compared to the diploids. Questions remain about variation within a site. Future research could be done to help understand what this means for managing species with differing ploidy levels.



4) **Adrienne Baxter** is majoring in Biology with a focus in ecology and a minor in Entrepreneurship Organizations and Society at Mount Holyoke College and is expecting to graduate in 2022.

Title: Investigating the relationship between restored woodland plant communities and landscape context

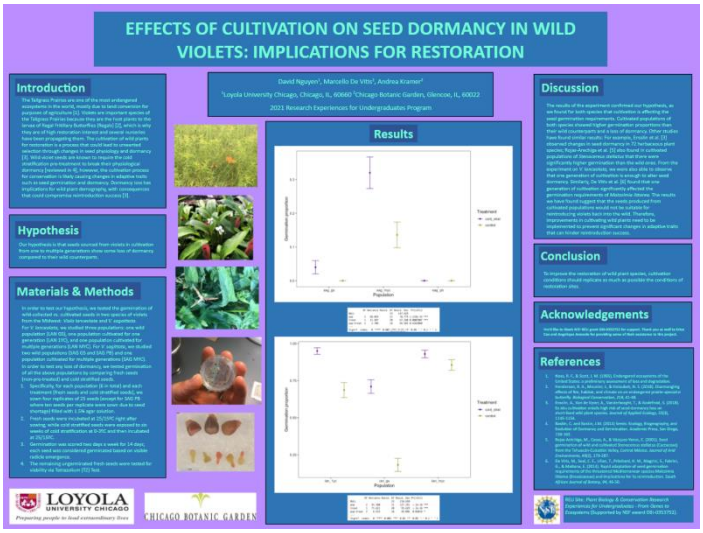
Abstract: Oak woodlands are threatened in the Midwestern U.S. due to human development in natural areas. The reduction of oak woodlands is correlated with the loss of herbaceous diversity and the increase in invasive species. Ecological restoration efforts are being taken by many forest preserves including the Forest Preserves of Cook County (FPCC). By restoring these habitats, woodland communities will support higher ecosystem functioning and will be more resilient in the face of climate change. In this study, we conducted plant community surveys at five restored oak woodlands in FPCC to assess how richness, diversity and community composition differ across restorations. We used arcGIS and FragStats to look for a correlation between plant biodiversity and the proportion of different land cover types (i.e., landscape context). We found that restoration efforts result in various biodiversity outcomes in herbaceous plant communities even when under similar management. However, we found that landscape context does not play a significant role in the species richness at restoration sites. These results may be due to our small sample size or other untested factors that influence restoration outcomes. To build predictable restoration practices, future research should assess the factors that influence variation in restoration outcomes.



5) **David Nguyen** is majoring in Biology with Ecology Emphasis and a minor in Japanese Language and Culture at Loyola University Chicago and is expecting to graduate in 2023.

Title: Effects of Cultivation on Seed Dormancy in Wild Violets: Implications for Restoration

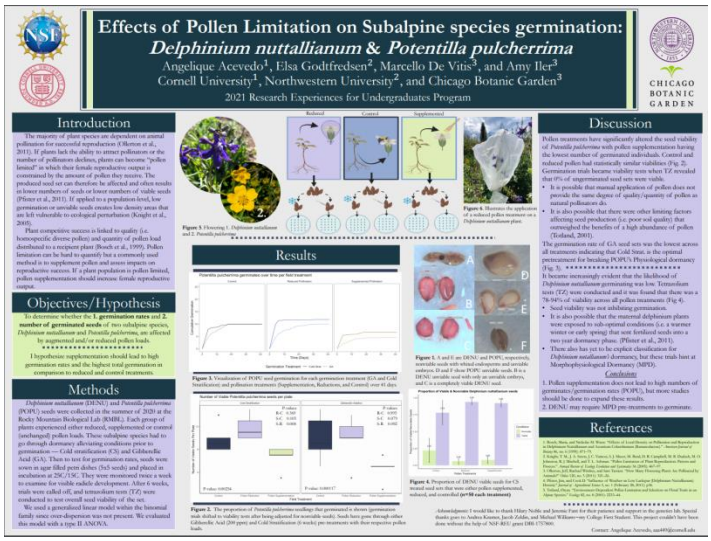
Abstract: The Tallgrass Prairies are one of the most endangered ecosystems in the world, mostly due to land conversion for purposes of agriculture. Violets are important species in this ecosystem because they are the host plants to the larvae of Regal Fritillary Butterflies, which led to high restoration interest in them and several nurseries propagating them. The cultivation of wild plants for restoration is a process that could lead to unwanted selection through changes in seed physiology and dormancy. Wild violet seeds are known to require the cold stratification pre-treatment to break them out of physiological dormancy; however, the cultivation process for conservation is likely causing changes in adaptive traits such as seed germination and dormancy. Dormancy loss has implications for wild plant demography, having consequences that could negatively affect reintroduction success. Our hypothesis is that seeds coming from cultivated violets of one to multiple generations will show some loss of dormancy compared to their wild counterparts. We tested our hypothesis by testing germination of wild-collected vs. cultivated seeds of two species of violets. Our results show that violet seeds from cultivated populations have higher germination than wild populations and a loss of dormancy, which could hinder reintroduction success of violets.



6) **Angelique Acevedo** is majoring in Environment & Sustainability with a minor in Biometry and Statistics at Cornell University and is expected to graduate in 2023.

Title: The Effects of Pollen Limitation on Subalpine species: *Delphinium nuttallianum* and *Potentilla pulcherrima*

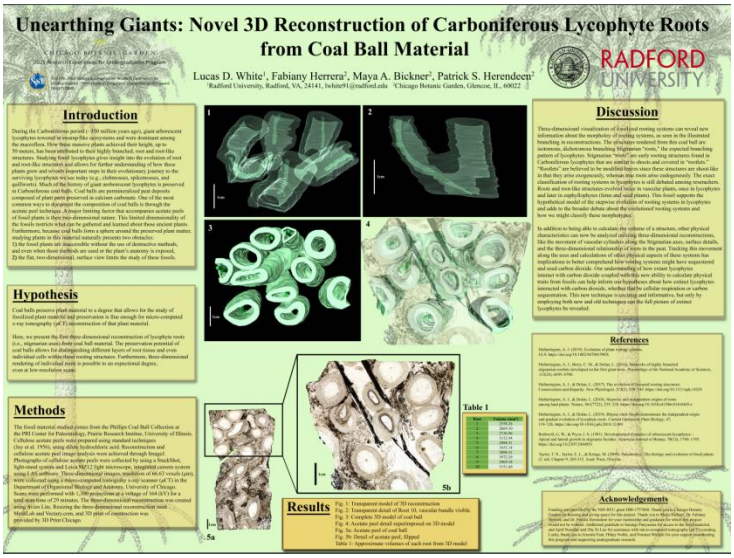
Abstract: The Rocky Mountain Biological Lab (RMBL) in Colorado is studying how plant competitive success is linked to the quality and quantity of pollen loads distributed to a recipient plant. If plants cannot attract pollinators or the number of pollinators declines, plants can become “pollen limited” in which their female reproductive output is constrained by the amount of pollen they receive. Low seed output creates low-density areas that are left vulnerable to ecological perturbation. Similarly, our project is focused on the effects of pollen availability on the reproductive success of two subalpine species—*Delphinium nuttallianum* (DENU) and *Potentilla pulcherrima* (POPU). Germination trials were used as a metric to quantify reproductive success. Seeds that were collected from RMBL, and were used in trials, went through one of three treatments: pollen reduction, natural pollinator treatment, or supplementing pollen. It was projected that pollen supplementation would allow a maternal plant to maximize the distribution of resources per seed. However, our results indicate that supplemented POPU seeds experienced the lowest germination rates and fewest total germinates of all 3 treatments. This may be due to other limiting factors that affected seed production during fertilization. Delphinium seeds never sprouted, but seed sets were 78-94% viable, indicating that seeds are possibly experiencing a deep dormancy.



7) **Lucas White** is majoring in Ecology & Plant Conservation and Studio Art, with minors in French, Women's and Gender Studies, and Chemistry at Radford University, and expected to graduate in 2024.

Title: Unearthing Giants: Novel 3D Reconstruction of Carboniferous Lycophytes Roots from Coal Ball Material

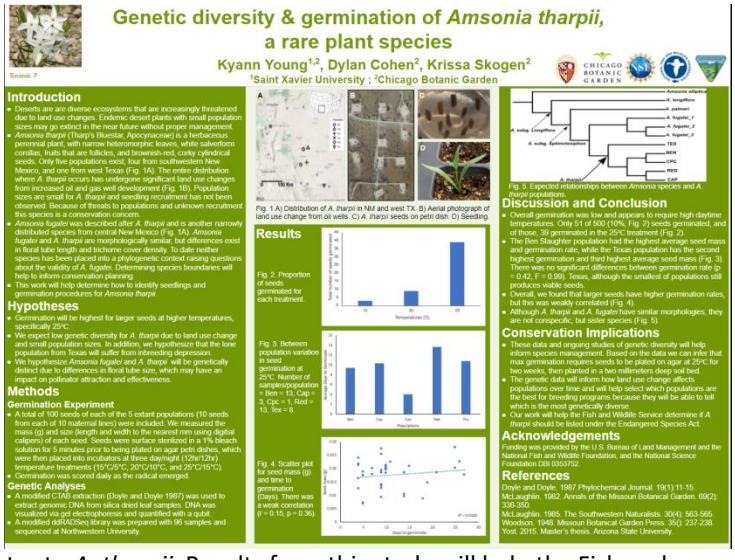
Abstract: During the Carboniferous period (~350 million years ago), arborescent lycophytes dominated in swamp ecosystems. How these massive plants achieved their height (~50 meters) has been attributed to their branched root-like systems. Studying fossil lycophytes gives insight into the evolution of root-like structures and reveals important steps in their evolutionary journey to the surviving lycophytes we see today (clubmosses, spikemosses, and quillworts). Much of the history of lycophytes is preserved in Carboniferous coal balls; permineralized peat deposits composed of preserved plants in calcium carbonate. The preservation potential of coal balls allows for distinguishing different layers of root tissue and even individual cells within these rooting structures; however, a limiting factor that accompanies studying fossil plants are their two-dimensionality, restricting what can be learned about these ancient plants. We present the first three-dimensional reconstruction of lycophyte roots from coal ball material. The structures rendered in this coal ball are isotomous, dichotomous branching Stigmarian "roots." Tracking the movement of preserved "roots" and calculating physical aspects (like volume) of these systems can now be analyzed using three-dimensional reconstructions. The use of three-dimensional reconstructions has implications to assist in better comprehending how rooting systems might have sequestered and used carbon dioxide.



8) **Kyann Young** is majoring in Biochemistry with a minor in Biology at Saint Xavier University and expected to graduate in 2022

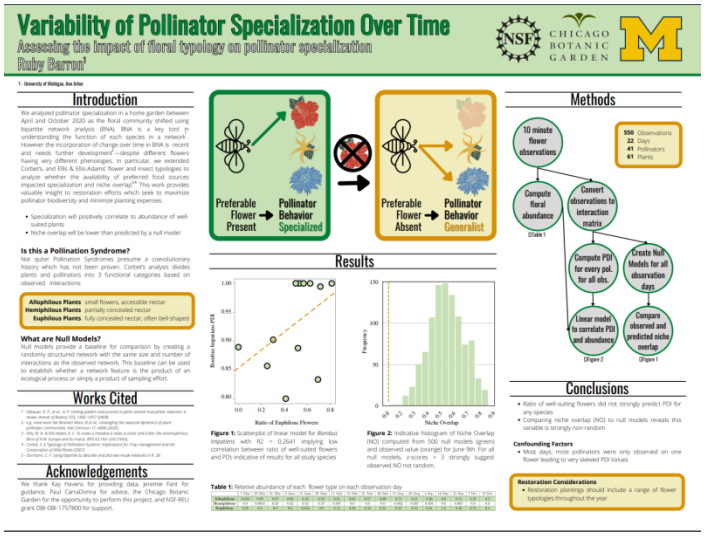
Title: Genetic diversity and germination of *Amsonia tharpii,* a rare plant species

Abstract: Desert environments are diverse ecosystems with many endemic plant species. These xeric lands are increasingly threatened due to anthropogenic changes. *Amsonia tharpii* (Apocynaceae) is a herbaceous, perennial plant with a narrow distribution and five small populations; four from New Mexico and one in Texas. *Amsonia fugatei* is another narrow endemic from central New Mexico. Differences between *A. tharpii* and *A. fugatei* are subtle, leading to questions concerning species status. Furthermore, recruitment is unknown for *A. tharpii*, and seedlings have yet to be observed in the field. A germination experiment was conducted with three different treatments in order to determine the best growing conditions for *A. tharpii*. We also generated Double Digest Restriction site associated DNA sequence data to learn if *A. fugatei* is a distinct species from *A. tharpii*. About 10% of seeds germinated, and 25℃ treatment had the highest radicle emergence. There was no significant difference in germination rate or seedling emergence across the five populations of *A. tharpii*. Molecular results suggested *A. fugatei* is sister to *A. tharpii*. Results from this study will help the Fish and Wildlife agency to determine whether or not to list *A. tharpii* under the Endangered Species Act.



9) **Ruby Barron** will be a senior studying Environmental Engineering and Evolution, Ecology, and Biodiversity at the University of Michigan. They expect to graduate in May 2022.

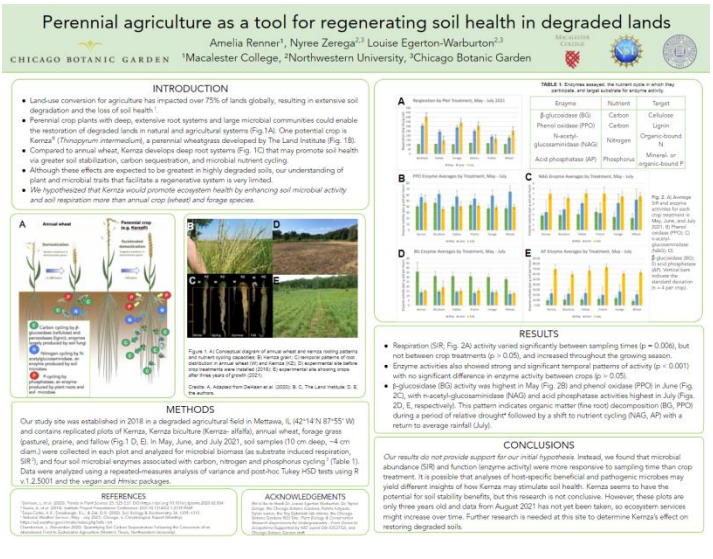
Title: Variability of Pollinator Specialization Over Time: Assessing the Impact of Flower Typology on Pollinator Specialization



Abstract: While flower communities are highly dynamic throughout the year, this time component is often overlooked in plant-pollinator interaction network studies. However, recent work has shown that interaction network structure is dynamic over time. This study integrates contemporary approaches in bipartite network analysis with studies into flower typology to analyze changes in pollinator food preferences. It was hypothesized that a pollinator's degree of specialization would show a negative correlation to the relative abundance of well-suited flowers, and that at all observation days, the system would show a non-random trend in niche-overlap indicating discrete food preferences. Data were provided by Kay Havens documenting plant-pollinator interactions observed at a home garden with 61 plant and 41 observed pollinator species over 22 days spanning mid-April to mid-October 2020. First, each species was assigned to a typological category, and the relative abundance of each flower category was computed for each date. Then, the observations were processed into interaction matrices in R from which two analyses were performed: 1) Partial Differences Index—an index of specialization robust over a wide range of sampling efforts—were computed for all species on all days and their responsiveness to relative abundance of suited flowers tested via linear models and 2) Niche Overlap was calculated for each day and compared to null models computed for each day. Analysis one showed little correlation which may be due to a large proportion of singleton observations for each insect on any day indicating flower suitedness played little role in degree of specialization. However, analysis two showed a strong nonrandom relationship suggesting some other ecological mechanism drives degree of specialization.

10) **Amelia Renner** is a student studying biology at Macalester College and is expected to graduate in 2023.

Title: Perennial agriculture as a tool for regenerating soil health in degraded lands

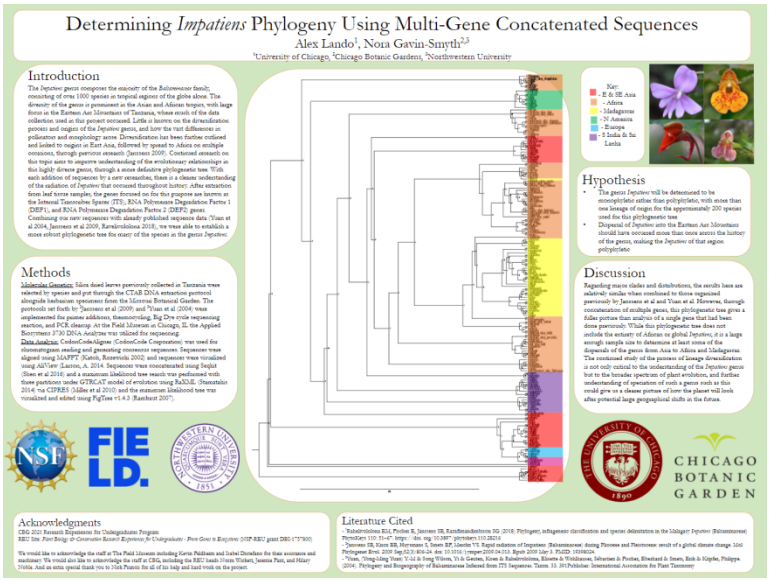


Abstract: Agricultural land use conversion has impacted over 75% of global lands, resulting in extensive soil degradation. Perennial crop plants provide a possible remedy, as their extensive root systems, large microbial communities, and no-till requirements could enable restoration of degraded landscapes. One potential crop with restoration potential is Kernza® (*Thinopyrum intermedium*), a perennial wheatgrass developed by the Land Institute. Kernza's deep roots could possibly restore degraded soils through soil stabilization, carbon sequestration, and microbial nutrient cycling. We hypothesized that Kernza would promote ecosystem health by enhancing soil microbial activity more than annual crop (wheat) or forage species. Research took place at a former agricultural site in Mettawa, Illinois, where plots of Kernza, wheat, Kernza/alfalfa biculture, forage grasses, prairie, and fallow soils had several enzyme activities and soil induced respiration (SIR) measured. Measured enzymes were β-glucosidase to measure cellulose specific carbon-cycling; phenol oxidase to measure lignin specific carbon cycling; N-acetyl-glucosaminidase to measure organic-bound nitrogen cycling; and acid phosphatase to measure mineral and organic bound phosphate cycling. Results showed seasonal differences, but no significant differences by plot treatment. These results indicate that further research is necessary, especially as Kernza roots establish, to determine the ability of Kernza to restore degraded soils.

11) **Alex Lando** is studying at the University of Chicago and is expected to graduate in 2023

Title: Determining *Impatiens* Phylogeny Using Multi-Gene Concatenated Sequences

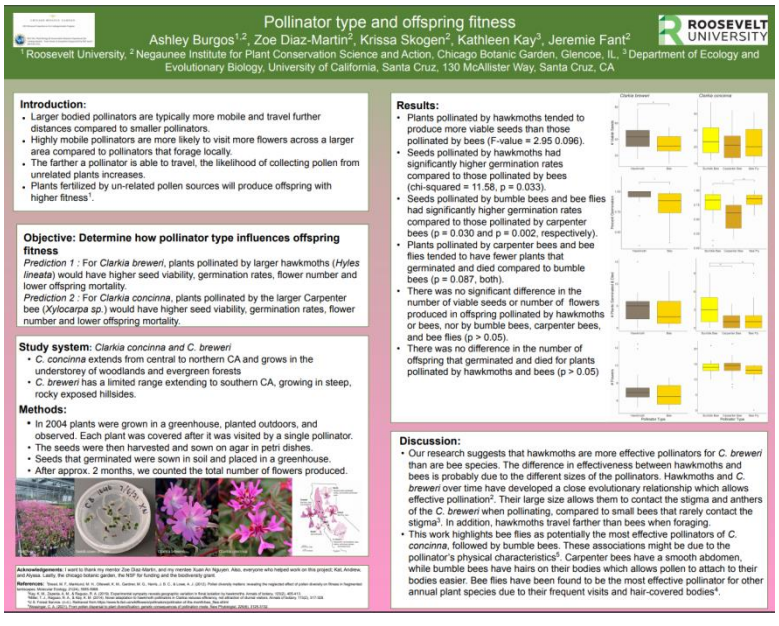
Abstract: *Impatiens*, our genus of interest within Balsaminaceae, has a wide dispersal range globally but has a high concentration of biodiversity focused largely in the Asian and African tropics. The origins of the species from these locations being in question has led to larger discussions on dispersal patterns of African plant species and is therefore of importance to understand in totality. In this project we seek to present a phylogenetic tree representing speciation events, focusing largely on species endemic to the Eastern Arc Mountains of Tanzania. Through a series of extraction, quantification, and analysis procedures, we were successful at creating a phylogenetic tree describing the origins of almost 200 Impatiens species. The tree displayed using three concatenated genes of interest, known as ITS, DEF1, and DEF2, shows monophyly in the genus of impatiens while at the same time displaying the unique non-monophyly of the African species, expanding our understanding of their evolutionary history.



12) **Ashley Burgos** is majoring in Biology at Roosevelt University, and expected to graduate in 2021.

Title: Pollinator type and offspring fitness

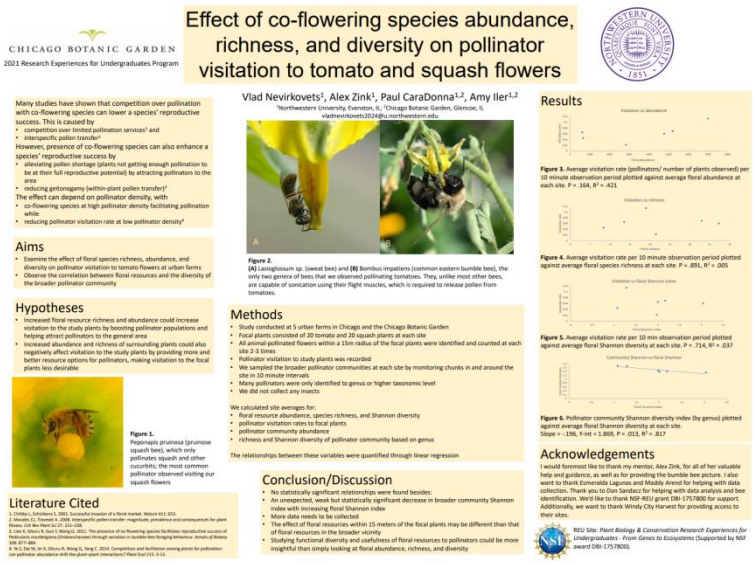
Abstract: Pollinators play an important role in plant reproduction. Larger bodied pollinators are typically more mobile and travel further distances compared to smaller pollinators. The farther a pollinator is able to travel when foraging increases the likelihood of collecting pollen from unrelated plants. Plants fertilized by un-related pollen sources will produce offspring with higher fitness. The goal of this study is to determine how pollinator type influences offspring fitness. Specifically the number of viable seeds produced, offspring germination rates, offspring mortality, and number of flowers produced by the offspring. Plants were planted in the field, observed, and covered after visited by a single pollinator. The seeds were then harvested, and grown for approximately 2 months in a greenhouse before data was collected. For *C. breweri*, we found that seed pollinated by hawkmoths had significantly higher germination rates compared to those pollinated by bees. For *C. concinna*, we found that seeds pollinated by bumblebees and bee flies had significantly higher germination rates compared to those pollinated by carpenter bees. Our research suggests that hawkmoths are more effective pollinators for *C. brewer*i than are bee species. Hawkmoths and *C. breweri* over have developed a close evolutionary relationship which allows effective pollination. Hawkmoths large size allows them to contact the stigma and anthers of *C. breweri* when pollinating unlike smaller bees. Additionally, our data suggest that bee flies are potentially the most effective pollinators of *C. concinna*, followed by bumble bees. Bee flies have been found to be the most effective pollinator for other annual plant species due to their frequent visits and hair-covered bodies. Similar to bumble bees, bee flies have a furry coat which allows pollen to stick when foraging. This research will provide us with an important understanding of the role that different pollinators play in influencing offspring fitness.



13) **Vlad Nevirkovets** is majoring in biology with a concentration in ecology at Northwestern University, expected to graduate in 2024.

Title: Effect of co-flowering species abundance, richness, and diversity on pollinator visitation to tomato and squash flowers

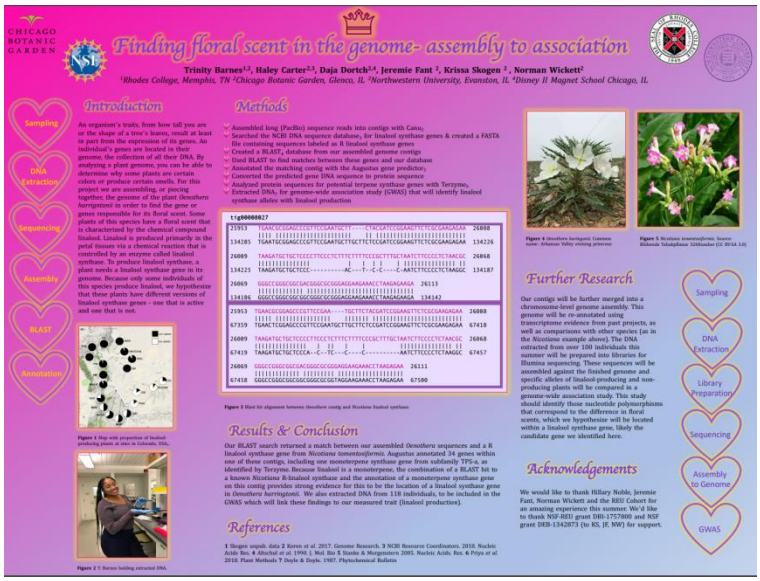
Abstract: Co-flowering species can have both a positive and negative effect on a species' reproductive success. Negative effects can include competition for limited pollination resources and heterospecific pollen transfer. However, co-flowering species can also help attract pollinators to an area and alleviate pollen shortage. We investigated the effects of co-flowering species abundance, richness, and diversity on pollinator visitation to tomato and squash flowers at five urban farms in Chicago and the Chicago Botanic Garden. We also looked at the effects of floral resources on the broader pollinator community abundance, richness, and diversity. We found an unexpected weak but statistically significant decrease in pollinator community Shannon diversity index with increasing floral Shannon index. Besides that, no statistically significant trends were found. There is a lack of data to conclude definitively about any of the variables. It may also be insightful to look at different metrics than the ones we studied.



14) **Trinity Barnes** is a rising junior at Rhodes College majoring in Environmental Studies with a minor in Urban Studies expected to graduate in May 2023.

Title: Finding floral scent in the genome - assembly to association

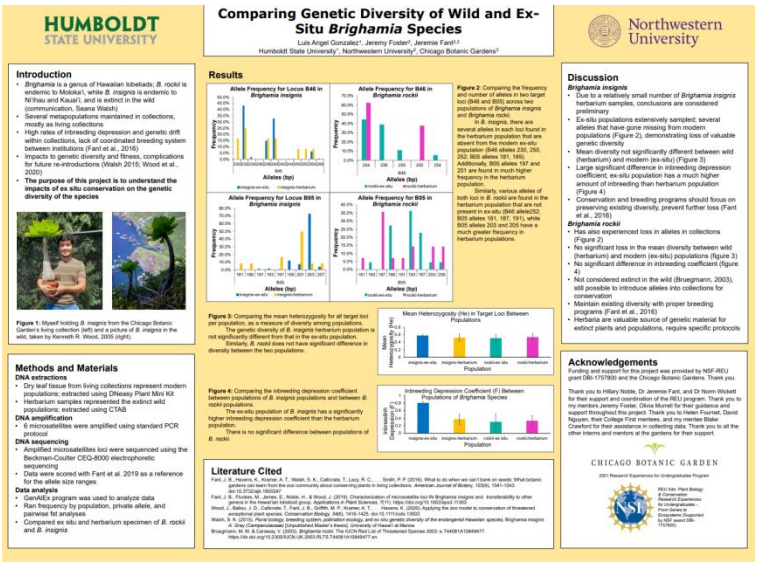
Abstract: Floral scent is extremely important when it comes to attracting pollinators. A species' floral scent can be a mix of scent compounds, or characterized by one dominating chemical. The most frequently sampled compound in floral scent emissions is linalool. *Oenothera harringtonii* is one plant species whose scent is often dominated by linalool production. But the issue we've noticed is that some plants of this species don't make any linalool at all. The goal of this research project is to understand what is controlling this difference genetically by extracting, sequencing, and comparing the DNA of different *Oenothera harringtonii* plants to each other and to known linalool genes of other species. We are able to identify a probable linalool synthase gene in this species and to extract DNA from 118 individuals to compare different versions of this gene.



15) **Luis A. Gonzalez** is majoring in Botany at Humboldt State University and is expected to graduate in 2022.

Title: Comparing Genetic Diversity of Wild and Ex-Situ *Brighamia* Species

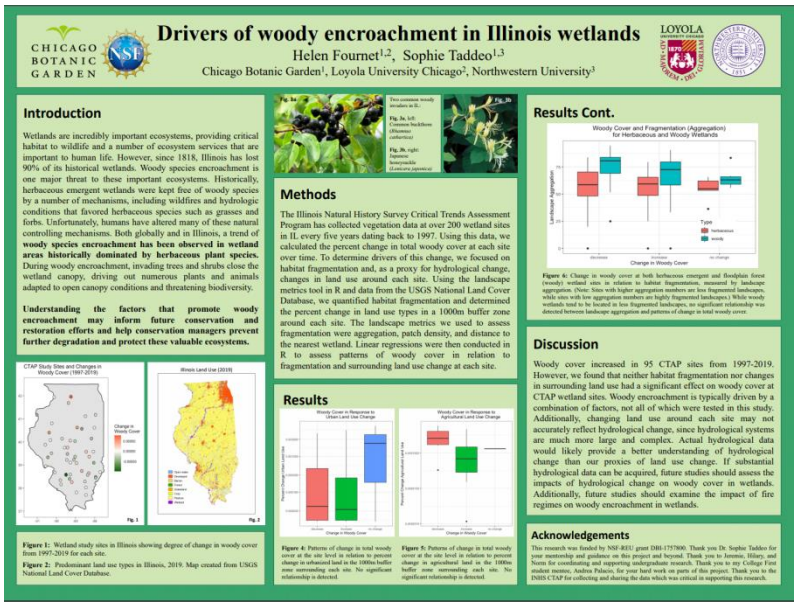
Abstract: *Brighamia* is a genus of Hawaiian lobeliads. *B. rockii* and *B. insignis* are critically endangered, with *B. insignis* being extinct in the wild. Several metapopulations exist in living collections, which has led to high levels of inbreeding depression and genetic drift. This has impacted the genetic diversity and fitness of the species, complicating future reintroductions. The purpose of this study is to explore what diversity has been lost between wild and ex-situ populations of both species. This was accomplished through DNA extractions of tissue from herbarium collections and living plants, and the amplification and sequencing of 6 microsatellite loci. The sequences of individuals were scored to determine the alleles. Frequency by population, private allele, and pairwise fst analyses (GenAlEx) were performed to compare allele frequencies in herbarium and ex-situ populations of both species. Preliminary results indicate that several alleles have been lost from ex-situ populations of both species, representing diversity that has been lost; however, no significant loss in mean diversity was demonstrated. A significant amount of inbreeding exists in the modern populations of *B. insignis*. Conservation efforts should aim to maintain diversity in ex-situ populations, and a coordinated breeding system between institutions is a necessary tool to accomplish this.



16) **Helen Fournet** is majoring in Environmental Science with a minor in Biology at Loyola University Chicago and is expected to graduate in December 2021.

Title: Drivers of Woody Encroachment in Illinois Wetlands

Abstract: Globally and in Illinois, a trend of woody species encroachment has been observed in wetland areas historically dominated by herbaceous plant species. Human activity has altered many of the controlling mechanisms that historically favored herbaceous plant species, allowing woody species such as trees and shrubs to encroach upon these landscapes. Understanding the factors that promote woody encroachment can inform future conservation/restoration efforts to help conservation managers prevent further degradation. To assess drivers of woody encroachment in Illinois, we calculated change in woody cover over time at each site using field surveys from the Illinois Natural History Survey's Critical Trends Assessment Program. We also used data from the USGS National Land Cover Database to quantify habitat fragmentation and land use change around each site over time as a proxy for hydrological change and conducted linear regressions in R to assess the effect on woody cover. We found no significant relationship between woody cover and fragmentation nor land use change. Woody encroachment is a complex ecological phenomena influenced by a number of factors not limited to changing land use. Future studies should assess the influence of changing fire regimes and hydrological systems as a driver of woody encroachment in wetlands.



PROGRAM INFORMATION:
The Chicago Botanic Garden has hosted a Research Experiences for Undergraduates (REU) Site, supported in-part by NSF, since 2003. This year 30 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, 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, Norm Wickett, 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 has been as rewarding for you as it was for the students.

College First program: 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.