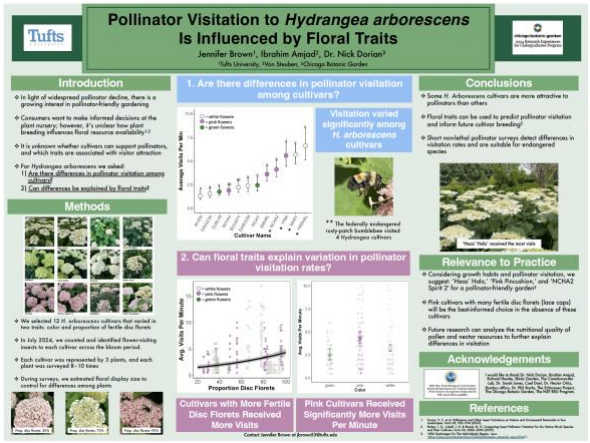
Chicago Botanic Garden
Research Experiences for Undergraduates
Plant Biology & Conservation: From Genes to Ecosystems
Poster Symposium
August 16, 2024

chicago botanic garden
PLANTS.PEOPLE.PLANET.

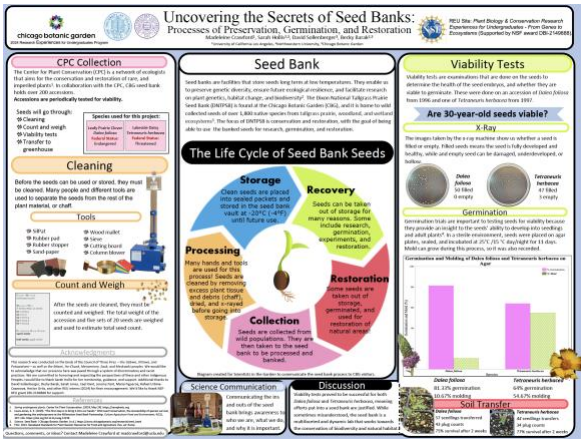
Jennifer Brown is majoring in Biology and Theatre at Tufts University and expects to graduate in 2026.



Pollinator Visitation to *Hydrangea arborescens* Is Influenced by Floral Traits

In light of widespread pollinator decline, there's a growing interest in pollinator-friendly gardening. However, it's unclear how plant breeding influences floral resource availability and whether cultivars can support pollinators. To address this knowledge gap, we studied *Hydrangea arborescens* and asked two questions: 1) Are there differences in pollinator visitation among cultivars? 2) Can differences be explained by floral traits? We selected 12 *H. arborescens* cultivars varying in two traits: color and proportion of disc florets (proxy for pollen availability). In July 2024, we counted and identified flower-visiting insects to each cultivar using visual, nonlethal surveys. Each cultivar was represented by three plants, which were surveyed 8–10 times. Floral display size was estimated to control for differences among plants. We found that some cultivars were more attractive to pollinators than others. We also documented the endangered *Bombus affinis* visiting four cultivars. Floral traits predicted pollinator visitation, with more visits to cultivars containing a higher proportion of disc florets, and to pink and white cultivars (vs. green). Considering growth habits and pollinator visitation, we suggest 'Haas' Halo,' 'Pink Pincushion,' and 'NCHA2 Spirit 2' for pollinator-friendly gardens. Future research can analyze nutritional qualities of pollen and nectar to further explain differences in visitation.

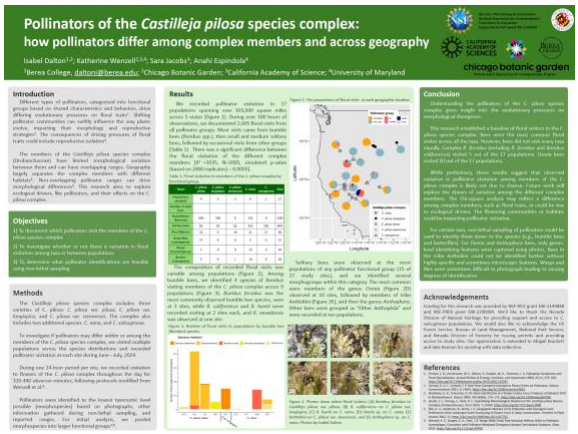
Madeleine Crawford is majoring in Environmental Science with a minor in Ecology and Evolutionary Biology and a concentration in Conservation Biology at University of California, Los Angeles. She is expected to graduate in 2024.



Uncovering the Secrets of Seed Banks: Processes of Preservation, Germination, and Restoration

Seed banks are essential for preserving plant genetic diversity, enhancing ecological resilience, and deepening our understanding of seeds and their environments. The Dixon National Tallgrass Prairie Seed Bank (DNTPSB) at the Chicago Botanic Garden conserves seeds from over 1,800 native species across Midwestern tallgrass prairie, woodland, and wetland ecosystems. This poster outlines the processes involved in managing a seed bank and emphasizes its role in seed preservation. These processes include cleaning, counting, weighing, and viability testing. Seeds must be separated from excess plant material, counted, and weighed to estimate quantities. Viability is assessed through X-ray imaging and germination trials to ensure that seeds remain capable of sprouting after long-term storage. This project focused on the Center for Plant Conservation (CPC) rare plant collection at CBG. Seeds from *Dalea foliosa* and *Tetraneuris herbacea*, stored since 1996 and 1997 respectively, were tested for viability. The testing confirmed that the seeds were viable, as indicated by healthy-looking X-ray images and satisfactory germination rates. These findings affirm the effectiveness of seed bank conservation efforts and highlight the various processes within the lab.

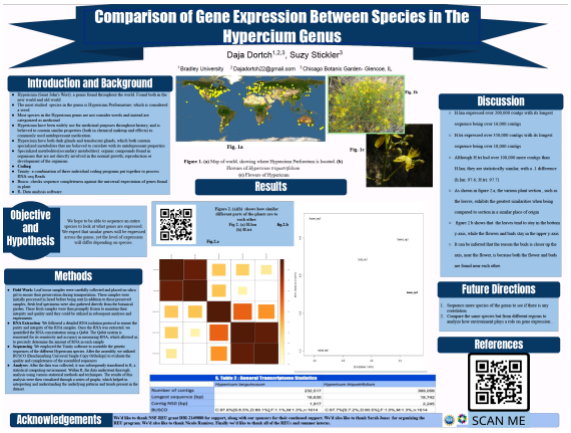
Isabel Dalton



Pollinators of the *Castilleja pilosa* species complex: how pollinators differ among complex members and across geography

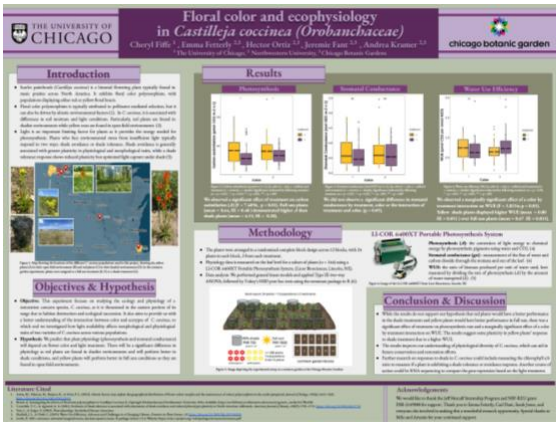
Different types of pollinators drive differing evolutionary pressures on floral traits. The members of the *Castilleja pilosa* species complex have limited morphological variation between them and geography largely separates them. This study aimed to 1) document which pollinators visit the members of the *C. pilosa* species complex, 2) investigate whether or not there is variation in floral visitation among taxa or between populations, and 3) determine what pollinator identifications are feasible using non-lethal sampling. We recorded 2,005 floral visits to 17 populations *of C. pilosa* complex spanning over 165,000 square miles. Floral visitors included chiefly bumble bees (*Bombus* sp.), solitary bees (e.g., *Osmia* sp., *Anthidiini, Anthophora*, and *Lasioglossum* (Dialictus) sp.), butterflies (Lepidoptera), flies (Diptera), wasps (Hymenoptera), and beetles (Coleoptera). There was a significant difference between the floral visitation of the different complex members [X2 =1035, N=2005, simulated p-value (based on 2000 replicates) = 0.0005]. This research established a baseline of floral visitors to the *C. pilosa* species complex. These results suggest that observed variation in pollinator visitation among members of the complex is likely not due to chance. For certain taxa, non-lethal sampling of pollinators could be used to identify them down to the species.

Daja Dortch



The *Hypericum* species, are known for their medicinal properties, produced by a variety of secondary metabolites, including hypericin and hyperforin, which are valued for their antidepressant. This project aims to elucidate the way in which these genes express themselves. Using RNA sequencing and a plethora of bioinformatic tools, we analyzed the transcriptome of two *Hypericum* species and identified key ways in which genes are expressed throughout the plant. Our results revealed differential gene expression across different plant tissues, highlighting the regulatory complexity of secondary metabolite production. Additionally comparative transcriptomic analyses between Hypericum species shed light on evolutionary adaptations and species-specific gene functions. Understanding these gene expression dynamics provides valuable insights into the metabolic engineering of Hypericum for enhanced production of bioactive compounds and offers potential applications in pharmaceutical development. This poster presents our findings on the genetic and molecular basis of secondary metabolite biosynthesis in Hypericum, contributing to the broader field of plant biology.

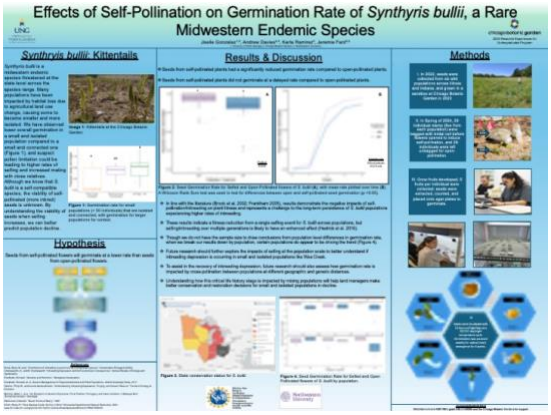
Cheryl Fiffe is majoring in Biological Sciences and Visual Arts at the University of Chicago and is expecting to graduate in 2027.



Floral color and ecophysiology in *Castilleja coccinea (Orobanchaceae)*

Castilleja coccinea is a biennial flowering plant that exhibits floral color polymorphism, displaying red or yellow floral bracts. Herbarium records have suggested that flower color may vary by habitat; red plants are found in shadier environments while yellow ones are found in open field environments. We investigated how light availability (full sun vs. 40% shade) affects physiological traits of two varieties of *C. coccinea* across 12 populations grown in a common garden at the Chicago Botanic Garden. Data included environmental monitoring, morphological data, as well as physiology data measured on the leaf level for a subset of plants (n = 144) using a LI-COR 6400XT Portable Photosynthesis System. To test for effects of treatment, color and the interaction of color and treatment we used general linear models and a two-way ANOVA with Tukey Kramer post-hoc comparisons. We observed a significant effect of treatment on photosynthetic rate, with full sun plants having higher carbon assimilation, and a marginally significant effect of a color by treatment interaction on WUE. Yellow plants demonstrated higher WUE under shade conditions, which suggests some plasticity in their response to shade treatment, and more broadly improved our understanding of physiological diversity of *C. coccinea,* which can aid in future conservation and restoration efforts.

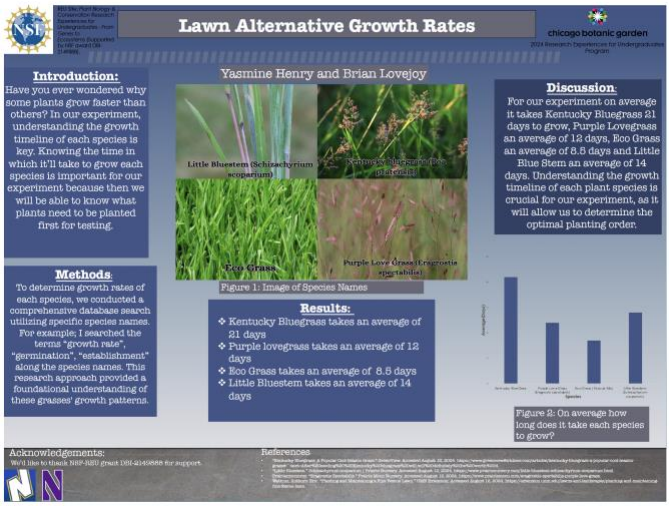
Jiselle Gonzalez



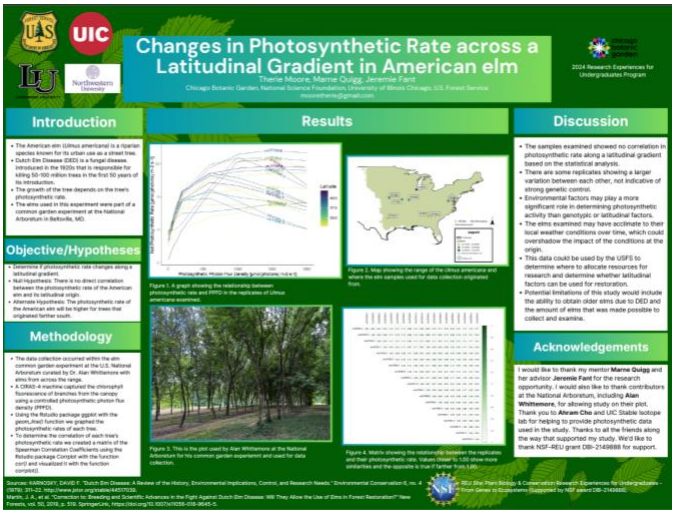
Self-compatibility is defined as a flower producing seed after self-pollination, but the viability of seeds produced is not well understood. When a population becomes small and isolated, the chances of both inbreeding with a close relative and self-pollination become high which may decrease plant fitness. In a self-compatible plant species, we predict that seeds from self-pollinated flowers will germinate at a lower rate than seeds from open-pollinated flowers. By understanding the viability of seeds when selfing increases, we can better predict population decline. For *Synthyris bullii,* a state-threatened midwestern endemic plant species, seeds were collected from six wild populations across Illinois and Indiana, planted and grown in a sandbox at the Chicago Botanic Garden. Thirty individuals, five from each population, were open-pollinated and an additional thirty individuals were self-pollinated. Once flowered, fruits were collected; seeds were extracted, counted, and placed onto agar plates to germinate. Germination was assessed weekly for radical (root) emergence over a four-week period. We found that seeds from self-pollinated individuals had a lower germination rate than seeds from open-pollinated individuals. This has implications for the long-term persistence of this population and will guide management decisions in the future. Future research could explore how germination rates are impacted by cross-pollination between populations at different geographic and genetic distances.

Yasmine Henry

Our project is all about figuring out the growth patterns of 4 different plant species. The main goal is to know the specific timeframes for when each one grows. Once we have the data on the unique growth signatures for each species, we can use that to plan our planting schedule. This is important because coordinating the growth cycles of the plants can significantly enhance the overall performance and long-term viability of the urban greening system.



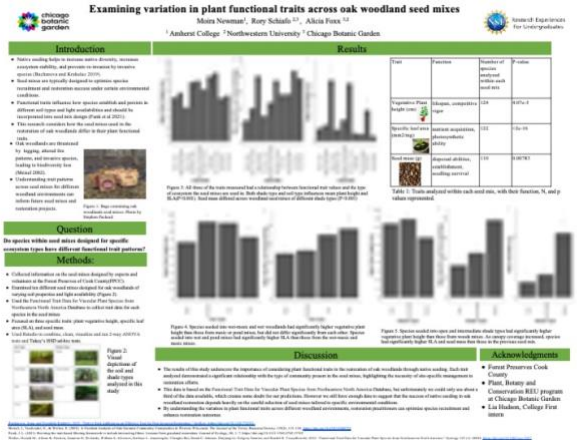
Therie Moore is majoring in Biological Sciences (BS) with an emphasis in Ecology and Evolutionary biology with a minor in Chemistry at Lindenwood University and is expected to graduate in 2024.



Changes in Photosynthetic Rate across a Latitudinal Gradient in American elm

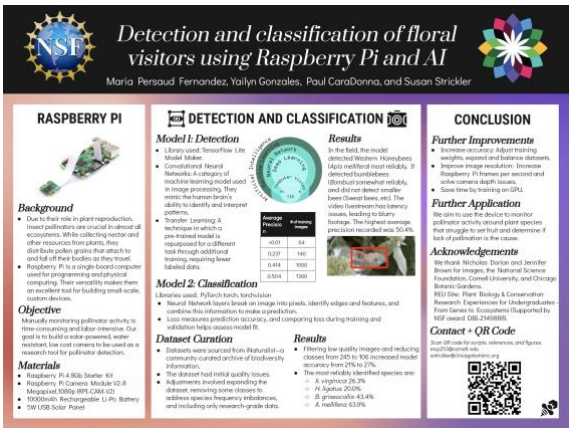
Since the 20th century, Dutch Elm Disease has devastated *Ulmus americana* populations in the eastern U.S., severely limiting its use as a prominent street tree and to retain biodiversity. As it currently stands, there is no cure or consistently effective treatment that has made it possible for the species to flourish as it once did. Due to this, it has become increasingly important to engage in restoration efforts and examine different ways to better restore this species. In this study, we investigated whether a correlation exists between the photosynthetic rate and the latitudinal gradient of *U. americana*. To do this, canopy leaves were sampled from a common garden experiment at the National Arboretum, conducted by Alan Whittemore, with each tree's location of origin recorded. Using a CIRAS-4 machine, we determined each leaf's photosynthetic rate by measuring the chlorophyll fluorescence against a controlled photosynthetic photon flux density (PPFD), which is the measure of the light used for photosynthesis. For data analysis, we used Rstudio to generate an appropriate graph and performed a Spearman correlation coefficient. This yielded results that showed no observable correlation between photosynthetic rate and a latitudinal gradient. This lack of correlation may suggest that photosynthetic rate is influenced more by local environmental factors than by genetic or latitudinal factors.

Moira Newman



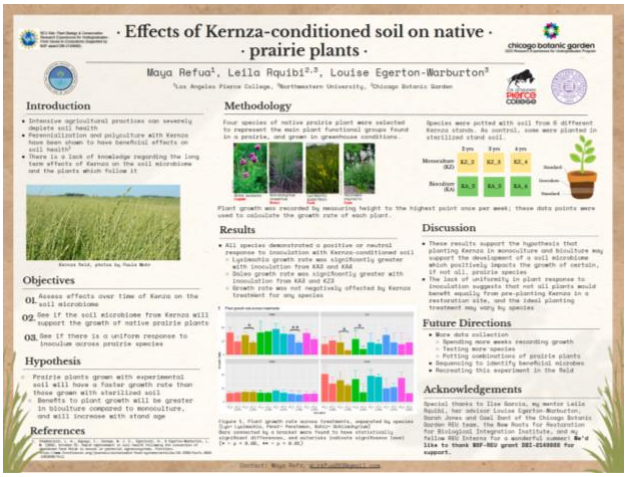
Restoring plant diversity in oak woodlands requires using native plant species because it can increase ecosystem stability, especially using a functional trait framework. Functional traits should inform what kinds of native species are in those seed mixes because they can better predict how a system will change and grow over space and time. We are examining a total of ten different seed mixes designed for an oak woodland system of varying soil properties and light availability. Each trait we analyzed demonstrated a significant relationship with the type of ecosystem present in each of the 10 seed mixes we analyzed, highlighting the necessity of site-specific management in restoration efforts. We focused on three specific traits: plant vegetative height, specific leaf area (SLA), and seed mass. Regarding mean plant height and SLA, both soil and shade types played crucial roles. For seed mass, the interaction with community type was predominantly influenced by shade type, with increased canopy coverage leading to a significant rise in mean seed mass weight. Our data suggests that the success of native seeding in oak woodland restoration depends on the careful selection of seed mixes tailored to specific environmental conditions. By understanding the variation in plant functional traits across different woodland environments, restoration practitioners can optimize species recruitment and enhance restoration outcomes.

Maria Persaud Fernandez



Pollinators play an important role in the pollination and reproduction of many plant species. However, documenting pollination events in action and identifying numerous floral visitors is both challenging and time-consuming. Recent advances in artificial intelligence have increased the accessibility of computer vision technology. Computer vision is a branch of machine learning in which a model is trained to interpret and understand visual information. Raspberry Pi is a single-board computer used for programming and physical computing. Their versatility makes them an excellent tool for building small-scale, custom devices.
We aimed to build a solar-powered, water resistant, low cost camera to be used as a research tool for pollinator detection and classification. The refined prototype will later be applied to many other plant species, providing an efficient and automated tool for quantifying and identifying floral visitors involved in pollination.

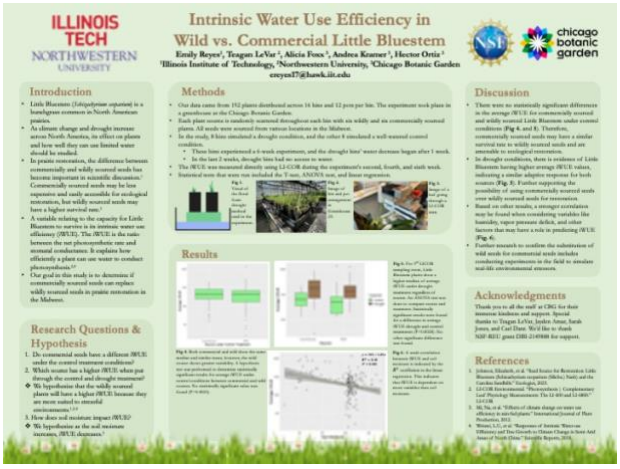
Maya Refua is majoring in Biology at Los Angeles Pierce College. She is expected to transfer in 2025 and graduate in 2026.



Effects of Kernza-Conditioned Soil on Native Prairie Plants

Intensive agricultural practices can negatively impact soil health; some studies suggest that perenialization and polyculture with Kernza may benefit soil health and offset these negative effects. To address the lack of knowledge regarding the long term effects of Kernza on the soil microbiome and subsequent planting, and assess Kernza's potential as a restoration tool, four species of native prairie plants were grown in pots inoculated with soil from Kernza monoculture and Kernza-Alfalfa biculture stands ranging in age from two to four years. Plant height was measured weekly and used to calculate growth rate. After seven weeks, the growth rate for *Lysimachia quadriflora* was significantly greater with inoculation from three- and four-year stands of Kernza-Alfalfa biculture, and the growth rate for *Dalea purpurea* was significantly greater with inoculation from three year monoculture and biculture stands. There was no significant difference in growth rate for any other species and treatments. This initial evidence suggests that Kernza monoculture and biculture may impact the microbiome such that certain native prairie plants experience growth benefits, though not all plants would benefit equally from pre-planting Kernza in a restoration site, and ideal planting treatment may vary by species.

Emily Reyes is majoring in Environmental Chemistry with a minor in Environmental Engineering at the Illinois Institute of Technology and is expecting to graduate in 2026.

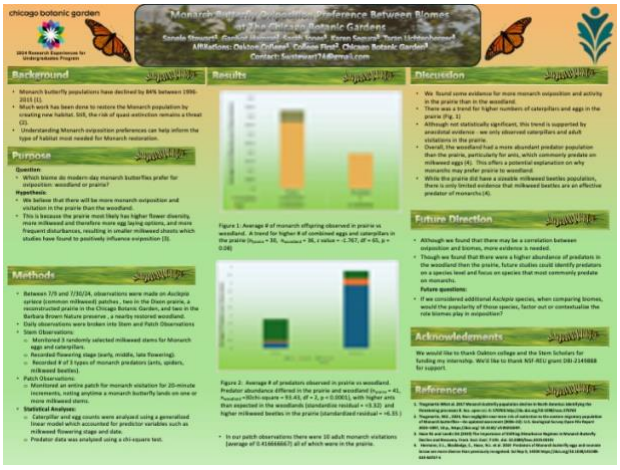


Intrinsic Water Use Efficiency in Wild vs. Commercial Little Bluestem

Little Bluestem (*Schizachyrium scoparium*) is a bunchgrass commonly used for Midwest ecological restoration. As climate change and drought increase across North America, their effects on Little Bluestem and how well they can use limited water should be studied. The intrinsic water use efficiency (iWUE) is an important variable relating to the capacity of Little Bluestem to survive in limited water environments. The difference between commercially and wildly sourced seeds for restoration has also become important in scientific discussion. Our objective is to determine if commercially sourced seeds can replace wildly sourced seeds for restoration. In the study, half of the plants experienced a simulated drought and the other half were well-watered controls in a greenhouse. The iWUE was measured three times throughout the experiment using the instrument, LI-COR. The results show similar average iWUE values for commercial and wild sources in the controlled environment, significant differences in average iWUE between treatments, and a weak correlation between soil moisture and average iWUE. We conclude that commercially sourced seeds are a reliable substitution for wildly sourced seeds in terms of their iWUE. To support this

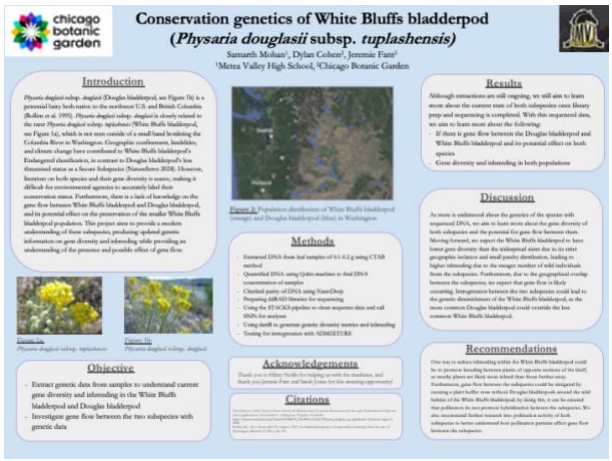
conclusion, experimentation with seed sourcing and iWUE should be done in the field to simulate real-life stressors.

Sanele Stewart
Monarch Butterfly Oviposition Preference Between Biomes at The Chicago Botanic Garden



Abstract: Monarch butterflies have in recent decades seen a large decline in populations. Threat of quasi-extinction increases, we need to learn the necessary information to prevent significant loss in monarch populations. Oviposition (egg laying) is one of the most important decisions a monarch can make, and understanding what factors influence this decision could help inform monarch conservation practices. In this study we looked at monarch oviposition preference between Prairie and Woodland. We accomplished this by looking at egg, caterpillar, and predator abundance in the said biomes. We found that the prairie had more monarch activity and less predation than the woodland, but we did not find a statistically significant difference. There needs to be more research to better understand monarch oviposition and inform conservation efforts.

Samarth Mohan is studying at Metea Valley High School
Conservation genetics of White Bluffs bladderpod (*Physaria douglasii* subsp. *tuplashensis*)



Physaria douglasii subsp. *douglasii*, also known as the Douglass bladderpod, is a mustard species endemic to the Pacific Northwest closely related to a rarer bladderpod species: *Physeria douglasii* subsp. *tuplashensis*, also known as the White Bluffs bladderpod. Both have very similar morphological features, yet the White Bluffs bladderpod is more geographically restricted than its cousin to a small river-bordering strip of bluff in Washington; furthermore, White Bluffs bladderpods are heavily threatened due to landslides and climate change. Our project focuses on providing a modern understanding of the genetic state of the subspecies, assessing gene diversity, inbreeding, and gene flow with the Douglas bladderpod. To do this, we extracted DNA using the CTAB method from leaf samples from both subspecies and quantified extracted DNA with a Qubit machine. From there, we aim to sequence the extracted DNA through the DDRAD method, and use dartR and other softwares to generate gene diversity, inbreeding, and gene flow metrics. Moving forward, we expect the gene diversity of the White Bluffs bladderpod to be very low due its strict geographic isolation and small, patchy distribution; consequently, we expect the population to have high inbreeding due to the meager number of wild individuals. Furthermore, we expect that introgression between the subspecies is likely due to geographic overlap in their habitats, and that such gene flow could lead to hybridization that could genetically diminish the White Bluffs bladderpod.

PROGRAM INFORMATION: The Chicago Botanic Garden has hosted a Research Experiences for Undergraduates (REU) Site, supported in-part by NSF, since 2003. This year 13 undergraduate students participated in our ten-week summer 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, Sarah Jones, Hilary Noble, Suzy Strickler, Cael Dant

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