2014

6TH ANNUAL UNDERGRADUATE RESEARCH SYMPOSIUM

Proudly presented by

THE FIELD MUSEUM

CHICAGO BOTANIC GARDEN

THE MORTON ARBORETUM

Research presentations inWard Lecture Hall (Lecture Hall 1)
Poster presentations in the West Lobby
Friday, August 15

Symposium Schedule

8:00 – 8:45 am — Poster set-up in West Lobby in front of Simpson Theatre, mounting board, easels, push pins and tape provided

9:00 – 9:15 am — Opening of the Symposium and welcome from FMNH REU program heads Drs. Petra Sierwald (FMNH), Jeremie Fant (CBG) and Bryant Scharenbroch (MA)

Session 1

Moderator: Estevam L. Cruz da Silva, Postdoctoral Fellow, Field Museum

9:15 – 9:30 am — **Fishing around the world: spiders of the genus *Dolomedes***
Anne Gibbons, University of Michigan – Ann Arbor, and Field Museum of Natural History, Chicago, IL

9:30 – 9:45 am — **Speciation and diversification of mammals on islands**
Chris Kyriazis, University of Chicago, and Field Museum of Natural History, Chicago, IL

9:45 – 10:00 am — **Inferring the history of morphological diversification in sedges**
Breane Budaitis, Ohio Wesleyan University, and Morton Arboretum, Lisle, IL

10:00 – 10:15 am — **Analysis of breadfruit domestication (*Artocarpus altilis*, Moraceae)**
Matthew Murphy, Illinois College, and Chicago Botanic Garden, Glencoe, IL

10:15 – 11:00 am — Poster Session #1
Group Photo
Coffee Break

Poster Session: Poster presenters, please stand by your poster, so that members from the audience can ask questions.

Group photo: All speakers and poster presenters in West Door Lobby at 10:45 am sharp, please assemble with Stephanie Ware

Coffee Break: Refreshments provided in Lecture Hall 2. Please do not take food or drink into Ward Lecture Hall (Lecture Hall 1)

Session 2

Moderator: Fabiany Herrera, Postdoctoral Fellow, Chicago Botanic Garden

11:00 – 11:15 am	**Resolving the phylogeny of the Wirthiotremateae (Graphidaceae) with morphological and molecular data** *Ian Medeiros*, College of the Atlantic, and Field Museum of Natural History, Chicago, IL
11:15 – 11:30 am	**What's in a name? That's what we call a species - addressing species delimitation in script lichens** *Luis Allende*, Northeastern Illinois University, and Field Museum of Natural History, Chicago IL
11:30 – 11:45 am	**Fungi of Mexico: documenting diversity and mycorrhizal status with genetics and stable isotopes** *Rosalba Herrera*, Loyola University, and Chicago Botanic Garden, Glencoe, IL
11:45 – Noon	**Soil Fungal Biomass: Its degradation and contribution to soil organic matter** *Benjamin Sanchez-Sedillo*, University of New Mexico, and Chicago Botanic Garden, Glencoe, IL
Noon – 12:15 pm	**Green Roof Ecology** *Monica Cesinger*, Amherst College, and Chicago Botanic Garden, Glencoe, IL
12:15 – 1:00 pm	Lunch Break

Lunch is provided for speakers, poster presenters and mentors in Lecture Hall 2. Please do not take food or drink into Ward Lecture Hall (Lecture Hall 1).

Audience Lunch options: Field Bistro (first floor) and Explorer Café (ground floor)

National Science Foundation
WHERE DISCOVERIES BEGIN

Session 3

Moderator: Emma Bialecki, Research Assistant, Morton Arboretum

1:00 – 1:15 pm	**Towards a sustainable designer urban soil for trees** *Kathrine Klaus*, University of Illinois, and Morton Arboretum, Lisle, IL
1:15 – 1:30 pm	**Effects of urban trees and green infrastructure on water quality and runoff** *Brian Maule*, Northern Illinois University, and Morton Arboretum, Lisle, IL
1:30 – 1:45 pm	**Lessons from 35 years of migratory bird collisions in Chicago** *Max Witynski*, Cornell University, and Field Museum of Natural History, Chicago, IL
1:45 – 2:00 pm	**When seed sourcing matters for restoration on the Colorado Plateau** *Giselle Varrientos*, University of Wisconsin – Platteville, and Chicago Botanic Garden, Glencoe, IL
2:00 – 2:45 pm	Poster Session #2 Coffee Break

Poster Session: Poster presenters, please stand by your poster, so that members from the audience can ask questions.

Coffee Break: Refreshments provided in Lecture Hall 2. Please do not take food or drink into Ward Lecture Hall (Lecture Hall 1).

Session 4

Moderator: Benjamin Rubin, Graduate Student, Field Museum

2:45 – 3:00 pm	**Population Genetics of *Hyles lineata*** *Andrea Gruver*, Gustavus Adolphus College, and Chicago Botanic Garden, Glencoe, IL
3:00 – 3:15 pm	**Plant-herbivore interactions with hybrid *Echinacea* plants in native prairie** *Maureen Page*, Scripps College, and Chicago Botanic Garden, Glencoe, IL
3:15 – 3:30 pm	**A thousand-legged mystery: The evolution of millipedes** *Wilson Guillory*, University of Arkansas, and Field Museum of Natural History, Chicago, IL
3:30 – 3:45 pm	**Morphological integration in the mandibles of living reptiles and fossil synapsids** *Armita Manafzadeh*, University of California – Berkeley, and Field Museum of Natural History, Chicago, IL
3:45 – 4:00 pm	**Morphological evolution of carnivoran milk teeth** *Dana Reuter*, Mount Holyoke College, and Field Museum of Natural History, Chicago, IL
4:00 – 4:15 pm	Closing of Symposium with remarks from Drs. Kenneth Angielczyk (FMNH), Jeremie Fant (CBG) and Bryant Scharenbroch (MA)

About the FMNH REU: In 2009, curators Petra Sierwald and Peter Makovicky received a National Science Foundation Research Experience for Undergraduates (REU) site grant. This grant was renewed in 2012 and curator Ken Angielczyk took over for Dr. Makovicky. Over this time, the Field Museum has hosted 48 talented young scientists for 10-week intensive summer research internships. These young scientists have worked very closely with our amazing pool of curators and collections experts and explored a stunning range of scientific questions surrounding biological diversity. They also have participated in a 6-week phylogenetic course and a number of field trips. The internship culminates in a one-day research symposium where each REU intern is able to present his or her research to museum staff and other interested parties.

In 2012, Dr. Sierwald formed a relationship with the directors of the Chicago Botanic Garden's REU program, Drs. Jeremie Fant and Dan Larkin. In 2013, the Chicago Botanic Garden and the Field Museum co-hosted the 5th Annual Undergraduate Research Symposium at the Field Museum. We also added a poster session so that affiliated undergraduate interns could also present their summer research. This joint project was a resounding success.

This year, we are very excited to add the Morton Arboretum intern program to our group. We look very forward to a continuing relationship between these three amazing Chicago scientific institutions dedicated to mentoring upcoming scientists!

Titles and Abstracts

ORAL PRESENTATIONS

What's in a name? That's what we call a species - addressing species delimitation in script lichens

Luis Allende, Northeastern Illinois University, and Field Museum of Natural History, Chicago IL

Script lichens(*Graphis scripta*) consists of a morphologically diverse group of licheinized fungi, that was until recently considered to represent a single species. Due to an absence of secondary chemistry and lack of taxonomically useful characteristics, species delimitation within this complex has been difficult and thus far has been based entirely on overall appearance of the apothecium. In this study we used molecular sequence data along with measured characters of the apothecia(length, width and thallus margin), to reconstruct a phylogeny in order to identify distinct lineages. We generated sequences for four genetic markers in 65 North American and European specimens which were added to previously collected data from 54 additional samples. We then performed a phylogenetic analysis using the method of maximum likelihood. Eight distinct lineages were then distinguished using the general mixed Yule coalescent model (GMYC). These genetically distinct lineages however did not correspond to morphological species recently described within the complex. It was also not possible to describe these clades based on differences in measured characteristics. Future studies will require the identification of additional taxonomically useful characters before species within this complex can be formally recognized.

Inferring the history of morphological diversification in sedges

Breane Budaitis, Ohio Wesleyan University, and Morton Arboretum, Lisle, IL

Section *Ovales*, in the sedge genus *Carex*, exhibits a remarkable degree of morphological variation. The underlying processes explaining morphological diversification in sedges have gained momentum in recent publications. This study investigates the history of morphological diversification of sedges in Section *Ovales* in a phylogenetic context. Perigynium solidity and achene width are the most reliable predictors of phylogeny while culm width was the least reliable predictor. In general, trait differentiation within Section *Ovales* was found to vary at the subclade level, indicating much of the trait diversification is within the Eastern North American clade (ENA) and within the Western North American grade (WNA) rather than between the two. Conversely, a clean split between ENA clade and WNA grade is found in climatic niche space suggesting additional factors are important in explaining trait diversification. Strong phylogenetic tracking of some reproductive morphological traits may be constrained by phylogeny,

while weak phylogenetic tracking of other traits may suggest functional significance in climatic and habitat adaptation. A general increase in the rate of morphological evolution was found at the base of the ENA clade, possibly co-occurring with the increase in rate in evolution of chromosome number. Increased rates in the evolution of morphological traits and the number of chromosomes may signify a shift in selection regimes at the base of the ENA clade. Further work is needed to determine the extent of convergent morphological evolution between the ENA clade and WNA grade to gain a better understanding of the trait variability observed within Section *Ovales*.

Green Roof Ecology

Monica Cesinger, Amherst College, and Chicago Botanic Garden, Glencoe, IL

While green roofs provide important sustainability benefits to city environments by reducing a building's energy needs, preventing damage to roofs, and reducing storm water runoff, their ability to directly aid in conservation through the support of native species has remained relatively untapped. How to create biodiverse green roofs is an understudied but very important question to cities seeking to become less ecologically harmful. Understanding the hostile and variable micro-climates of green roofs would critically advance the design of the novel ecosystems on them. This study explored how micro-climactic differences might influence a green roof's ability to support native Illinois prairie plants in stepping-stone like environments. Data was gathered from prairie species on three green roofs. We measured individual plants' survival and growth over a 2 month period as a way to gauge the ability of that species to survive on each particular site. Microclimates of the three roofs were assessed through measurements of temperature, nutrient levels, sediment particle size, and water infiltration rate. Variation in these microclimate factors were found between all three roofs. Plant survival varied with both species and site. Species were most often observed to demonstrate relatively more survival success in deep substrate and higher pH. Statistically significant variation in growth rate, measured as change in height, was found both between species and between sites. 8 out of 18 species varied in surface coverage between sites. For 6 of 18 species, change in height varied significantly with location. These observations show that the success of a species on green roofs can indeed vary with changes in microclimate. Using the data gathered, we may be able to also explore how these microclimate factors might affect species differently based on family and ecotype, and why. Furthermore, even within roofs there are notable climate differences which merit greater attention. We can conclude that microclimatic variation should definitely be considered when designing a biodiverse green roof, though more research is necessary to determine the causal relationships between plant success and green roof microclimate.

Fishing around the world: spiders of the genus *Dolomedes*

Anne Gibbons, University of Michigan – Ann Arbor, and Field Museum of Natural History, Chicago, IL

With 44,906 species described, spiders rank seventh in species diversity among other orders of organisms. Spiders can be found on all continents except Antarctica, living on vegetation, webs, and even water. The family Pisauridae is commonly known as nursery web spiders. In this family, the female spider builds a silken nest for her young and protectively guards it until the juvenile spiders are mature enough to leave. Of the 48 genera of Pisaurid spiders, one cosmopolitan genus, *Dolomedes*, is the most diverse, with 98 described species. Many species of *Dolomedes* are called "fishing spiders" because they are usually found near bodies of fresh water and are able to run across the surface of the water, even submerging to hunt small fish. Using the *Dolomedes* collection in the Field Museum, as well as loans from other museums, the goal of the project was to add images, descriptions, and measurements to the morphological atlas of *Dolomedes* specimens. Using this data, we created a phylogenetic tree to tell us the evolutionary history of the genus. To do this, spiders were examined with a light microscope, dissected, mounted and dried on stubs for the scanning electron microscope (SEM). We dissected the tarsal claw and male and female genitalia because they are the most complex morphological features of spiders used for identification. In addition, spine patterns on the leg from each species were recorded and coded into characters. Microscope and digital images were used to compare morphological characters between species, eventually using these characters to create a phylogenetic tree with programs Mesquite and TNT. Finally, during the examination of material from a Chinese collection, we found the male of *Dolomedes raptoroides*, which was illustrated using SEM images and photos. The specimen was measured and described and we prepared a manuscript for publication in the periodic *Zootaxa*. In the final phylogenetic analysis, our data generated 5 most parsimonious trees, using equally-weighted characters. The final consensus tree included 23 taxa and 39 characters (116 steps, Ci=39, Ri=50), but the results did not related the morphological resemblance between species and the geographic distribution. This may be due to gaps in the species sampling from Africa and Europe. In the future, an analysis with a more geographically diverse sample of *Dolomedes* species will allow for a greater understanding of past evolutionary events.

Population Genetics of *Hyles lineata*

Andrea Gruver, Gustavus Adolphus College, and Chicago Botanic Garden, Glencoe, IL

Hyles lineata is the most widespread species of *Hyles* in North America, ranging from South America to Canada. *Hyles lineata* serves as an important pollinator for a wide range of plant species. The ability of the species to fly long distances allows them to transfer pollen between fragmented populations of plants, maintaining genetic diversity. To date, no population study of *Hyles lineata* been carried out in North America. In this study we amplified and sequenced 605bp of the mitochondrial gene Cytochrome Oxidase I (COI) to determine the extent of genetic structure within the species across the

southwestern United States. Using 31 samples collected in the field combined with 9 South American samples obtained online from BOLD, 19 haplotypes were discovered; 15 of which were unique to a single individual, and 4 of which were shared across the sampled population. Haplotype A was the most widespread haplotype shared between 15 individuals, 14 from North America and 1 from Mexico. Haplotype B was shared between 5 individuals, 2 from North America, and 3 from South America and the Caribbean Islands. Geographical haplotype maps were created, as well as neighbor joining trees. The diversity and spread of haplotypes infers there are low levels of genetic structure within the species across the Americas, possibly resulting from high levels of gene flow between populations of *Hyles lineata* due to their long dispersal ability. In order to make any affirmative conclusion more samples are needed. We plan to collect samples from Arizona and New Mexico, as well as sequence 94 additional samples to add to the initial populations. These additional samples will allow us to draw conclusion regarding haplotype diversity and genetic structure of the species. This study has begun to explain the largely unknown population genetic structure of *Hyles lineata*. This information will be an important step in better understanding the evolutionary relationship between moth pollinators and their mutualistic relationships with plants.

A thousand-legged mystery: The evolution of millipedes

Wilson Guillory, University of Arkansas, and Field Museum of Natural History, Chicago, IL

Millipedes (Arthropoda: Diplopoda) are an exceptionally diverse group of arthropods with over 13,000 known species and an estimated 80,000 total, and are important nutrient cyclers in forest ecosystems worldwide. However, relatively little is known about their anatomy, ecology, and evolution, making the analysis of millipede phylogeny, morphology, and behavior very challenging. The present study generated image data for the creation of a comprehensive millipede morphological atlas. Atlas images will form the base for detailed morphological descriptions; the morphological data, when combined with molecular data, will be employed as characters for phylogenetic analyses of the interrelationships between millipede families. Selected morphological images will be integrated in a world-wide, illustrated family identification tree. Millipede specimens of four species from the orders Spirobolida, Polydesmida, and Stemmiulida were dissected and cleaned using an ultrasonic cleaner and enzymatic treatment with pancreatin. The specimens were then photographed with a light microscopic imaging system to generate detailed color images with high depth of focus. The specimens were subsequently dried and mounted for scanning electron microscopy, where they were separately imaged to allow for the examination of surface structures and features difficult to see with a light microscope due to transparency or small size. Males and females of the same species were both imaged in cases of sexual dimorphism. Several apomorphic and synapomorphic characters were noted, with especial attention paid to the mandibles and gnathochilaria. Apomorphic characters in Spirobolida included the presence of a small anterior tooth and the lack of an anterior fringe on the molar plate, while differences between families were also found. Mouthparts of Polydesmida and

Stemmiulida were morphologically similar to each other, supporting a closer relationship between those two groups than to Spirobolida.

Fungi of Mexico: documenting diversity and mycorrhizal status with genetics and stable isotopes

Rosalba Herrera, Loyola University, and Chicago Botanic Garden, Glencoe, IL

Fungi have an important role in the environment as a main decomposer. Research in identifying fungal species from seasonal dry tropical forests is understudied. Having knowledge of the fungal species and their trophic status can expand on the concept of tropical systems affecting the ectomycorrhizal fungal communities. Fungal samples were collected and dried from Mexico's Yucatan Peninsula. Genetics and stable isotopes analyses were used to identify the fungus genus and specie. Aldrich Extract-n-Amp Plant kit and protocol was used for extracting DNA as well as the Mobio Power Clean kit to clean the samples of any non-fungal residue. Samples were analyzed through gel electrophoresis to ensure high quality DNA was present. Polymerase chain reaction (PCR) was performed to the samples with high quality DNA using ITS and LSU primers. The PCR samples were then cycle sequenced. Once samples were sequenced, search engines such as Basic Local Alignment Search Tool (BLAST) and Ribosomal Database Project (rdp) were used to identify the samples. Phylogenetic trees were produced to have notion of which specie was most related to which fungal genus. In certain occasions the sample was in a genus group, however, it was separated from the species known. It could potential new specie not classified within the genus. To determine the fungal samples trophic status, stable isotopes of Carbon-13 and Nitrogen-15 analyses were performed to a small amount of dried, grind powder of each sample. Mycorrhizal fungi are defined by high level of Nitrogen-15. Saprotrophic fungi are defined by low level of Nitrogen-15.

Towards a sustainable designer urban soil for trees

Kathrine Klaus, University of Illinois, and Morton Arboretum, Lisle, IL

Growing healthy trees in artificial urban soils is challenging; these soils often constrain the establishment, growth, and longevity of urban landscape trees. These soils tend to drain well, but have low water-holding and nutrient supply capacities. The purpose of this study was to compare the performance of the current urban soil standard against a natural forest soil, as well as a new, intermediate specification (tree soil). Additionally, both mulched and non-mulched samples were studied to determine the effects of mulching on each soil type. Trees were watered for the first 65 days, after which watering was stopped to assess performance in drought conditions. Surface respiration and stomatal conductance were measured weekly. For each of these measurements, mulched pots consistently measured significantly higher than those with a bare surface. Respiration was significantly higher in the urban soil during the watering period, while the tree soil was significantly higher during the drought period. Stomatal conductance was not significantly different between soil types until the last week of measurements under drought conditions, in which the tree soil performed best. Overall, the tree soil

may be best for urban trees. These trees must be relatively self-sufficient, and should not rely on heavy watering for survival. Future studies should assess the performance of these soils under multiple watering and fertilization levels to further understand their suitability for the urban environment.

Speciation and diversification of mammals on islands

Chris Kyriazis, University of Chicago, and Field Museum of Natural History, Chicago, IL

Islands have long fascinated biologists on account of the peculiar sets of organisms often found evolving in isolation from the mainland. The Philippines, an archipelago of over 7,000 islands, has increasingly become recognized as an ideal natural laboratory for studying the processes underlying the formation of new species, on account of a complex geological history that has produced some of the highest documented concentrations of endemic species, particularly in well-studied vertebrate groups including mammals and birds. Perhaps one of the most impressive radiations is that of the murid rodents, with at least 55 endemic species confined to the Philippine archipelago, a number that continues to rise as sampling of genetic data becomes more widespread. Particularly notable about the dynamics of speciation within murid rodents in the Philippines are the high rates of *in situ* diversification, in which new species arise on the same island, each species often confined to a single isolated mountain range. In this study, we examine the degree of divergence within an endemic lineage on the island of Luzon, *Bullimus luzonicus*, commonly known as the large Luzon forest rat. This species is distributed over most of the island and across a wide range of elevations, calling into question the degree to which local populations may have been able to diverge historically. We sequenced 149 tissue samples from 16 localities on the island of Luzon for the mitochondrial gene cytochrome b in order to investigate the fine-scale patterns of divergence within the island. Resulting phylogenies show significant divergence between groups from different geographic regions of the island, with at least three well-supported groups that likely constitute new undescribed species, calling for further sampling of nuclear DNA to corroborate mitochondrial evidence. The results of this study add to a growing body of literature documenting the surprising volume of underappreciated mammalian diversity worldwide as well as the astounding levels of unique biodiversity found within the Philippines.

Morphological integration in the mandibles of living reptiles and fossil synapsids

Armita Manafzadeh, University of California – Berkeley, and Field Museum of Natural History, Chicago, IL

The co-option of mammalian ossicles from the postdentary jawbones of their ancestors is a classic example of exaptation, and is well-documented in the fossil record through a number of transitional forms. Over the course of synapsid evolution, the articular and quadrate bones migrated from the jaw joint into the middle ear where they were co-opted for hearing, the angular bone evolved into the ectotympanic, and the other postdentary bones were reduced and lost. On the contrary, sauropsids retained these bones as part of the jaw. However, despite increased studies of the capacity of systems

to evolve, the potential influence of modularity as a precursor for evolvability in this transition has not been investigated. To explore this possibility, we collected two-dimensional landmark-based morphometric data from mandibles of a wide range of living reptiles, as well as a test case of fossil synapsids, to examine whether all the bones of the mandible form a single integrated unit or if subgroups of bones form distinct modules. Mandibles of 446 reptile specimens across 38 families, as well as 7 specimens of the therapsid *Diictodon*, were photographed from the lateral view. Landmarks and semi-landmarks were digitized using Rohlf's tpsDig2 version 2.17 with focus on the dentary and two postdentary bones. We then used Klingenberg's method implemented in MorphoJ version 1.06b to test the *a priori* hypothesis of dentary versus postdentary modularity. We did not find a strong signal of modularity for all modern reptiles. However, modularity is apparent in some suborders (Lacertilia and Serpentes), demonstrating some degree of correlation with jaw kinesis. Comparison with fossil synapsids proved dubious, with findings biased towards very high levels of integration due to the effects of preservational artifacts. While our results do not allow for a prediction of the basal character state for sauropsids, evidence of modularity in some squamates demonstrates that the modularity we predict for synapsids is not unprecedented among amniotes.

Effects of urban trees and green infrastructure on water quality and runoff

Brian Maule, Northern Illinois University, and Morton Arboretum, Lisle, IL

In the late 1990's, Morton Arboretum installed a permeable parking lot to improve the quality of water flowing into Meadow Lake. Integral to its design were 9' wide bioswale medians, due to their ability to retain soil moisture. It is believed that healthier trees enhance the bioswale's retentive capacity by transpiring extra water out of the system. This study analyzed the health and productivity of trees in Morton Arboretum's bioswales. For 21 bioswale and 20 control trees, stomatal conductance, leaf greenness, and various soil parameters were catalogued over a five week period. Quercus macrocarpa was found to perform best compared to other species in both settings, while Cercis canadensis and Carpinus caroliniana were healthier in the control setting. Tolerance of various moisture conditions appeared to be a key trait for success of trees in bioswales.

Resolving the phylogeny of the Wirthiotremateae (Graphidaceae) with morphological and molecular data

Ian Medeiros, College of the Atlantic, and Field Museum of Natural History, Chicago, IL

The family Graphidaceae (lichenized Ascomycota: Ostropales), including the species formerly classified in the separate family Thelotremataceae, is the most important lichen family in the tropics in terms of both species diversity and biomass. Graphidaceae may also be the most speciose lichen family worldwide, with over two thousand species currently known and hundreds more likely undiscovered and undescribed. There are many interesting ecological and evolutionary questions that can be asked about such a large clade; to comprehensively answer these questions, though, we must first

understand the family's phylogeny and species diversity. Previous research at the Field Museum and elsewhere has shown that many of the traditional genera of thelotremoid Graphidaceae are polyphyletic, and has suggested that a group of 17 species from these genera may form a previously unrecognized clade. To study this group with greater resolution we generated sequences for five gene loci (mtSSU, nuLSU, RPB1, RPB2, and EF1-α) and collected morphological data. Our molecular work demonstrates that this potential clade, now designated as the tribe Wirthiotremateae, is indeed monophyletic. Morphological data suggests the correct phylogenetic placement of several Wirthiotremateae species for which we have no genetic data. The molecular data also shows that our herbarium collections for tribe Wirthiotremateae include between two and three previously undescribed species in the genera *Wirthiotrema* and *Austrotrema*. Several taxonomic changes are necessary now that the monophyly of Wirthiotremateae is confirmed, including the resurrection of the genus *Asteristion*, the expansion of *Nadvornikia* to include two non-mazaedial species, and the creation of the new genus *Austrotrema*. New combinations to be made are *Asteristion alboolivaceum* (=*Thelotrema albo-olivaceum*), *A. cupulare* (=*T. cupulare*), *A. leucophthalmum* (=*T. leucophthalmum*), *A. platycarpoides* (=*T. platycarpoides*), *A. platycarpum* (=*T. platycarpum*), *Austrotrema bicinctulum* (=*T. bicinctulum*), *Nadvornikia expallescens* (=*Leucodecton expallescens*), and *N. peninsulae* (=*Myriotrema peninsulae*). These nomenclatural changes, accompanied by our phylogenetic analysis, a dichotomous key to genera and species in the tribe, descriptions of new species, and discussions of distribution and ecology, will be made in a forthcoming monograph of the Wirthiotremateae. This publication will help facilitate future ecological and evolutionary studies on this and other Graphidaceae lineages.

Analysis of breadfruit domestication (*Artocarpus altilis*, Moraceae)

Matthew Murphy, Illinois College, and Chicago Botanic Garden, Glencoe, IL

The growing population of the world and the threat of climate change are constantly putting new pressures on our current crop system, and the small variety of crops in the current system puts it at great risk of disease. To help address these problems, researchers are putting more focus on underutilized crops. The genus *Artocarpus* (70 spp., Moraceae), which contains the valuable Southeastern Asian tree crops of breadfruit (*A. altilis*) and jackfruit (*A. heterophyllus*), contains many underutilized species of interest. One of these is *Artocarpus odoratissimus* (terap, marang), which is native to Borneo but has been introduced and cultivated into the Philippines. This study used nuclear and chloroplast DNA microsatellite data from 107 samples collected from Sabah, Malaysia (Borneo) to study the relationship between cultivated *A. odoratissimus* and *barbutus* form, which is the wild putative type that may be the wild progenitor of *A. odoratissimus*. The nuclear data set showed that the barbutus samples formed a distinct population from the *A. odoratissimus* samples; Furthermore, there was little gene flow taking place between the *barbutus* and *A. odoratissimus*, which supports that *barbutus* is distinct from *A. odoratissimus* but not a wild progenitor to it. However, a chloroplast haplotype network analysis revealed two haplotypes that both contained *odoratissimus* and *barbutus* at the center of the network, which is more consistent with the wild

progenitor being the *barbutus* form. The *odoratissimus* form displayed the greatest diversity in chloroplast haplotypes, but the nuclear data showed that the genetic diversity was not significantly different between the two forms. This study is the first to look into the relationship between the two forms, but more sampling from the rest of Borneo and the Phillipines, along with increased sample size of *barbutus*, will likely reveal more on these issues.

Plant-herbivore interactions with hybrid *Echinacea* plants in native prairie

Maureen Page, Scripps College, and Chicago Botanic Garden, Glencoe, IL

North-American prairie grasslands are among the most endangered resources in the United States. Northern tallgrass prairie habitat covers an area reduced to less than 5% of its historical extent. *Echinacea angustifolia*, purple coneflower, is widely distributed across this region and serves as a model organism for long-lived, herbaceous, prairie forbs. *E. angustifolia* is self-incompatible and thus relies on insect pollinators for successful reproduction. Pollinators are often implicated in the origin of new plant species because adaptation to different pollinators can drive divergence in floral traits and bring about reproductive isolation. The Echinacea Project has identified 26 species of bees that visit *E. angustifolia*, but some pollinators may be more efficient than others. To test for pollinator efficiency we excluded pollinators with mesh bags and then observed a single pollinator visit on 150 heads of *E. angustifolia*. We quantified efficiency based on the number of shriveled styles 48 hours after the visit. This project is a continuation of pollinator observations conducted in 2010, 2012, and 2013. The data for all four years of observations show that pollinator taxa influences the number of shriveled styles with *Andrena sp.* as the most efficient pollinator. Understanding the specific efficiency of different pollinators that visit Echinacea angustifolia will provide help in predicting the persistence of *E. angustifolia* populations based on the presence of key pollinators.

Morphological evolution of carnivoran milk teeth

Dana Reuter, Mount Holyoke College, and Field Museum of Natural History, Chicago, IL

Carnivoran tooth morphology has been well documented over the years to gain insight into their ecology and phylogeny. Despite this knowledge, there has been very few efforts to study their deciduous tooth morphology. In this study we investigated the evolution of carnivoran milk teeth in a phylogenetic comparative framework, focusing on how their shapes are related to those of adult teeth. We measured milk and adult teeth of 33 species from the families Canidae, Ursidae, Mustelidae, Felidae, Hyaenidae, Herpestidae, Nandiniidae, Viverridae, and Procyonidae. We used the phylogeny and measurements to see general trends in the morphology of both the milk teeth and their adult counterparts. We conducted: (1) principal component analysis to identify major variations among species in relative shear length, carnassial shape, and pre-carnassial shape and size, metrics that are closely tied to diet differences in adults; (2) phylogenetic regression analysis to the strength of correlation between milk and adult tooth shapes. We found that, although milk teeth are very similar to adult teeth in their morphology,

there are some differences within some dentally specialized groups; for example, felids and hyaenids have proportionally more grinding area in their milk teeth and bears have relatively small milk teeth compared to their adult counterparts. Canids are conservative in their morphology compared with other taxa. Carnassial shape is significantly more variable in adults than in juveniles (Fligner-Killeen test, P = 0.004) because the evolutionary rate is higher in adult carnassial shape ($\sigma 2 = 3.8 \times 10\text{-}3$) than in milk carnassial shape ($\sigma 2 = 1.4 \times 10\text{-}3$). These findings suggest that milk tooth morphology harbors potentially valuable information for phylogenetic reconstruction. The more limited variation in the shape of deciduous carnassial tooth may reflect evolutionary constraint or a more homogeneous selective pressure on juveniles across specie. Testing these hypotheses will require further research incorporating extinct groups and information on juvenile diets and weaning ages.

Soil Fungal Biomass: Its degradation and contribution to soil organic matter

Benjamin Sanchez-Sedillo, University of New Mexico, and Chicago Botanic Garden, Glencoe, IL

Microbes such as bacteria and fungi are major contributors to the global carbon cycle. The contribution of these organisms starts with the decomposition of organic matter, most notably biopolymers. These microbes excrete enzymes that are capable of breaking down biopolymers making the molecules more manageable for use. Biopolymers within the fungal cell wall constitute a large portion of below ground biomass making fungal necromass a large contributor to the carbon cycle. A previous study has looked at the degradation of a single species of fungi, *Fusarium avenaceum*. In this study, I undertook a field decomposition study to examine the in situ decomposition of fungal necromass in three saprotrophic fungal species. I documented tissue mass loss, analyzed changes in necromass chemical composition using Fourier-transformed infrared (FTIR) spectroscopy, and measured the activity of an enzyme (NAG) that is used by organisms to cleave bonds in the chitin biopolymer, the main component in the fungal cell wall. Similar results were found in all three species. As the enzymatic activity increased there was a decrease in mass and also notable changes in the carbohydrate region (1200-950 cm-1 range) of the infrared spectra, including a loss in the 967 cm-1 absorbance attributed to the chitin monomer, glucosamine. After day 14 the decrease in mass became relatively stable and there was a sharp decline in NAG activity. These results would suggest that within the first 14 days chitin was rapidly hydrolyzed leaving behind more recalcitrant portions of the fungal cell wall.

When seed sourcing matters for restoration on the Colorado Plateau

Giselle Varrientos, University of Wisconsin – Platteville, and Chicago Botanic Garden, Glencoe, IL

Extensive research over the last century has shown populations often become locally adapted to biotic and abiotic conditions, but it is only in the last decade that research has started to identify how plant populations may be adapting to new competitive environments imposed by the introduction of non-native species. For these reasons, four populations of a native grass species (*Sporobolus airoides*) distributed throughout much of the western United States were used in this study. This grass often shares

habitat with *Acroptilon repens* (Russian knapweed), which imposes a competitive environment that may influence the traits of *S. airoides*. Here, the following questions were addressed: do site-specific differences exist between populations? Will plants from a sub-population show signs that they are adapting to differences imposed by knapweed? To address these questions, a common garden study was used. Seeds for site-specific differences were sourced from four populations across the range of *S. airoides*; of these, one was growing sympatrically with knapweed. Using lab methods, broad and fine-scaled measurements were taken on plants from these areas. Detailed morphological measurements were taken, including below-ground mass, length and number of both fine and coarse roots. Root morphology is highly indicative of the plant's capacity to compete for resources, which is especially important given the limited research exploring the effects of competition with non-native plants on root traits. The results of this study show significant broad-scale differences in above-ground mass ($p=0.041$) and leaf count ($p=0.0015$) among populations. Differences for finer-scale measurements were found for leaf length ($p=0.0033$) and below-ground mass ($p=0.0087$) between maternal lines. However, no significant differences were found between plants growing in or out of knapweed, and therefore adaptation to the competitive environment created by knapweed was not supported. These results suggest that while differences exist within and among populations, they are not easily predictable and additional research is needed to understand what may be driving these differences.

Lessons from 35 years of migratory bird collisions in Chicago

Max Witynski, Cornell University, and Field Museum of Natural History, Chicago, IL

Bergmann's rule states that broadly-distributed organisms within a clade average smaller in warmer environments and larger in colder environments. Thus, given the warming climatic trend of the past few decades, one would expect recent adaptation in accordance with Bergmann's rule to result in smaller body sizes among organisms. The Chicago Bird Salvage Dataset, which is the result of window-casualty collecting at McCormick Place since 1980 and in the Chicago Loop since 2002 and contains a sample size of ~72,000 individual migratory birds, is particularly well suited to analysis of recent morphological changes in North American nocturnal-migrant passerines (songbirds). Sex, age and measurement data have been consistently recorded since the museum first began receiving window-killed birds more than three decades ago. We used R (version 3.1.0) to analyze morphological data on bills, tarsi, wings, and mass for all species with sample size $N \geq 50$ to search for evidence of microevolutionary trends over the study period. We found strong negative trends in bill length in the majority of species, suggesting selection for shorter bills has occurred broadly in North American passerines over the study period. Tarsi also showed strong negative correlations in the majority of species, though these trends were not as strong as those for bill. We also found significant but relatively weak negative trends in mass for most species, and a mixture of relatively weak positive and negative correlations for wing length (sometimes considered a proxy for body size). While previous research has illustrated birds' capacity

for rapid morphological change as a response to environmental pressure, most studies have focused more narrowly on island systems or individual species. Our study is unique in describing broad patterns of morphological change across continentally distributed species.

POSTER PRESENTATIONS

Evolutionary versatility and efficiency of mammalian masticatory muscles

Lissette Arellano, DePaul University, and Field Museum of Natural History, Chicago, IL

Rodents are the largest group of mammals and are extremely diverse. With more than 2400 species, rodents vary widely in appearance, size, habitats, and diets. Early in their evolutionary history, three distinct jaw muscle arrangements evolved across taxa that have remained to this day. To better understand the function and efficiency of these differing masticatory morphologies, ten rodent species that vary in jaw muscle arrangements, diets, and habitats were studied. In order to determine and compare the functional importance of these arrangements, it is necessary to have a better understanding of the way in which different parts of the masticatory apparatus co-vary across different taxa. For this purpose, measures of teeth, muscle attachments, mandibles, and jaw muscle lever arms were obtained. The findings indicate that the mouse-rat clade mostly exhibits covariance patterns more similar to those of the squirrel-related taxa than to those of South American rodents known as caviomorphs. The Northern Luzon giant cloud rat, however, appeared to be an outlier in the mouse-rat clade. Further work was done to find whether a functional, biomechanical difference exists between the muscle systems. The mechanical advantage of each masticatory apparatus was obtained for two tasks: chewing and gnawing. Mechanical advantage is a measure of a system's ability to amplify force. By measuring the mechanical advantage for each adductor muscle in mandible positions typical of chewing and gnawing, the relative efficiencies of these masticatory processes were found for each of the ten species. The data collected from these mechanical advantage studies supports the initial findings that the Northern Luzon giant cloud rat is an outlier in the mouse-rat clade that uses its masticatory muscles more like a caviomorph than a rodent of the squirrel-related taxa. Overall, the data demonstrate that rodents in the mouse rat clade exhibit masticatory versatility across morphologies.

Estimating Impacts of Bison Grazing on Rare Plants at the Nachusa Grasslands

Pairsa Belamaric, Humboldt State University, and Chicago Botanic Garden, Glencoe, IL

This coming fall, bison will be released on the Nachusa Grasslands. Bison grazing is expected to result in decreased graminoid and litter cover. In response, recruitment rates are predicted to increase for the rare Prairie Bush Clover (*Lespedeza leptostachya*). We conducted a preliminary study to capture baseline data to estimate how future grazing events will affect community structure on areas were *L. leptostachya* have long established populations. Specifically, our study explores the relationship between

current habitat and community composition with the population structure of this rare plant on the Nachusa Grasslands. Vegetation data and soil samples were collected and analyzed from six sites with various census-sizes of *L. leptostachya*. Height and cover classes were taken for all species captured by nine randomly placed meter squared plots on each site. Two soil samples were taken from each plot, as well as soil taken from directly beneath an *L. leptostachya* individual for each site. Nutrient and texture analyses were run on all soil samples. Soil texture and litter cover are correlated with census population size and height of the dominant grass, Little Blue Stem (*Schizacharium socparium*), had a significant effect on height of *L. leptostachya* in 2 of 3 sites where these data were measured in 2013. Our analyses also depict a clear difference in species composition between the six study areas driven by burning events and other human inflicted management techniques.

Interactions between a Suite of Biocontrol Weevils and the Ecosystem of *Cirsium pitcheri*

Allison Brackley, University of Illinois – Chicago, and Chicago Botanic Garden, Glencoe, IL

Invasive species cause economic and biodiversity loss worldwide. Biocontrol tactics can be a useful and effective tool for land managers to combat these invasions and many species of weevil act as biocontrol agents in this endeavor. *Larinus minutus* and *Larinus obtusus* are biocontrol weevils which have been used to combat the spread of *Centaurea stoebe* (syn. *Centaurea maculosa*), an invasive weed. *Larinus planus* is a non-native, adventive weevil that has been known to use the endangered thistle *Cirsium pitcheri* as a host plant. An investigation of these weevil species was conducted using behavioral observations, with a particular focus on each group's utilization of their enclosures, as well as their activity levels and detectability to an observer. An ethogram was constructed using the duration of each activity; for example, L. minutus spent 32% of its time perched. Ethogram results for *L. minutus* and *L. obtusus* were compared using principal components analysis. Despite their morphological similarity, these two species showed unique behavioral patterns and activity levels. Placement data from all three species was compared using a PERMANOVA and these data were statistically different ($p<0.001$). *Larinus planus* varied from the other species in its placement and also had a higher rate of detectability (81% vs. 75% for L. obtusus and 71% for *L. minutus*). Ethographic data for these species are useful, as behavioral information on the genus *Larinus* is rare, and both *L. minutus* and *L. obtusus* are used commonly in the United States and Canada for biocontrol. Results indicate that while L. obtusus and *L. minutus* have a similar appearance and both utilize *C. stoebe*, they are not interchangeable and may perform differently in the same environment.

Do oak species that are genetically associated with warmer climatic niches have greater isoprene emission rates?

Elizabeth Carter, DePaul University, and Morton Arboretum, Lisle, IL

Quantifying genetic diversity in *Lepidospartum burgessii* using microsatellites
Rachel Cheung, Carleton College, and Chicago Botanic Garden, Glencoe, IL
Chloe Siegel, University of Illinois Urbana-Champaign, and Chicago Botanic Garden, Glencoe, IL

Assessing performance of volunteers to monitor the urban forest
Erik Desotelle, University of Wisconsin – Stevens Point, and Morton Arboretum, Lisle, IL

Impacts of Climate Change on Germination of Native Species.
Courtney Devoid, Middlebury College, and Chicago Botanic Garden, Glencoe, IL

Over the next century, the planet is expected to undergo global climate changes that will impact plant species performance, regeneration, and persistence. Climate has a large influence on plant recruitment and regeneration; it is a critical force driving species distribution, seed dormancy, and germination. This project investigated the responses of early life stages to changes in climatic variables by testing the environmental tolerance ranges for populations of *Asclepias syriaca L.* (Apocynaceae) located along a latitudinal gradient. Three populations of *Asclepias syriaca* were collected in 2013 from Minnesota, Illinois, and Missouri to test for local adaptation in different climate hardiness zones. Seeds from each population were cold-stratified for six, eight, and ten weeks to simulate different winter lengths, then placed on a thermogradient table with temperature zones ranging from 15-30˚C. State, temperature zone, and cold stratification period all had significant effects on germination rates (Cox proportional hazard test, $R2 = 0.283$, state $p = 0.0273$, zone $p < 0.001$, stratification length $p < 0.001$). Additionally, stratification length and state of origin were significant interaction variables ($p = 0.0443$). The eight and ten week cold stratification periods had a higher probability of germination than the six week cold stratification period for all three states. Minnesota and Illinois had a higher probability of germination than Missouri. The results show that germination responses of *A. syriaca* are impacted by the state of origin, length of cold stratification, and incubation temperature. The intraspecific germination responses suggest that climatic changes could result in altered species performance, persistence, and germination rates because populations are locally adapted to specific climatic conditions.

Carbon storage and dynamics of The Morton Arboretum
Christina Fites, Indiana University – South Bend, and Morton Arboretum, Lisle, IL

Utilizing the Isolated Theropod Tooth Record to Answer Paleoecological Questions
Aaron Goodman, University of California – Davis, and Field Museum of Natural History, Chicago, IL

Isolated theropod teeth are much more common than skeletons in the fossil record, and can therefore provide vital insight into the paleoecology and diversity of ancient ecosystems. This study aims to identify isolated teeth from three different geological formations, in order to test hypotheses of apex predator turnover in the Cretaceous of North America. Morphological, dimensional, and microstructural data were collected on

teeth from the Early Cretaceous Antlers (n=37), Cloverly (n=10), and Cedar Mountain (n=7) Formations of North America, and were analyzed using a combination of morphometric and cladistic methods. Our cladistic data suggests that the largest teeth collected both from the Trinity and the Cloverly are consistent with being from the >5 ton allosauroid *Acrocanthosaurus*, though they differ statistically in morphometrics. We also found that teeth from the youngest member of the Cedar Mountain Formation (Mussentuchit) are grouped together cladistically, and form a tight and distinct cluster in morphospace, suggesting a turnover between the apex predator clades during the Early Cretaceous. These teeth belong to megaraptorans, which are thought to be derived allosauroids. If this is correct, our findings are consistent with the hypothesis that allosauroids competitively excluded tyrannosauroids from the apex predator niche until the Late Cretaceous.

Phylogeography of the *Pteroglossus azara* (Ramphastidae) complex: Implications for prioritizing conservation and defining areas of endemism in the Amazon

Ethan Gyllenhall, University of Rochester, and Field Museum of Natural History, Chicago, IL

Amazonia is an area with incredible biodiversity, and the more it is explored the more we begin to understand complex that biodiversity is. In numerous cases, advances in the field of genetics coupled with traditional data have led researchers to recommend splitting populations that were previously assumed to be one species. This taxonomic reevaluation of Amazonian biodiversity has revealed additional evidence for areas of endemism, regions that contain multiple species that are not found anywhere else. In birds, these regions are often defined by major Amazonian rivers, where one species found on one side of the river is distinct (genetically, morphologically, or behaviorally) from a related species on the other side. These areas of endemism are important from a conservation standpoint, as failing to preserve a certain area of endemism could result in the extinction of dozens of species that evolved in it. There are eight traditionally recognized areas of endemism, with a ninth recently described one, the Jaú area of endemism. We studied genetic structure in a complex of medium-sized toucans (*Pteroglossus*) found in western Amazonia. This complex contains three subspecies, one of which, *P.a.azara*, occurs only in the Jaú area of endemism. We gathered data on six genes. The mitochondrial genes, CO1 and Cytochrome B, are what are discussed here. The nuclear genes (CHD-18, ALDO-5, MUSK-4, and ACO1-I9) are still being analyzed. The mitochondrial data suggests that *azara* is genetically distinct from the other subspecies (*mariae* and *flavirostris*), and that there is not discrete genetic structure separating the other two. This supports recognizing *P.a.azara* as a distinct species. It also presents an additional example of why the Jaú area of endemism should be recognized, and that conservation efforts should be made to protect it. This would also suggest that other taxa may follow this pattern.

Using native winners to improve restoration outcomes on the Colorado Plateau

Lisa Hintz, The Evergreen State College, and Chicago Botanic Garden, Glencoe, IL

In rangelands of the arid western United States, post-fire restoration efforts may be time sensitive in order to effectively prevent and control erosion and to establish native flora, thus, sourcing appropriate plant seed is critical. Decades of reciprocal transplant and common garden studies have shown local adaptation to be strong for many plant species. Applying locally adapted seed at appropriate sites may increase the efficiency and success of restoration efforts by mitigating losses through excessive plant failure. In this study, we examined local adaptation in *Cleome lutea* (Capparaceae [Capparidaceae]), a species with potential to be grown commercially for inclusion into restoration seed mixes. We grew nine populations of *C. lutea* in a common garden experiment in a climate-controlled growth chamber. Our nine populations were sourced from three climate clusters that were determined with a multivariate cluster analysis using Bioclim (Worldclim) and location data. We measured above- and belowground morphological characteristics and aboveground biomass after four weeks. Our results show significant differences among populations for eight of ten measures; however, these differences are not easily explained by climate cluster. For example, height to apical meristem and flowering phenology both varied significantly ($P<0.0001$) among populations but these differences were just as great within climate clusters as between them. Nonetheless, these results suggest genetic variation relative to site. Local adaptation to other edaphic conditions not included in this study may be occurring, while other factors such as maternal effects and/or genetic drift could be influencing these results. Since among population differences are present, population level genetic variation could potentially influence the success of this species in restoration efforts and may play an important role in adaptation to a variety of factors not assessed in the present study. Additional research is needed to determine the degree of local adaptation in *C. lutea* in order to better inform appropriate seed sourcing decisions.

Oak seedling survival and growth in relation to canopy structure and understory competition

Stuart Hupp, Virginia Tech, and Morton Arboretum, Lisle, IL

Prior to Euro-American settlement, oaks (*Quercus*) were the dominant genus in many forests across North America (Dey, 2002). However, the dominance of oaks has declined greatly in many forests due to changing climatic conditions, changes in fire regimes, increased browsing, exotic pests and vegetation, and logging (Abrams, 1992). In addition, in many forests in which an oak component remains a transition is occurring to dominance by more shade-tolerant mesic species (e.g., sugar maple) and there is very little regeneration of oak species. Restoring oak dominance and promoting oak regeneration have become important goals for managers across a variety of forest types and locations. The principle goal of this project was to improve understanding of the relation between light environment and oak seedling success in a larger project focused on developing canopy thinning methods for promoting oak regeneration in urban natural areas. We analyzed how canopy openness, light transmittance, and understory competition varied among treatments (20% and 10% basal area removal and control) and how each affected oak seedling growth. We expected growth to be greatest with the

most thinning; however, we also expected the negative effects of understory competition to be greatest in these locations. Seedling growth varied significantly among the thinning units (ANOVA: $F_{5,107} = 6.45$, $p < 0.001$), but growth only differed between the control and thinning treatments, not among the thinning intensities. Light availability was much greater at 2.5m in the 20% removal treatment, but this light was quickly attenuated by the understory layer and there was no difference in radiation at 0.5m (approximately the average seedling height). This effect illustrates the importance of the understory layer, but it is difficult to separate out the specific effect of this layer. A useful next step could be to manipulate understory vegetation within the experiment to isolate the impact of understory competition.

Delimiting Species Boundaries in the Face of Conflicting Phenotypic and Molecular Data

Marissa Locke, DePaul University, and Field Museum of Natural History, Chicago, IL

With the rise of readily available DNA sequencing technology, the accuracy of traditional morphology-based approaches to species delimitation are being called into question. Scientists have historically circumscribed species using phenotypic characters, ecological data, and/or behavioral traits. However, molecular sequence data, used alone or in combination with traditional lines of evidence, now plays a prominent role in assessing species boundaries. In lichen-forming fungal genera such as *Diploschistes*, crater lichens, morphology is highly variable making traditional morphology-based methods of species delimitation difficult and prone to misinterpretation of characters. The use of molecular characters may offer a more objective approach to species delimitation. In this study, we examine the phylogeny of *Diploschistes* and the use of molecular data to resolve discrepancies that traditional morphological data cannot. Nineteen species in the genus *Diploschistes* were sampled using the following four loci: ITS,mtSSU, RPB1, and RPB2. Overall, phylogenetic reconstructions were insufficient to resolve relationships among species. The majority of sampled species were not recovered asmonophyletic due to high genetic similarity. However, population assignment test revealed six genetic clusters. Traditional phylogenetic species delimitation can be difficult in recently diverged groups due to incomplete lineage sorting. The most appropriate approach to species delimitation is still not clear and depends to a large degree on the evolutionary history of the group of interest. Our findings suggest that coalescent theory and population genetics may offer a more objective approach to species delimitation but will require a greater number of individuals sampled and additional genetic markers. In addition, integrating data from independent sources (e.g., molecular, morphology, ecology) will likely be crucial to establishing robust hypotheses of species boundaries.

How to evaluate ravine vegetation? Testing a new meander-based protocol and comparing to plot-based data for Schenck Ravine.

Jaileen Merced, University of Puerto Rico, and Chicago Botanic Garden, Glencoe, IL

Ravines along Lake Michigan's north shore are home to rare species but many ravines are degraded. The goal of this project was to develop a rapid sampling method to determine the vegetation composition in ravines and compare these results to those

from Ravine Rapid Assessment (RRA) developed in 2013. This protocol was thorough but time- intensive. For this project we developed and tested the Ravine Floral Quality Assessment (RFQA). The RFQA is a timed meander of the ravine, where species presence and coverage is recorded in three communities (table, slope, and bluff) which are sampled on the north and south facing sides of the ravine. Total richness, native richness, and average of coefficient of conservatism (aC) were used to compare the RRA and RFQA. We also calculated weighted C (wC) for the RFQA. The vegetation community was analyzed with non-metric multidimensional scaling. In both protocols the north-facing side of the ravine had the highest aC for all communities. Highest total and native richness was found on slopes using both protocols. The rarest plants in the ravine occurred on slopes according to the aC, and meander-based RFQA better captured rare species. However wC show different patterns because non-rare species have greater cover. In contrast to aC, the south-facing table had the highest wC. Community analysis showed that slopes sampled with both protocol aligned with previous data. In contrast, tables and bluffs sampled with both protocol were less similar to each other and previous data. Variation in table and bluff results could have been caused by disturbance to these communities and their relatively small area. While the RRA provides quantitative, spatially explicit information about ravine communities, the RFQA quickly and accurately evaluates vegetation community composition. The RFQA should be tested in different ravines to evaluate efficacy and adaptability in different conditions.

Impacts of tallgrass prairie restoration on decomposition and microbial communities

Ramsey Millison, DePaul University, and Chicago Botanic Garden, Glencoe, IL

Prairie restoration primarily focuses on aboveground processes, such as the removal of invasive species and the reintroduction of native species, while belowground processes, decomposition and microbial activity, are neglected. Because of this, little is known on how prairie restoration affects belowground processes. In this research litter decomposition and microbial communities were compared on a restoration/management gradient between prairie remnants and prairie restoration sites. Decomposition studies were conducted at 22 sites using the native plants *Andropogon gerardii*, *Rudbekia subtomentosa*, and *Baptisia spp.* Microbial community characterization studies were conducted by assaying decomposition samples for enzymes produced by fungi and associated with decomposition. Since decomposition plays such a significant role in the ecosystem, it is imperative to ascertain if prairie restoration/management efforts actually work and matter. This research could further be used to better and refine restoration techniques.

Osteohistology of a Small Sauropodomorph from Antarctica

Stephanie Pedersen, Augustana College, and Field Museum of Natural History, Chicago, IL

The purpose of this study is to look at the microstructure of bone in order to look at the growth of a small basal sauropodomorph dinosaur specimen from the Early Jurassic Hanson Fm. of Antarctica. This specimen is very small (femur length= 235.5mm), but

bone histology can determine if its size is due to it being a juvenile, or if it represents a mature specimen of a small bodied –species. Histology can also be used to determine if high latitudes had any effect on the growth of this dinosaur by comparing it to histological studies of related species from lower latitudes such as Mussaurus, Plateosaurus, and Massospondylus. Cross sections of the femur, two ribs (one longitudinal study), two gastralia, and the fibula were prepared through standard paleohistological techniques. These sections commonly showed highly vascularized fibrolamellar tissue displaying rapid growth of the animal. Primary osteons are present with very few secondary osteons indicative of remodeling present. No growth markers such as Lines of Arrested Growth (LAGs) were observed in the limb bones, but 1-2 were present in the gastralia and ribs. However, the LAGS that were present were asymmetrical in order to account for the curvature of the bones. Since this specimen displayed such rapid growth and such little evidence of LAGS, histology suggests this animal had died at an early ontogenic stage.

Assessing the use of morphological characteristics to predict branch attachment strength

Felipe Santich, University of California – Davis, and Morton Arboretum, Lisle, IL

Branch failure during storm events is a common problem for urban trees, causing property damage, power outages, and personal injury and death. Improving our knowledge of characteristics that affect branch attachment strength is crucial to help improve the resiliency of urban trees to storm damage. This study was designed to test the effects of branch-trunk diameter ratio (aspect ratio), union shape and presence of included bark on branch attachment strength. Ninety trunk- branch unions of *Acer platanoides* (Norway maple) were harvested and taken to a customized winching apparatus for destructive testing. Branches were pulled to failure using a winch and cable, and an in-line load cell recorded force to a data acquisition system. Branch attachment strength decreased as aspect ratio increased for branches with and without included bark ($R2 = 0.60$ and 0.53 respectively). The effect of this relationship was greater when included bark was present ($P < 0.01$). The presence of included bark tended to be influenced by branch union shape. These findings suggest that trees with high aspect ratio will be more likely fail during storms, and the presence of included bark may increase this likelihood.

Strategies to Engage Chicago Communities in their Urban Ecosystem

Zoe Spector, University of Illinois Urbana-Champaign, and Field Museum of Natural History, Chicago, IL

Environmental education and community engagement initiatives through the Field Museum's Science Action Center and its partners bring Chicago community members together to strengthen the bonds between different communities and their natural environment. Many of these projects focus on south side communities where there is little "green space," and/or a history of disenfranchisement. Engaging community members, especially youth, in environmental education and leadership development is a key strategy the Field Museum puts forth because it encourages job readiness, green

careers, and community involvement. I examine the engagement strategies of four initiatives. The initiatives include three examples of different daylong events, in which the Field Museum is a partner, and one 10-month youth development program at the Field Museum. These include: 1.) The Openlands Little Calumet River cleanup, part of the Openlands Water Trails Workshops; 2.) Beaubien Woods Celebration Day, an annual community event focused on the local environment; 3.) Hobart Water Festival, an educational and festive annual event focused on local water; 4.) The "Green Ambassadors" program, a 10 month youth engagement initiative through the Field Museum that focuses on two Chicago neighborhoods to improve the relationships among them and their natural environment. As indicators of levels of engagement, I look at consistency and duration of participation of community members, enthusiasm, and overall participant interest. Through these different initiatives, I highlight what types of engagement strategies are successful in connecting urban communities with their natural environment, and identify key indicators of activities and stewardship initiatives that engage youth.

Assessing Genotypic Bias in Neotropical Army ant Caste Determination

Andrea Thompson, Harold Washington College, and Field Museum of Natural History, Chicago, IL

Eciton burchellii parvispinum is a top Neotropical predator with great ecological importance. The adult workers of a colony are divided into four castes: minors, media, submajors, and majors that exhibit strong polymorphism that helps them specialize in accomplishing specific tasks. Most notable are the majors that are many times larger than the other workers, with giant sickle shaped mandibles that are used for defense of the colony against potential predators. *Eciton burchellii parvispinum* also are highly polyandrous, with one queen that mates with up to 17-20 males to produce her sterile workers. 18 colonies from Área de Conservación Guanacaste (AGC) in Costa Rica were sampled for this study. 13 microsatellites were amplified from DNA extracts and measurements off morphological variation using geometric and linear morphometrics. By using microsatellite data to infer matriline and patrilines, we will match the genotypic data to morphological data to infer if morphological variation has any patriline bias in caste determination.

Fossil Plants from Mongolia

Carolyn Thornton, College of Wooster, and Chicago Botanic Garden, Glencoe, IL

The Early Cretaceous of Mongolia provides a source of information on a time and place that should represent an extensive diversification of angiosperms but is not well understood. Study of the region began in order to find evidence of some of the earliest angiosperms, but much non-angiosperm material has also been collected. This material needs to be analyzed to understand the flora of this time period and its relationship to extant groups. Bulk samples of lignified plant material were picked through to separate out well-preserved specimens. Leaves were isolated from samples from the localities of Tevshiin Govi and Tugrug and were photographed for morphology and anatomy (shape,

venation). Specimens were also prepared for light microscopy by clearing and staining and for scanning electron microscopy in order to study epidermal anatomy (stomata, cell shape). Micrographs were analyzed to describe specific morphological and epidermal characters and the leaves were divided into morphotypes based on these characters. Seven morphotypes were found from Tevshiin Govi and two morphotypes were found from Tugrug. These morphotypes were then compared with known plant families, though several morphotypes had too few features to identify. Two morphotypes have bands of stomata and venation similar to the Pentoxylales. One morphotype, a thin, needle-like leaf, appears similar to Voltzialeans, but could also be a member of Cupressaceae or Pinaceae. One morphotype matches previously described *Podozamites spp.*, a member of the conifers. Another morphotype is a fern but is too fragmented to identify further. The seven morphotypes from Tevshiin Govi represent the current known diversity of the site while the morphotypes from Tugrug are only a start to measuring diversity. These results, as well as further work with these morphotypes to more confidently identify them and isolate additional morphotypes from the sites, will provide data to be used in reconstructing whole plants and understanding the Mongolian Cretaceous flora.

Genetics for good: helping to conserve a rare plant in the Pacific Northwest

Deisi Williamson, DePaul University, and Chicago Botanic Garden, Glencoe, IL

Genetic diversity between plant populations that have undergone reintroduction efforts plays a crucial role for plant population survival. Without genetic diversity within and between plant populations, plants are at higher risk of being effected by deadly pests, pesticides and natural disasters, which in turn will lower a plant population's overall fitness and therefore it becomes an unsuccessful reintroduction effort. *Castilleja levisecta*, also known as golden paintbrush, has recently undergone reintroduction efforts. Once native to the Pacific Northwest, golden paintbrush is now extirpated in Oregon. For reintroduction, seeds were collected from extant Washington populations and propagated in seed-increase beds at a common nursery. Subsequent seeds were outplanted in reintroduction sites. To observe how genetic diversity may change throughout the reintroduction process, this study compares genetic information between populations at multiple propagation stages. To compare genetic diversity, DNA from leaf samples were extracted using a modified Chelex extraction method. DNA was amplified with a PCR and seven microsatellite primers, which were then read through capillary electrophoresis. Population similarity and genetic diversity was analyzed using Structure and GenAlEx. In result, the data collected suggests there is a dissimilarity between wild source populations and their corresponding seed production beds. The level of dissimilarity was not consistent between populations. This suggests populations differed in reaction to different propagation methods. This suggests that the effect of propagation methods differed between plant populations. Loss of genetic information within propagation could cause lower fitness within reintroduction populations.

Student Participants

Field Museum REU Participants

Luis Allende, lmallend@neiu.edu, Northeastern Illinois University, sophomore.
Project: *What's in a name? That's what we call a species - addressing species delimitation in script lichens* with Dr. Thorsten Lumbsch (Curator and Associate Director of the Integrative Research Center, S&E)

Anne Gibbons, aegibbons17@gmail.com, University of Michigan - Ann Arbor, junior.
Project: *Fishing around the world: spiders of the genus Dolomedes* with Drs. Petra Sierwald (Curator, Arachnida and Myriapoda, S&E) and Estevam da Silva (Postdoctoral Researcher, Arachnida and Myriapoda, S&E)

Wilson Guillory, wxguillo@email.uark.edu, University of Arkansas, freshman.
Project: *A Thousand-legged Mystery: The Evolution of Millipedes* with Dr. Petra Sierwald (Curator, Arachnida and Myriapoda, S&E)

Chris Kyriazis, CKyriazis33@gmail.com, University of Chicago, junior.
Project: *Speciation and Diversification of Mammals on Islands* with Drs. John Bates (Curator, Birds, S&E) and Lawrence Heaney (Curator, Mammals, S&E)

Armita Manafzadeh, armita.manafzadeh@berkeley.edu, University of California – Berkeley, sophomore.
Project: *Morphological Integration in the Mandibles of Living Reptiles and Fossil Synapsids* with Dr. Kenneth D. Angielczyk (Curator, Geology, S&E)

Ian Medeiros, imedeiros@coa.edu, College of the Atlantic, sophomore.
Project: *Resolving the Phylogeny of the Wirthiotremateae (Graphidaceae) with Morphological and Molecular data* with Drs. Robert Lücking (Adjunct Curator and Collections Manager, Botany, S&E) and Thorsten Lumbsch (Curator and Associate Director of the Integrative Research Center, S&E)

Dana Reuter, reute22d@mtholyoke.edu, Mount Holyoke College, junior.
Project: *Morphological evolution of carnivoran milk teeth* with Drs. Kenneth Angielczyk (Curator, Geology, S&E) and Susumu Tomiya (Postdoctoral Researcher, Geology, S&E)

Max Witynski, birdmax922@gmail.com, Cornell University, freshman.
Project: *Lessons from 35 years of migratory bird collisions in Chicago* with Drs. David Willard (Adjunct Curator, Birds, S&E), Ben Marks (Collection Manager, Birds, S&E), Douglas Stotz (Research Ecologist, Science Action Center) and Ben Winger (Graduate Student, Birds, S&E)

REU Site: Access to Global Biodiversity Studies for Undergraduates (supported by the National Science Foundation, DBI: 08-49958: PIs Petra Sierwald and Peter Makovicky; DBI 11-56594: PIs. Petra Sierwald and Kenneth Angielczyk, see at: http://fieldmuseum.org/about/c-r-research-experiences-undergraduates-reu

AFFILIATED FIELD MUSEUM SCIENCE SUMMER INTERNS

Lissette Arellano, arellanoliss@gmail.com, DePaul University, junior.
Project: *Evolutionary versatility and efficiency of mammalian masticatory muscles* with Dallas Krentzel (Graduate Student Researcher, Geology, S&E)

Aaron Goodman, amgoodman@ucdavis.edu, University of California - Davis, junior.
Project: *Utilizing the isolated theropod tooth record to answer paleoecological questions* with Dr. Peter Makovicky (Curator, Geology, S&E)

Ethan Gyllenhall, ethanofthegulls@gmail.com, University of Rochester, sophomore.
Project: *Phylogeography of the Pteroglossus azara (Ramphastidae) complex: Implications for prioritizing conservation and defining areas of endemism in the Amazon* with Dr. Jason Weckstein (Research Associate, Birds, S&E)

Marissa Locke, marissa_locke@yahoo.com, DePaul University, junior.
Project: *Delimiting Species Boundaries in the Face of Conflicting Phenotypic and Molecular Data* with Dr. Steven Leavitt (Postdoctoral Researcher, Botany, S&E)

Stephanie Pedersen, stephaniepedersen11@augustana.edu, Augustana College, senior.
Project: *Osteohistology of an Antarctic sauropodomorph dinosaur* with Dr. Peter Makovicky (Curator, Geology, S&E)

Zoe Spector, zspector@fieldmuseum.org , University of Illinois Urbana-Champaign, sophomore.
Project: *Strategies to Engage Chicago Communities in their Urban Ecosystem* with Alison Paul (Youth Conservation Action Coordinator, Science Action Center) and Mario Longoni (Urban Anthropologist, Science Action Center)

Andrea Thompson, thompsonandrea1991@gmail.com, Harold Washington College, sophomore
Title: Assessing Genotypic Bias in Neotropical Army ant Caste Determination with Dr. Corrie Moreau (Curator, Insects, S&E) and Max Winston (Graduate Student, Insects, S&E)

Fulbright African Visiting Research Scholar: **Tshifhiwa Nangammbi**, tshifhiwanangammbi@yahoo.com, Tshwane University of Technology, South Africa.
Project: *Genetic characterization of Oreochromis niloticus and indigenous riverine fishes through the use of Microsatellites for a better conservation of the indigenous fishes in Limpopo, South Africa* with Dr. Kevin Feldheim (Pritzker Lab Manager, S&E)

CHICAGO BOTANIC GARDEN REU PARTICIPANTS

***Pairsa Belamaric**, pnb27@humboldt.edu, Humboldt State University, junior.
Project: *Estimating Impacts of Bison Grazing on Rare Plants at the Nachusa Grasslands* with Dr. Pati Vitt (Susan and Roger Stone Curator, Dixon National Tallgrass Prairie Seed Bank Conservation Scientist)

***Allison Brackley**, abrack2@uic.edu, University of Illinois – Chicago, junior.
Project: *Interactions between a Suite of Biocontrol Weevils and the Ecosystem of Cirsium pitcheri* with Christopher Warneke (Graduate Student Researcher)

***Monica Cesinger**, mcesinger14@amherst.edu, Amherst College, junior.
Project: *Green Roof Ecology* with Kelly Ksiazek (Researcher, Plant Science and Conservation)

Rachel Cheung, cheungr@carleton.edu, Carleton College, sophomore.
Project: *Quantifying genetic diversity in Lepidospartum burgessii using microsatellites* with Dr. Evelyn Webb Williams (Postdoctoral Research Associate)

***Courtney Devoid**, cdevoid@middlebury.edu, Middlebury College, junior.
Project: *Impacts of Climate Change on Germination of Native Species* with Jessamine Finch (Graduate Student Researcher)

Andrea Gruver, agruver@gustavus.edu, Gustavus Adolphus College, junior.
Project: *Scent variation: its role in attracting both pollinators and herbivores in Evening Primroses* with Dr. Jeremie Fant (Conservation Scientist Molecular Ecology Lab Manager)

Rosalba Herrera, rherrera1080@yahoo.com, Loyola University, freshman.
Project: *Fungi of Mexico: documenting diversity and mycorrhizal status with genetics and stable isotopes* with Benjamin Morgan (Graduate Student Researcher)

***Lisa Hintz**, hinlis24@evergreen.edu, The Evergreen State College, sophomore.
Project: *Using native winners to improve restoration outcomes on the Colorado Plateau* with Maggie Eshleman (Graduate Student Researcher) and Nora Talkington (Graduate Student Researcher)

***Jaileen Merced**, jaileen91@yahoo.com, University of Puerto Rico, junior.
Project: *How to evaluate ravine vegetation? Testing a new meander-based protocol and comparing to plot-based data for Schenck Ravine* with Rachel Goad (Manager, Plants of Concern)

Ramsey Millison, millisonramsey@gmail.com, DePaul University, junior.
Project: *Impacts of tallgrass prairie restoration on decomposition and microbial communities* with Lauren Umek (Graduate Student Researcher)

***Matthew Murphy**, murphy.matthew@mail.ic.edu, Illinois College, sophomore.
Project: *Analysis of breadfruit domestication (Artocarpus altilis, Moraceae)* with Elliot Gardner (Graduate Student Researcher)

***Maureen Page**, maureen.lukens.page@gmail.com, Scripps College, sophomore.
Project: *Plant-herbivore interactions with hybrid Echinacea plants in native prairie* with Dr. Stuart Wagenius (Conservation Scientist)

***Benjamin Sanchez-Sedillo**, Bensedio@unm.edu, University of New Mexico, junior.
Project: *Soil Fungal Biomass: Its Degradation and Contribution to Soil Organic Matter* with Dr. Louise Egerton-Warburton (Conservation Scientist, Soil and Microbial Ecology)

Chloe Siegel, chloessiegel@gmail.com, University of Illinois Urbana-Champaign, freshman.
Project: *Quantifying genetic diversity in Lepidospartum burgessii using microsatellites* with Dr. Evelyn Webb Williams (Postdoctoral Research Associate)

Carolyn Thornton, cthornton15@wooster.edu, College of Wooster, junior.
Project: *Fossil Plants from Mongolia* with Dr. Patrick Herendeen (Co-Director, Division of Plant Science and Conservation Director of Academic Partnerships Senior Scientist)

***Giselle Varrientos**, varrientosg@uwplatt.edu, University of Wisconsin – Platteville, junior.
Project: *When seed sourcing matters for restoration on the Colorado Plateau* with Dr. Andrea Kramer (Conservation Scientist, Ecological Genetics) and Alicia Foxx (Graduate Student Researcher)

Deisi Williamson, deisiwilliamson@gmail.com, DePaul University, sophomore.
Project: *Genetics for good: helping to conserve a rare plant in the Pacific Northwest* with Adrienne Basey (Graduate Student Researcher)

*Interns funded by REU Site: Plant Biology & Conservation Research Experiences for Undergraduates - From Genes to Ecosystems. (Supported by NSF awards DBI-0353752, DBI-0648972, and DBI-1062675) - See at: http://www.cbgreu.org/#sthash.XSNARY7C.dpuf

Morton Arboretum Summer Interns

Breane Budaitis, bgbudaitis@gmail.com, Ohio Wesleyan University, senior.
Project: *Inferring the history of morphological diversification in sedges* with Dr. Andrew Hipp (Senior Scientist, Plant Systematist and Herbarium Curator)

Elizabeth Carter, lizcarter359@yahoo.com, DePaul University, junior.
Project: *Do oak species that are genetically associated with warmer climatic niches have greater isoprene emission rates?* with Dr. Mark Potosnak (Professor, DePaul University)

Erik Desotelle, erik.o.desotelle@uwsp.edu, University of Wisconsin – Stevens Point, junior.
Project: *Assessing performance of volunteers to monitor the urban forest* with Dr. Bryant Scharenbroch (Urban Soil Scientist)

Cristina Fites, cmfites@gmail.com, Indiana University – South Bend, senior.
Project: *Carbon storage and dynamics of The Morton Arboretum* with Emma Bialecki (Forest Ecology Research Assistant)

Stuart Hupp, shupp92@vt.edu, Virginia Tech, junior.
Project: *Oak seedling survival and growth in relation to canopy structure and understory competition* with Dr. Robert Fahey (Forest Ecologist)

Kathrine Klaus, ktaklaus@gmail.com, University of Illinois, junior.
Project: *Towards a sustainable designer urban soil for trees* with Dr. Bryant Scharenbroch (Urban Soil Scientist)

Brian Maule, blmaule16@live.com, Northern Illinois University, junior.
Project: *Effects of urban trees and green infrastructure on water quality and runoff* with Dr. Bryant Scharenbroch (Urban Soil Scientist)

Felipe Santich, fdsantich@ucdavis.edu, University of California – Davis, senior.
Project: *Assessing the use of morphological characteristics to predict branch attachment strength* with Dr. Jason Miesbauer (Research Arborist)

Professional Participants

Organizers

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Dr. Andrew Hipp, Morton Arboretum, ahipp@mortonarb.org

Dr. Dan Larkin, Chicago Botanic Garden, dlarkin@chicagobotanic.org

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Dr. Petra Sierwald, Insects, Field Museum, psierwald@fieldmuseum.org

Stephanie Ware, Insects, Field Museum, sware@fieldmuseum.org

Symposium Moderators

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Dr. Fabiany Herrera, Chicago Botanic Garden, fherrera@chicagobotanic.org

Benjamin Rubin, Insects, Field Museum, brubin@fieldmuseum.org

Field Museum Phylogenetic Workshop Instructors

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Dr. Timothy Swain, Fishes, Field Museum, tswain@fieldmuseum.org

Mentors and Advisors

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